31 Proximal Tibia Plating Failed Fixation

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History of Previous Primary Failed Treatment

Proximal tibia fractures of the metaphysis, metadiaphysis and diaphysis occur commonly, with a bimodal age distribution, associated with lower energy mechanisms in elder patients and higher energy mechanisms, generally in younger and middle-aged patients. The majority of these fractures are extra-articular or with a nondisplaced extension of the fracture within the sagittal plane into the tibial plateau [1]. The surrounding soft tissue envelope includes minimal anterolateral musculature, more robust posterior musculature and the subcutaneous border of the anteromedial proximal tibia. Underlying knee arthrosis with associated stiffness and subchondral sclerosis may increase the risk for fracture and displacement in this location. Concurrent knee ligament injuries are common and may require repair or reconstruction.

Our case example includes a 52-year-old man who had multiple injuries in a high-speed motorcycle crash. He sustained a brief loss of consciousness, several left rib fractures with pneumothorax, left open radius and ulna shaft fractures and a fracture of the left proximal tibia (Fig. 31.1). Following resuscitation and administration of intravenous antibiotics, he went to the operating room for debridement and open reduction and internal fixation (ORIF) of his forearm, as well as closed reduction and spanning external fixation of the knee for the left tibia fracture (Fig. 31.2). Due to severity of soft tissue swelling about the left tibia, definitive surgery was deferred. The patient's history was significant for alcohol and recreational drug abuse and tobacco abuse (45 pack-years). He returned to the operating room 12 days later for open reduction and internal fixation of the proximal tibia with a locking plate and a combination of standard and locking small fragment screws (Fig. 31.3). Non-weight-bearing was anticipated for 2–3 months postoperatively, depending on fracture healing. He discharged from the hospital on postoperative day 2 and returned to the outpatient clinic 2 weeks later, where his tibia surgical wounds had healed, and knee range of motion was recommended. He did not return 6 weeks later as he had been advised. One year later he returned to the clinic complaining of persistent pain and activity-related swelling. His history, physical examination and radiography suggested nonunion of the tibia, and revision surgery was

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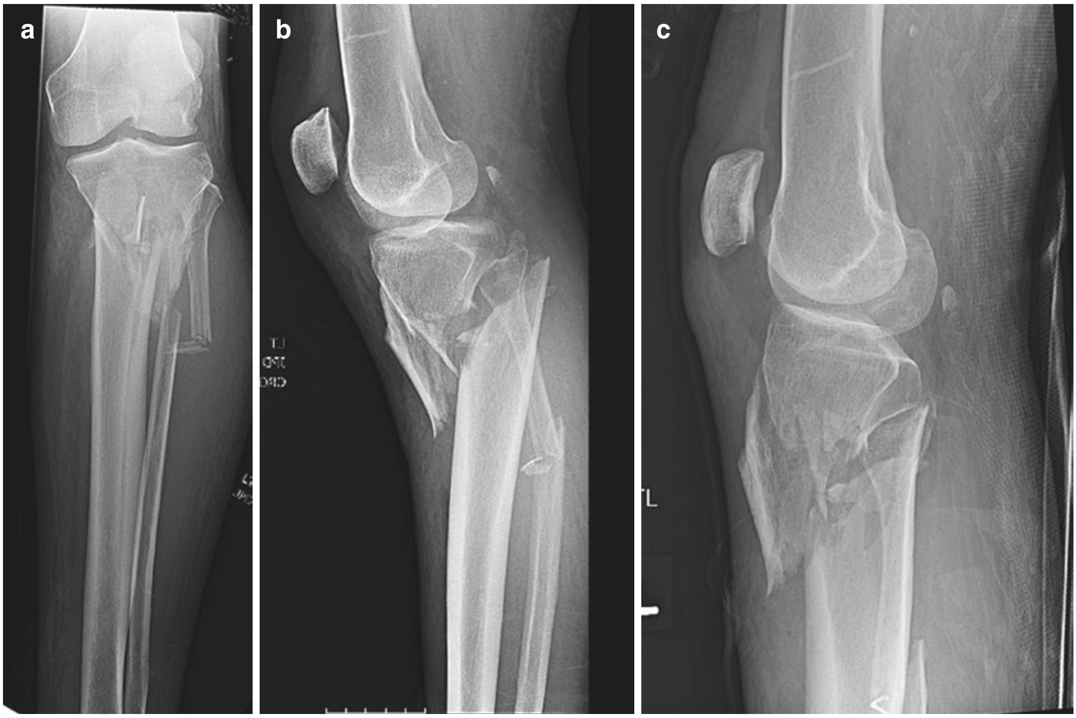

Fig. 31.1 Anteroposterior (**a**) and lateral (**b**, **c**) views of the left tibia obtained on presentation to the emergency department show comminuted displaced proximal tibia shaft fracture, including displaced fractures of the proximal fibula and of the tibia tuberosity. Nondisplaced fracture extension into the tibia plateau is present

advised (Fig. 31.4). Laboratory tests and a computed tomography (CT) scan were ordered; however, he did not obtain these, rather did not return to the clinic for 15 more months, after he had been arrested and sent to jail, followed by an inpatient program for substance abuse. Workup in anticipation of revision surgery was advised but denied by authorities until the patient had completed his rehabilitation program. He returned to the outpatient orthopaedic clinic, then 2.5 years after the initial surgery, with a nonunion and failed fixation (Fig. 31.5).

