14 Forearm Fracture Failed Fixation

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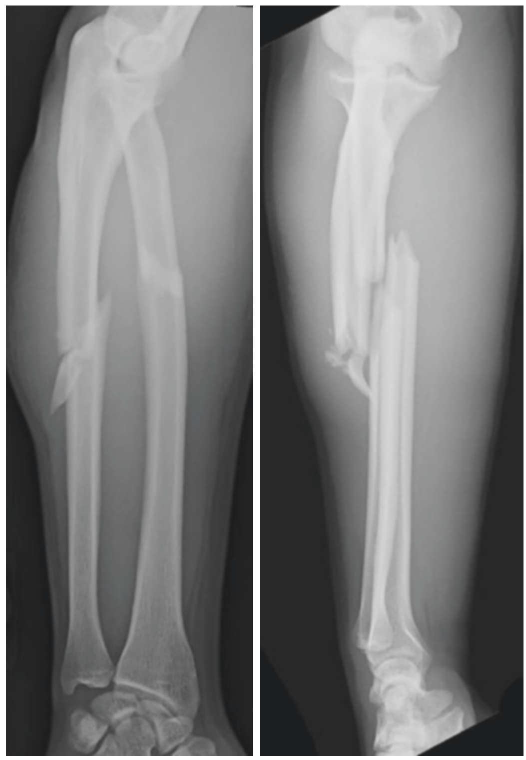
History of Previous Primary Failed Treatment

Patient is a 23-year-old right-hand dominant male, construction laborer, who initially sustained a closed injury to his right forearm following a motorcycle trauma 1 month prior to presentation. The patient was initially treated at an outside facility where plain radiographs showed a diaphyseal radius and ulna fracture (Figs. 14.1 and 14.2). The patient was taken to the operating room the day following presentation for surgical fixation of his forearm fracture.

Surgical operative report described a volar approach to the radial shaft and a dorsal approach to the ulna. The procedure was performed under a tourniquet. The radius was exposed along its entire length and an 8-hole 3.5-mm reconstruction plate was placed on the radial shaft in bridge mode across the fracture after length, alignment, and rotation had been established. Six cortices of nonlocking fixation were obtained on either side of the fracture. The ulna was similarly exposed along its entire length and an 8-hole 3.5-mm reconstruction plate was placed on the ulnar shaft in bridge mode across the fracture after length, alignment, and rotation had been established. Six cortices of nonlocking fixation were obtained on either side of the fracture (Figs. 14.3 and 14.4).



Figs. 14.1 and 14.2 Anteroposterior (AP) and lateral (Lat) radiographs from initial injury showing fractures of the radial and ulnar diaphysis

The patient was placed in a sugar tong splint following primary closure of both surgical

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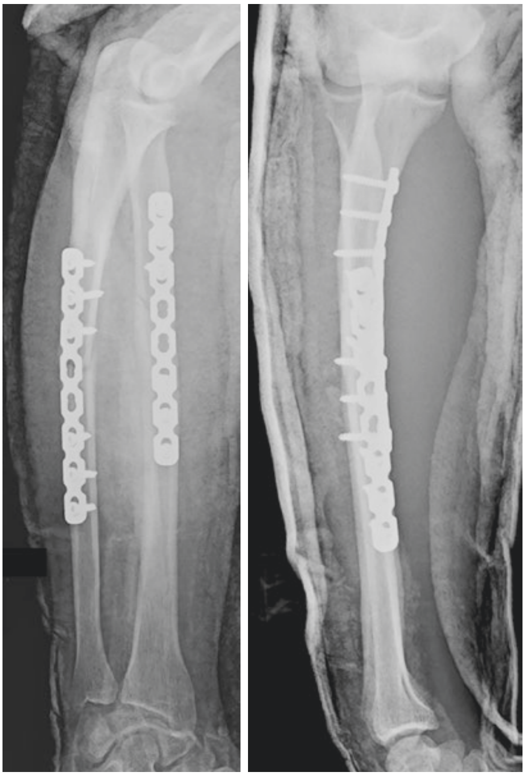
P. V. Giannoudis, P. Tornetta III (eds.), *Failed Fracture Fixation*,
https://doi.org/10.1007/978-3-031-39692-2_14



Figs. 14.3 and 14.4 Immediate postoperative AP and lateral radiographs showing reconstruction style plate fixation of radial and ulnar diaphysis

Figs. 14.5 and 14.6 AP and lateral radiographs 1 month following surgery showing acute loss of forearm alignment with bending of both plates

approaches and was made non-weight bearing on the right upper extremity. The patient presented to the outpatient orthopedic clinic 1 month following surgery with pain and deformity in the right upper extremity. He stated that his splint had come off at some point following discharge and he had been using the extremity for select activities of daily living.