Fig. 31.2 Intraoperative fluoroscopic views following closed reduction and spanning external fixation of the proximal tibia fracture

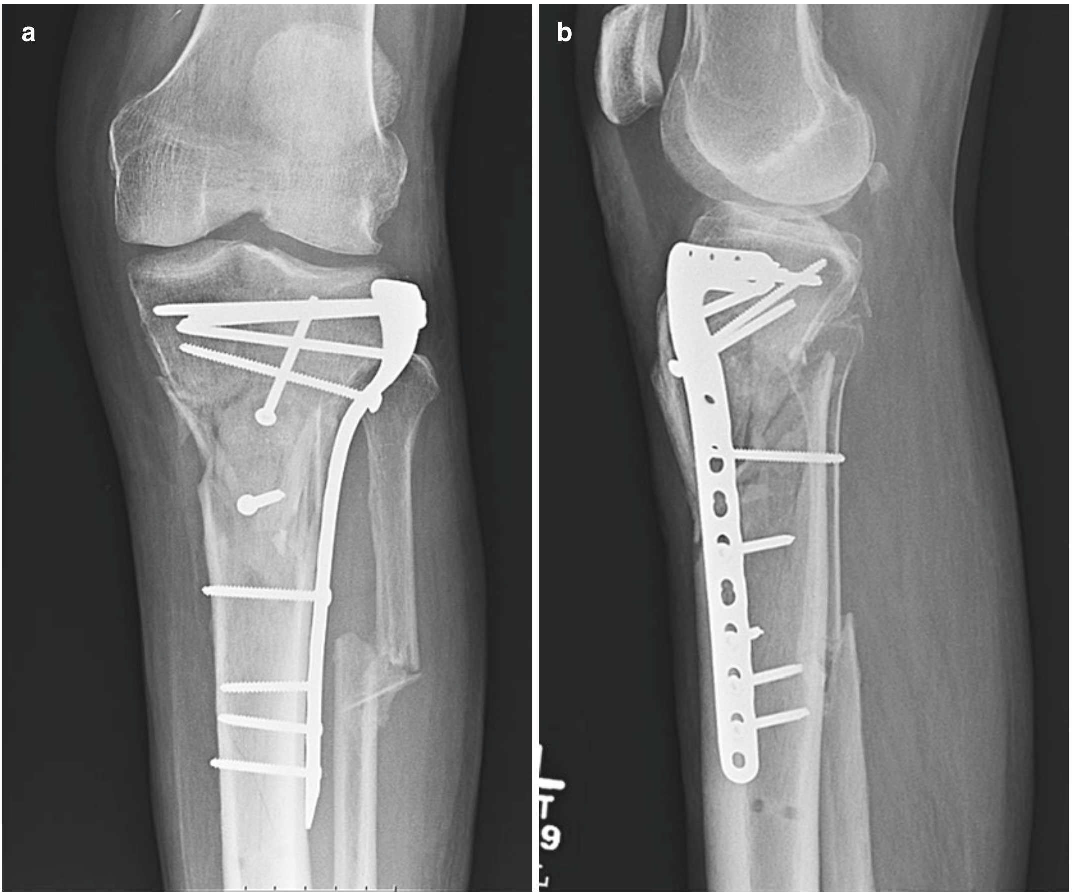

Fig. 31.3 Postoperative anteroposterior (**a**) and lateral (**b**) views showing open reduction and internal fixation of the proximal tibia with a small fragment proximal tibia locking plate and a combination of standard and locking screws