Evaluation of the Etiology of Failure of Fixation

Plain radiographs were taken of the patient's right forearm during his outpatient clinic visit 1 month following surgical fixation showed acute loss of alignment of the radius and ulna (Figs. 14.5 and 14.6). On the anteroposterior view, both the radius and ulna had approximately 30° of varus malalignment with apex-radial deformity. On the lateral view, there was loss of radial bow with slight apex ulnar malalignment. The ulna was also malaligned on this view with 15° of apex ulnar deformity.

Close evaluation of the radiographs did not show loss of screw fixation along the radius or ulna. The small fragment nonlocking screws remained well fixed without toggling or loosening. In both the radius and ulna, loss of alignment was the result of plate bending. This occurred at the fracture site in both bones where there was no fixation. The implant originally chosen for fracture fixation is a flexible implant that does not provide appropriate stability, especially when applied in bridge mode. No stability was accomplished through interfragmentary lag screws or plate-generated compression, resulting in a construct that was not rigid enough to allow for physiologic motion or weight bearing of any kind [1–5].

Clinical Examination

Clinical examination of the patient's right forearm showed notable gross deformity and varus angulation, in keeping with the radiographic deformity identified on radiographs. Evaluation of the soft tissues revealed healed volar and dorsal surgical incisions. There were no erythema, fluctuance, drainage, or areas of wound breakdown. The patient had warm and well-perfused fingertips with palpable 2+ radial and ulnar pulses and brisk capillary refill in all fingertips. The patient had intact and 5/5 strength in the muscular innervations of the anterior interosseous nerve, posterior interosseous nerve, and deep branch of the ulnar nerve. There was fully intact sensation in the ulnar and median nerve distribution; the radial nerve distribution was intact except for a small area of altered sensation along the posterior aspect of the dorsal thumb in the distribution of the radial sensory nerve.

The patient had tenderness to palpation along the midportion of the radius and ulna. There was no tenderness about the elbow or the wrist. He was able to actively flex his elbow to 90° and extend to 10°. He had active pronation to 10° and active supination to 15°. Passive motion was painful past the above-noted limits.

Diagnostic-Biochemical and Radiological Investigations

Initial injury and postoperative radiographs from the outside institution were not initially available and were requested prior to surgical revision surgery. Noting that there had been failure of the plate to provide appropriate stability, without loss of screw fixation, it was determined that plate deformation occurred through primarily a bending moment. There was less likely to be a significant rotational component to the deformity if the length, alignment, and rotation were deemed to be appropriate at the index surgical procedure. There was some ectopic bone formation about the interosseous membrane in the 1-month post-operative radiographs, but this was not bridging. There was no notable osseous healing or consolidation at the radial or ulnar fracture site. Understanding the primary deformity, lack of healing, and presence of early callus and ectopic bone, a computed tomography scan was not deemed to be indicated. Similarly, there was no role for magnetic resonance imaging. Plain radiographs of the contralateral, unaffected forearm were obtained for templating purposes.

Laboratory investigation included a complete blood count, C-reactive protein, and erythrocyte sedimentation rate to assess for inflammation and/or infection. In addition, a complete metabolic workup was performed. This included a thyroid cascade to evaluate for thyroid dysfunction and pre-albumin/albumin to evaluate for any nutritional deficiency.

Preoperative Planning

Preoperative plan involved supine patient positioning and the use of a radiolucent hand table. A nonsterile tourniquet would be used. Initial exposure and removal of both implants to allow for realignment were planned. The operative report from the outside facility noted the manufacturer and type of implants used but a broken screw removal set would be available if needed. The volar surgical approach would be made first to remove the implants from the radial shaft. Then the direct dorsal approach to the ulna would be made to remove the implants from the ulnar shaft. The ulna shaft would be mobilized using an elevator or similar instrumentation to allow for revision reduction and fixation of the radial shaft [6–8].

Previous forearm fixation failure was due to the selection of inappropriately flexible implants. There was no indication of bone loss and preoperative radiographs indicated that direct cortical reads may be available to set anatomic length, alignment, and rotation. Thus, the goal was for anatomic reduction of the radius first with multiple clamps and the use of minifragment 2.0 mm or 2.4 mm screws placed using the lag technique. Then, a 3.5-mm limited compression dynamic compression plate (LC-DCP) that exceeded the length of the previously placed reconstruction style plate was to be used as a neutralization plate or compression plate if the fracture pattern allowed. This would eliminate the possibility of any stress riser at a previous screw hole and provide instrumented bone for fixation proximal and distal to the previous plate location. Six cortices of nonlocking fixation on either side of the fracture were planned but the option to use locking screws if there was poor fixation or overlap of old and new screw paths.

After the radius was addressed, the ulna would be addressed using the same principles outlined for the radius. If a good cortical read was available and amenable for a lag screw, a minifragment screw or screws would be used. An LC-DCP plate that exceeded the previous plate length would then be used in neutralization or compression mode if an amenable transverse or oblique fracture was present. Similarly, the plan was for six cortices of fixation on either side of the fracture with nonlocking screws; locking screws would be used if necessary.

Intraoperative radiographs would be utilized as needed to assess length alignment and rotation of the forearm. The proximal and distal radioulnar joint would also be assessed to ensure revision forearm fixation did not result in subluxation or dislocation at either end of the forearm. Hemostasis would be achieved after deflation of the tourniquet, the drain would be placed as needed and primary closure would be performed with deep absorbable and superficial non-absorbable suture. The patient would be placed in a soft dressing after surgery. No weight bearing would be allowed but immediate range of motion would be started.

New Implant Selection

Implants previously placed in this case were 3.5 mm small fragment reconstruction-style plates. These are flexible implants uncommonly used in isolation to provide rigid fixation in diaphyseal radius and ulna fractures. In addition, with no inherent stability at the fracture site with lag screws or interfragmentary compression, these implants were placed in bridge mode, resulting in a construct with inappropriately low stiffness.

The new implants chosen were 3.5 mm small fragment LC-DCP) plates, which are stiffer implants and can appropriately be used in bridge or neutralization mode for diaphyseal forearm fractures. In addition, as noted in the preoperative plan, the chosen length would exceed the length of the initial implants to avoid the creation of a stress riser at a previous screw hole.

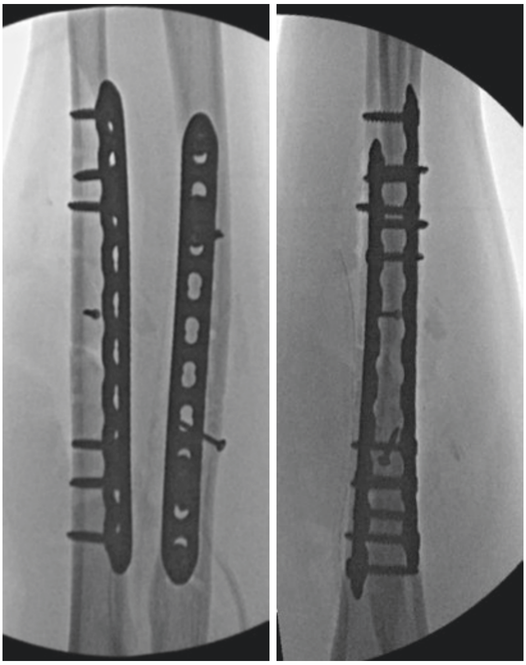
Need for Bone Grafting

In this case, the goal was anatomic reduction and interfragmentary compression of the fracture as the injury was closed and there was no reported bone loss. Therefore, there was no plan to use autogenous or allograft bone. In addition, based on close evaluation of the patient's preoperative radiographs, there was some indication that an interosseous synostosis was already forming and there was no desire for excessive graft material to be used unless necessary.

Revision Surgery

The patient was taken to the operating room and positioned supine with a nonsterile tourniquet on the upper arm. A hand table was used. Following preparation and draping of the right upper extremity and surgical time-out, the arm was exsanguinated using a compressive wrap, and the tourniquet was elevated. The volar approach was performed first using the previous surgical incision. The brachioradialis, radial artery, and superficial radial nerve were all identified and retracted radially. The pronator teres and flexor carpi radialis were retracted ulnarly. The pronator teres and supinator were identified about the plate and the previous plate was removed without difficulty. Next, the subcutaneous ulnar exposure was made using the previous skin incision. The extensor carpi ulnaris and the flexor carpi ulnaris were retracted to expose the plate and the implants were removed without difficulty. At this point, the ulnar fracture was mobilized using an elevator and attention was directed back to the radius.