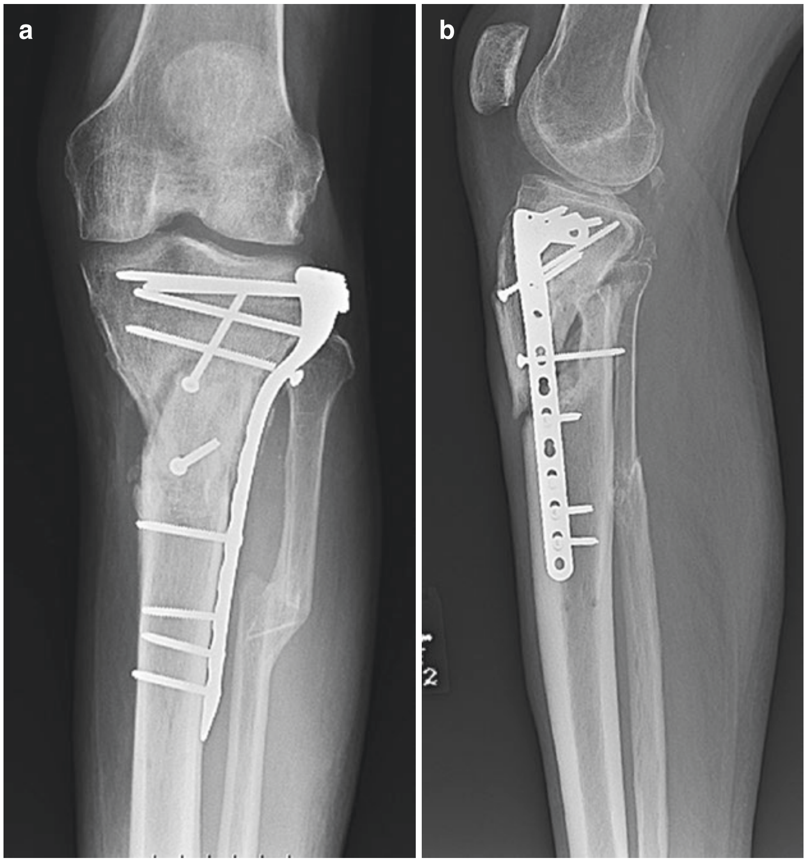

Fig. 31.4 Anteroposterior (**a**) and lateral (**b**) vies of the left tibia obtained 1 year after the index procedure demonstrate the articular surface and the tibial tubercle fractures to be united, while a primary fracture line, best visualized on the lateral view, has not united

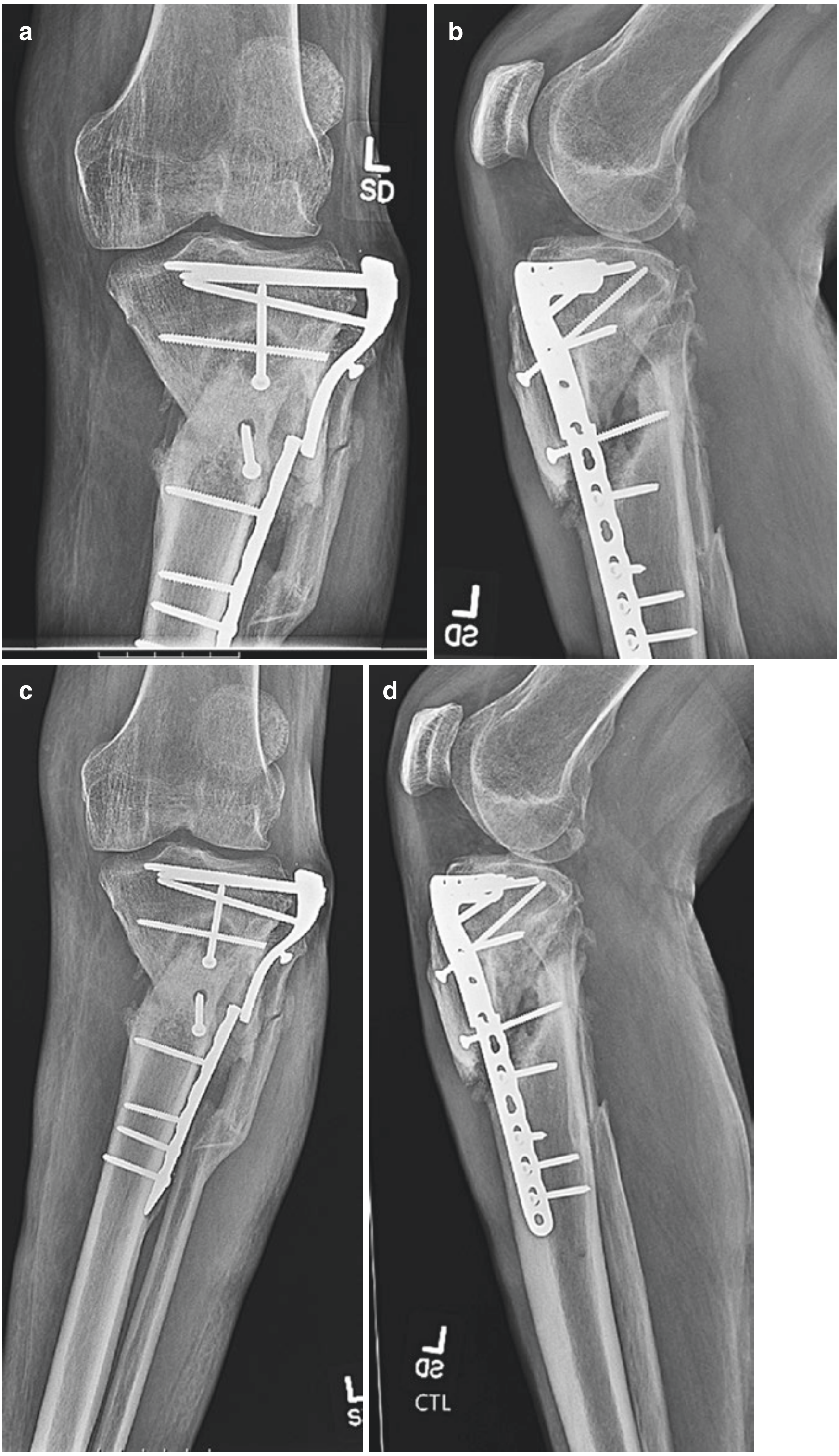

Fig. 31.5 Anteroposterior (**a**, **c**) and lateral (**b**, **d**) views of the tibia obtained 15 months later show persistent non-union of the tibia, with fracture of the plate and gross malalignment. The initial fibula fracture had united, then refractured slightly proximally

Evaluation of the Aetiology of Failure of Fixation

The patient developed a nonunion of the proximal tibia with failed plate fixation. Although one small fragment screw had been placed across that fracture site to achieve compression during the initial surgery, insufficient stability was present there over time, in conjunction with poor local biology, resulting in an atrophic appearing nonunion. The poor healing capability was likely a combination of the injury and patient factors. A high-energy mechanism of injury with surrounding soft tissue damage, coupled with local surgery, generated an environment expected to have prolonged healing time. The additional detriments of chronic poor vascularity due to extensive tobacco use and underlying malnutrition likely contributed to minimal healing response [2–6]. Nonadherence to initial non-weight-bearing recommendations probably accelerated the loosening of the fixation, especially at the area of the eventual nonunion. Over time, the plate fractured at the site of nonunion due to implant fatigue.

Clinical Examination

In addition to obtaining a thorough medical history, including medical and social risk factors for poor healing, awareness of the patient's vocational and recreational goals is important to achieving mutual understanding regarding likely benefits of surgery. Clinical examination should entail assessment of gait, focused on mobility, alignment and strength of the affected limb, and evaluation of adjacent knee and ankle joints for associated contractures. Contractures can impair osseous correction and may require procedures for soft tissue release or lengthening. Assessment of other areas of prior injury on the ipsilateral and contralateral limb must be made, and evaluation of underlying musculoskeletal variations at baseline should also be undertaken. Leg length discrepancy, and potential angular and rotational malalignment of the tibia and other parts of the legs should be identified [5]. Soft tissue surrounding the proximal tibia should be assessed for old traumatic and surgical scars, which may direct removal of prior implants and revision fixation. Soft tissues should be assessed for integrity and healing capability, presence of sinus tracts (active or remote) and pliability if drastic changes in limb alignment are anticipated [3, 4]. Involvement of a plastic surgeon to assist with elevation and management of old soft tissue flaps for coverage and/or augmentation of existing soft tissue coverage is often worthwhile. A thorough motor and sensory neurological examination and pulse examination should be documented.

Our patient from the case example had well-healed scars overlying the proximal and distal portions of the lateral plate. Small scars corresponding to the fixation for the tibial tubercle and for the primary oblique fracture line were also well-healed. Gross deformity and some mobility and pain were present at the site of the nonunion and failed fixation. Minimal swelling was noted. No sinus tracts or active wounds were present. The patient was using a cane to ambulate, not able to place weight on the affected left leg. Mild stiffness of the left knee and ankle were present and all muscle groups of the left leg appeared atrophic, consistent with disuse. Distal sensation and motor function were intact, and his dorsalis pedis and posterior tibial pulses were normal, symmetrical with the contralateral side.

Diagnostic-Biochemical and Radiological Investigations

Laboratory evaluation at a minimum should include complete cell count with differential, platelets, international normalized ratio (INR), albumin, C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). Tobacco cessation in longstanding tobacco users is a prerequisite to undertaking surgical treatment of nonunion for many practitioners. Urine cotinine testing is inexpensive, sensitive and easy to do. Optimization of protein malnutrition and correction of vitamin D deficiency should be encouraged preoperatively [2–4].

The patient in our case example had recently relocated to a group home, where he was getting regular meals, and he had been sober (of alcohol and recreational drugs) for approximately 3 months preoperatively. His total lymphocyte count was 2000 and his albumin was 4.2, suggesting ample protein stores to proceed with surgery. His ESR and CRP were normal, which, along with no history of prolonged wound drainage or sinus tracts, suggested the possibility of aseptic nonunion [3, 6].