The volar approach was utilized again for the evaluation of the fracture. A direct cortical read was available at the fracture site and a 2.4-mm



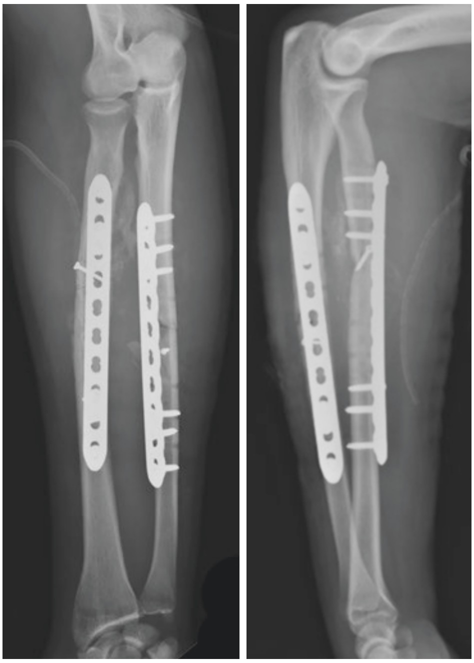
Figs. 14.7 and 14.8 AP and lateral intraoperative fluoroscopic images showing restoration of forearm alignment, with independent lag screw fixation and rigid LC-DCP plate fixation

screw was placed using the lag technique. Next, the radial bow was evaluated, and a 10-hole LC-DCP) was placed and balanced on the radial diaphysis. It was positioned such that it extended beyond the previous screw holes from the original hardware. The plate was precontoured and compression was generated through the eccentric placement of a nonlocking screw. Two bicortical nonlocking screws were placed on either side of the fracture and one locking screw was placed proximally and distally as the bone had been previously drilled adjacent to these screw positions. The ulnar approach was used to visualize and reduce the fracture. A 2.0-mm minifragment screw was placed using the lag technique across a small cortical fragment to then create a compressible surface. Similar to the radial shaft, the plate was slightly precontoured and compression was generated through an eccentrically placed nonlocking screw. Two bicortical nonlocking screws were placed on either side of the fracture and one locking screw was placed proximally and distally (Figs. 14.7 and 14.8).

The tourniquet was let down at 120 min, hemostasis was achieved, and a small Hemovac drain was placed deep into the volar closure. The forearm fascia was not closed, and the skin was closed with subcutaneous absorbable suture and superficial nonabsorbable suture. The patient was placed in a soft noncompressible dressing before being awakened. Postoperatively he was made non-weight bearing, received a single dose of perioperative antibiotics, and was allowed immediate elbow flexion and extension, forearm rotation, and full wrist and hand range of motion as tolerated. The drain was removed 24 h following surgery and the patient was discharged from the hospital.

Summary: Lessons Learned

In this case, a simple closed diaphyseal radius and ulna fracture were fixed with implants that were not sufficiently rigid to allow for an immediate range of motion. It is unclear whether patient noncompliance with initial non-weight-bearing restrictions was a factor in the early failure. Some evidence does exist regarding immediate weight bearing on plated both bone forearm fractures using rigid fixation with small fragment plates and eight cortices of fixation on either side of the fracture [9]. Knowing the initial fracture was closed and there was no bone loss, the goal was anatomic reduction and rigid fixation. This was accomplished by interfragmentary compression and the use of plates that were both longer and more rigid. This allowed for immediate range of motion and full weight bearing was allowed at 6 weeks with evidence of healing (Figs. 14.9 and 14.10). The patient did develop an incomplete radiographic radioulnar synostosis but this was not symptomatic for him and did not require any further surgical intervention by the last follow-up at 8 months (Figs. 14.11 and 14.12) [10].



Figs. 14.9 and 14.10 Immediate postoperative AP and lateral radiographs from revision surgery

Figs. 14.11 and 14.12 AP and lateral radiographs at 8 months showing maintenance of alignment and complete osseous healing of the radial and ulnar diaphysis

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