Radiographic evaluation should include biplanar views of the entire tibia, including the knee and ankle. Pathology such as arthrosis, other remote fractures and retained implants must be thoroughly investigated. Full-length standing radiographs of the legs may be beneficial [5]. Computerized tomography to assess alignment, healing and/or to discern bone quality, and possible presence of infection is generally indicated. Consultation with the radiologist regarding specific planes and dimensions for image reformatting may be helpful; adjustment of the technique to minimize implant artefact may also be performed to enhance the utility of advanced imaging studies.

Plain radiography often suggests atrophic or hypertrophic nonunion. While a hypertrophic nonunion reflects insufficient fracture stability, an atrophic nonunion reflects poor local biology, but may also reflect insufficient stability of fixation [1, 6]. Our case example demonstrated healing of the articular surface, tibial tuberosity and other secondary fractures; however, the primary area of fracture displacement on the initial injury radiographs (Fig. 31.1) had not united (Figs. 31.4 and 31.5). Although it is somewhat atrophic, the nonunion was likely due to insufficient stability in that area. This fracture pattern and orientation is relatively common, and attention to accurate reduction and interfragmentary compression of that fracture in the initial setting will mitigate the risk of nonunion.

Preoperative Planning

Preoperative planning includes implant removal, specific screwdrivers or other tools, which may be needed depending on the types of implants to be removed. Consultation with industry vendors may aid in identification of implants and specific instruments and instructions to facilitate removal. In the case example, small fragment hexagonal and locking screwdrivers were necessary. Broken screw removal tools should also be available, in case retention of screw fragments prevents sufficient reduction or fixation during the revision procedure. Osteotomes and rongeurs to remove bone adjacent to and overlying implants may be required. Once implants have been removed, curettes are needed to remove fibrinous material from old screw tracts. Intraoperative cultures should always be taken. I prefer to take at least two or three cultures from the nonunion and adjacent implants. Antibiotic prophylaxis should be deferred until cultures have been obtained [6].

Implant selection should be based on the location and orientation of the nonunion, the size of the proximal fragment, the presence (or absence) of intact extensor mechanism of the knee and the mechanical environment needed to optimize fracture healing. In other words, the malalignment should be corrected, nonunions compressed and nonunions stabilized in a mechanically sound way, ideally to promote early weight-bearing [5, 7, 8]. While intramedullary nails often afford earlier return to weight-bearing, nails may not provide adequate purchase of the proximal segment, particularly in osteoporotic bone and/or small fracture fragments [9, 10]. Another consideration is that when surgical exposure to remove plates will be extensive, the local biology is already disrupted by surgery in that area, whereas the intramedullary biology has not yet been disrupted, as in our case example [10–14]. While intramedullary nail fixation would be possible, it would also produce some initial, though temporary, disruption of the medullary blood supply, limiting the early healing in that area.

Our case example warranted interfragmentary compression of the nonunion, using large fragment screws, followed by protection with revision lateral plating. Lateral plating, with a large fragment plate, was chosen to minimize additional surgical dissection, to provide a different shape of implant, with new screw configurations in fresh locations, and to permit a combination of locking and standard screws, based on intraoperative assessment of bone quality. A second plate placed medially could be considered, but was not thought to be mechanically necessary, and would create more disruption of the surrounding soft tissue envelope and periosteum, to the detriment of healing of the nonunion [12].

The mainstay of adjuncts to healing of atrophic nonunions is iliac crest bone graft. Although a plethora of products exist as bone graft substitutes, some osteoconductive and some osteoinductive, the evidence-based assessment of each category is beyond the scope of this chapter [15]. In a young or middle-aged person, my preferred method is to harvest iliac crest autograft. Reamer/irrigator/aspirator (RIA) intramedullary harvest could also be considered [16]. However, variability in osteogenic potential has been noted, depending on the RIA technique.

Revision Surgery

The patient was taken to the operating room where he received general anaesthesia. He was positioned supine on a radiolucent table, with a small bump beneath the left hip. This provided slight internal rotation of the left leg to facilitate surgical access and imaging. The bump also facilitated access to the left anterior iliac crest for bone graft harvest. The entire left lower extremity and hemipelvis were sterilely prepped and draped.

The old lateral scars overlying the proximal and distal portions of the tibia plate were incised and connected with an extensile exposure. Tourniquet was not used, so that the soft tissue and bony vascularity could be readily assessed. Locked screws within the proximal portion of the plate were still locked to the plate. Implants were removed from the proximal segment. The distal screws in the plate had also maintained some purchase in the bone. All screws and the plate fragment were removed from that area. No gross evidence of infection was present. Anterior dissection was performed to access the two screws outside of the plate, and each was removed. Cultures were obtained from fibrinous tissue around the implants near the nonunion and from tissue within the nonunion. Intravenous antibiotics were administered.

Using fresh gloves and instruments, cancellous bone graft was harvested from the anterior iliac crest, via a cortical window. Haemostasis was achieved at that site, and layered closure was performed. The nonunion site was debrided of intervening fibrous tissue, and it was mobilized using osteotomes (Fig. 31.6a–d). The nonunion site appeared to have viable bone margins. Iliac crest bone graft was then placed within the nonunion and the nonunion was reduced and clamped, re-establishing appropriate sagittal and coronal plane alignment (Fig. 31.6e, f).

Interfragmentary compression across the nonunion was achieved with large fragment screws (Fig. 31.6f–h). A large fragment proximal tibia locking plate was then applied to the lateral cortex. A standard screw was inserted within the proximal portion of the distal fragment to secure the plate to the bone. Purchase was moderately good. Locked screws and standard screws were inserted within the proximal fragment. Due to the retained screw fragment, two of the locking screw trajectories could not be used, so standard screws were placed. The construct was completed with three additional bicortical standard screws distally (Fig. 31.6i, m).

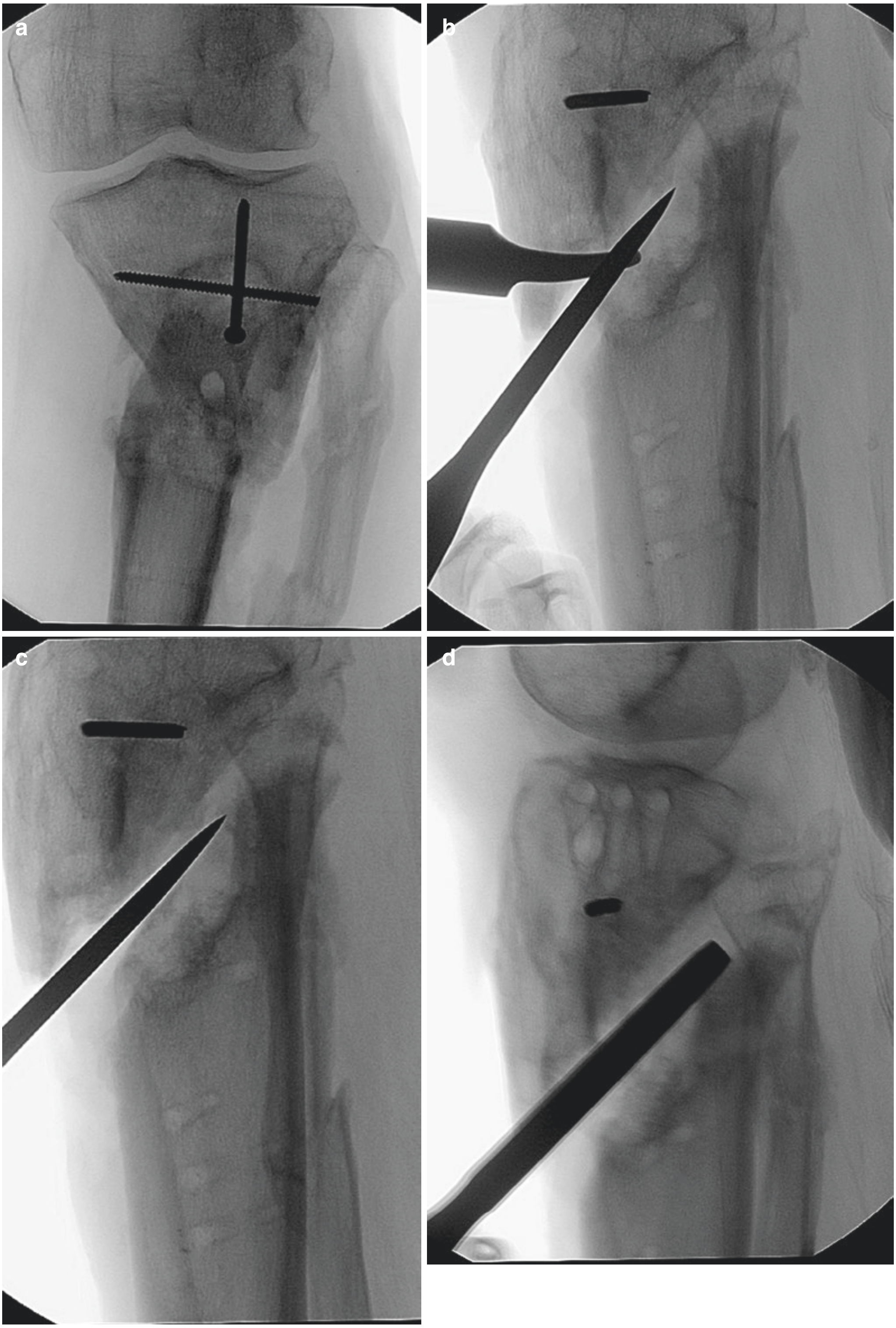

Fig. 31.6 Intraoperative fluoroscopic views show removal of the prior implants (**a**), and debridement and mobilization of the nonunion (**b**–**d**). The nonunion was reduced (**e**, **f**) and interfragmentary compression was achieved across the nonunion (**g**, **h**). Lateral plate fixation was performed (**i**, **m**)

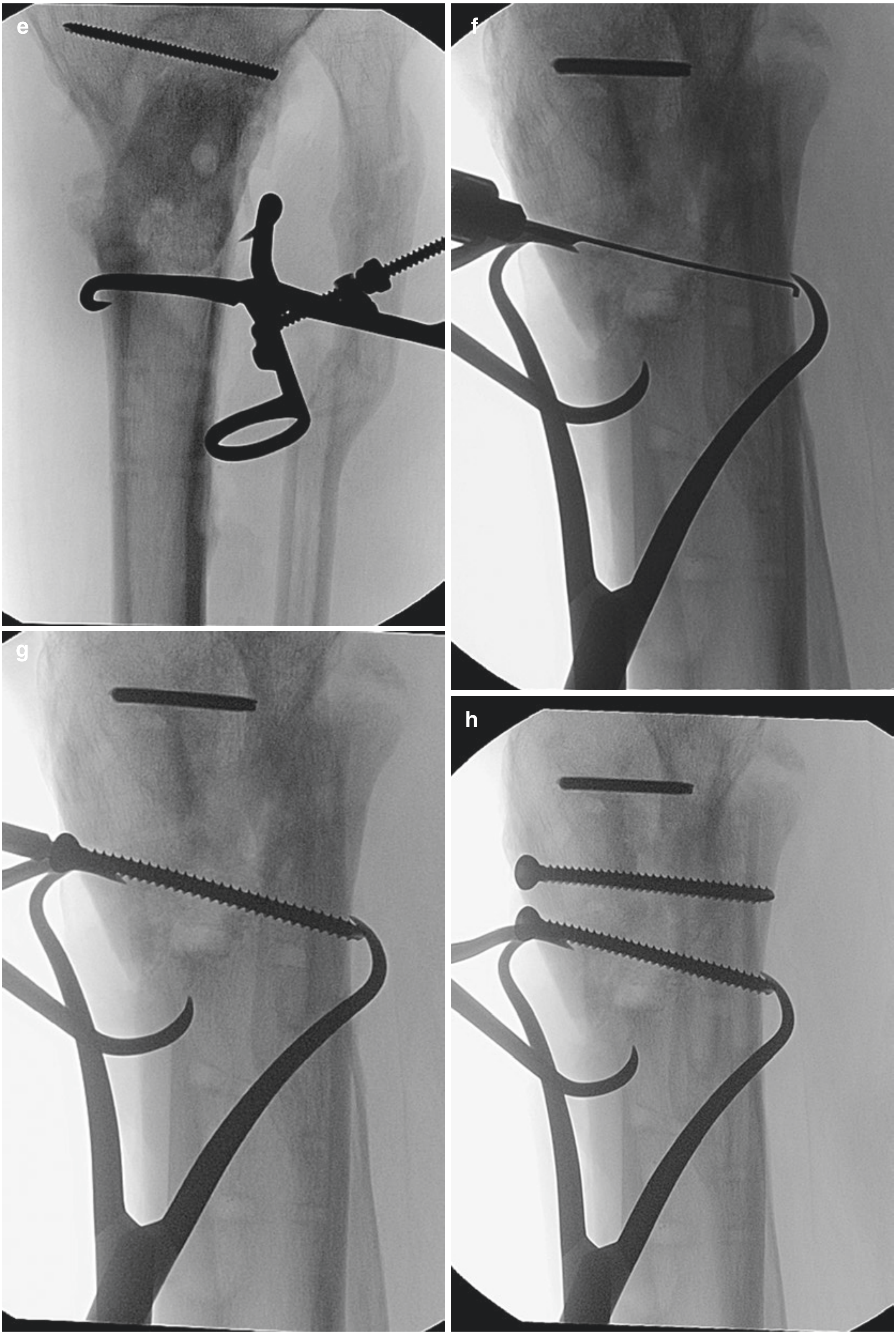

Fig. 31.6 (continued)

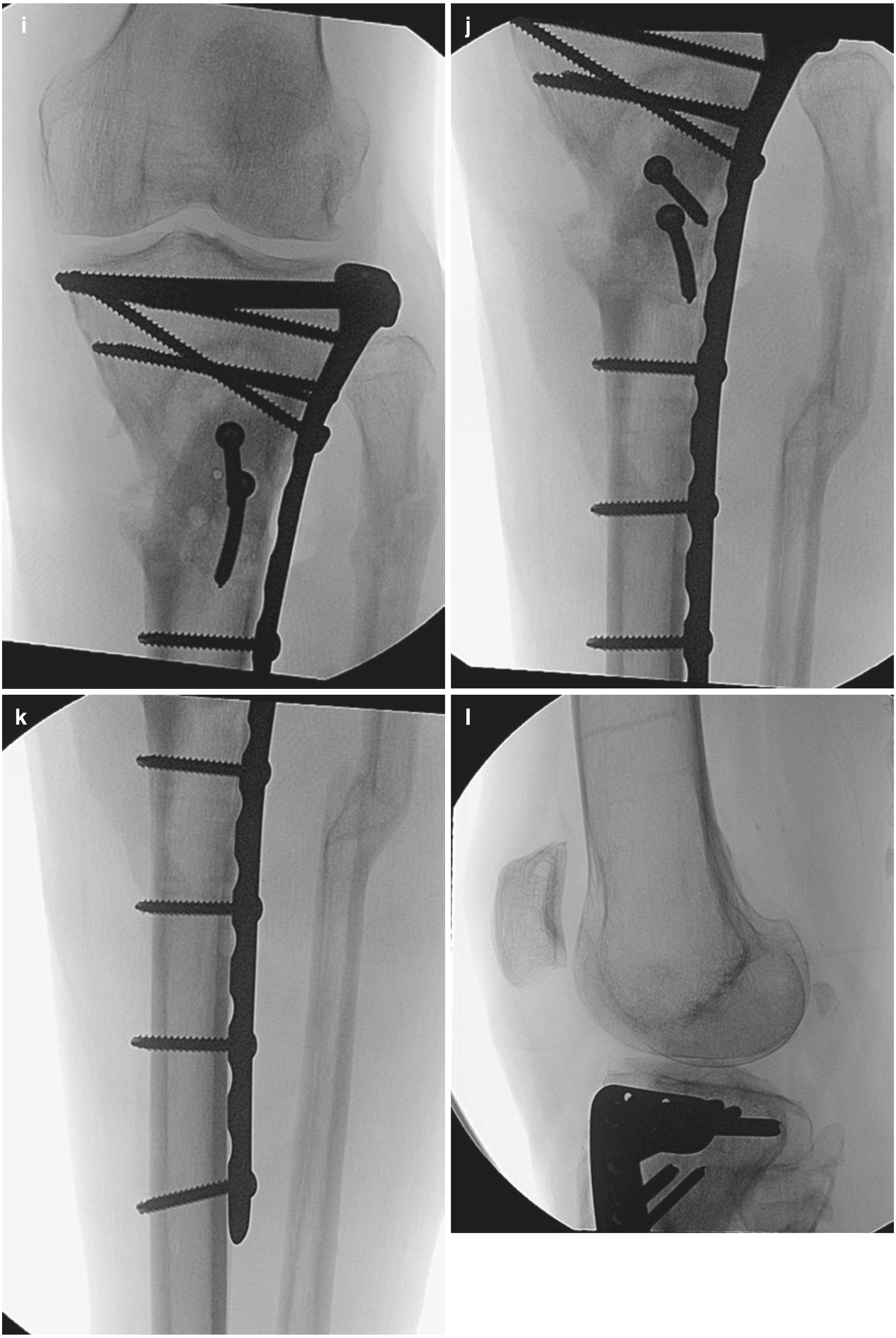

Fig. 31.6 (continued)

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The wound was copiously irrigated. One gram of vancomycin powder and 1.2 g of tobramycin powder were mixed with a few drops of normal saline to develop a thick paste, which was applied throughout the wound bed. Layered closure was then performed. The patient was placed into a long leg posterior splint to encourage soft tissue rest. He was admitted to the hospital overnight for pain control and for intravenous antibiotics. He was discharged home the following day maintaining a non-weight-bearing status on the left leg. At the 3-week postoperative period, the wounds had healed and knee range of motion was initiated, but non-weight-bearing was recommended for 1 month.

Summary: Lessons Learned

Thoughtful assessment of patient and injury features will result in the most effective treatment plans. This high-energy proximal tibia fracture was treated with staged internal fixation. Suitable fracture alignment was achieved, and soft tissues healed without incident. However, more interfragmentary compression and larger initial implants may have afforded a better mechanical environment to achieve primary fracture union. More aggressive perioperative interventions to address underlying tobacco, alcohol and drug abuse may have been successful long-term, which could have provided a more vascular and better nourished healing environment. Patient engagement in those activities would also have likely coincided with his adherence to weight-bearing restrictions, and attendance at scheduled clinic visits.

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