11 External Fixation for Upper Extremity Trauma

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11.1 External Fixator Use in Distal Radius Fractures

Distal radius fractures are the most common fractures, accounting for 17% of fractures in the elderly population. Its treatment is challenging because of accompanying osteoporosis in this population. After the advantages of locking plates in osteoporotic bone stabilization were recognized, they became widely used as the treatment of choice in distal fractures of the radius. In low-energy fractures with no comminution, volar locking plate osteosynthesis is the current gold standard because it enables stable osteosynthesis and early joint mobilization. However, in high-energy fractures with many fragments, it is almost impossible to provide anatomic repositioning using open approaches. In such cases, fixation without opening the fracture and repositioning of fracture fragments by ligamentotaxis make the external fixator a feasible option. In this chapter, techniques and functional outcomes of external fixators in fragmented intra-articular radius distal fractures will be discussed in view of the current literature.

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11.2 Radius Distal Functional Anatomy

A healthy wrist joint has the capacity of almost 90° flexion, 80° extension, 20° radial deviation, and 30° ulnar deviation. The anatomy of bones plays an important role in obtaining that range of motion. The lateral view of the radius distal tip has an angle of 11° between the long axis of the bone and the line connecting joint surfaces; this angle is called the volar tilt. Any change of this angle during fracture treatment may lead to loss of motion. Similarly, another angle (22°) is formed between the line connecting the joint surfaces and the line of the long axis in the AP plane. This angle is called radial inclination and should be maintained close to anatomic values during treatment in order to achieve optimal functional outcomes. The tip of the styloid process of the radius bone extends 12 mm from the crossing point of the radius joint surface and ulna to distally. Protection of the radial length is important to prevent possible arthrosis of radiocarpal and radioulnar joints (Fig. 11.1).

Perugia et al. conducted a retrospective study on 51 surgically treated distal radius fractures. The authors found that volar tilt was the most effective radiologic parameter on functional outcomes, and small changes in other parameters were not significant.

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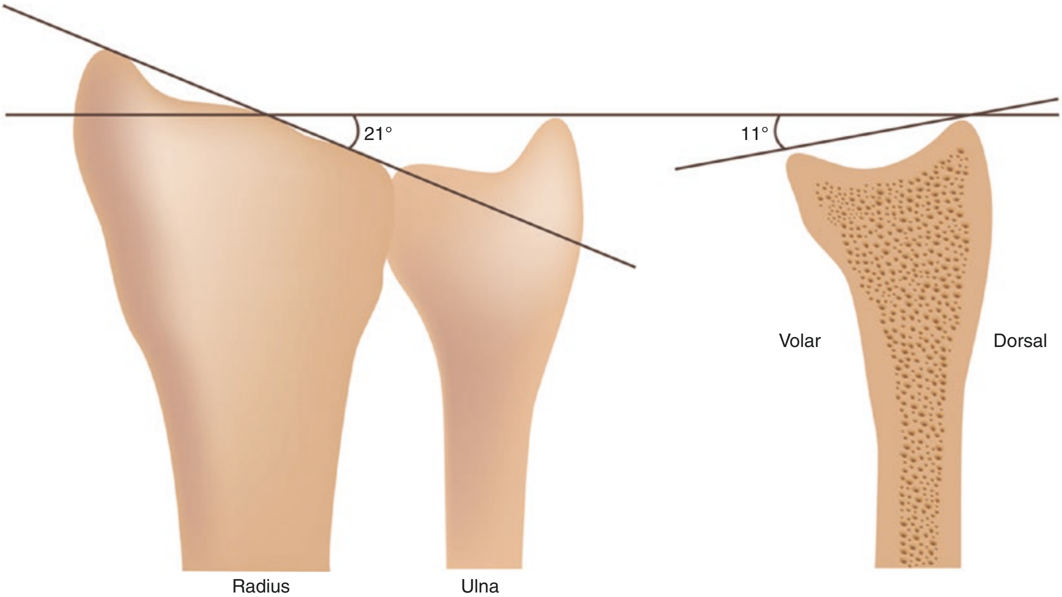

Fig. 11.1 Illustration of radial inclination and volar tilt

11.3 Classification

The most widely used classifications of radius distal tip fractures are Frykman, Fernandez, and AO classifications (Fig. 11.2).

The basic factor that determines treatment is involvement of the articular surface; if the fracture extends to the articular surface, the damage of this surface is the most important factor for the functional outcome of the treatment.

The main goal of treatment is to protect the anatomic features and to keep the joint surface compliant.

11.4 Treatment Options

- Closed reduction and circular plaster cast
- Closed reduction and percutaneous pinning
- Open reduction and plate-screw osteosynthesis (volar-dorsal plate)
- Osteosynthesis by using a non-bridging external fixator
- Osteosynthesis by using a bridging external fixator

Among the surgical treatments, volar plate osteosynthesis has come to the fore through the development of locking plate technology. In a meta-analysis that included randomized controlled studies comparing internal and external fixation, it was shown that anatomy could be better restored with internal fixation [1]. However, some other studies reported no difference between treatment methods. McQueen et al. [2] compared four treatment methods in a randomized controlled study and found no functional difference between external and internal fixations [2]. The same authors compared bridging versus non-bridging wrist external fixators and found that both radiologic and functional outcomes were in favor of non-bridging external fixators. They also suggested that non-bridging external fixation was the treatment of choice for unstable fractures of the distal radius that have sufficient space for the placement of pins in the distal fragment [3]. It should be known that fixation is impossible without bridging in intra-articular fractures, but external fixation may be performed without bridging in fractures that do not extend to the articular surface, such as the Colles fracture.

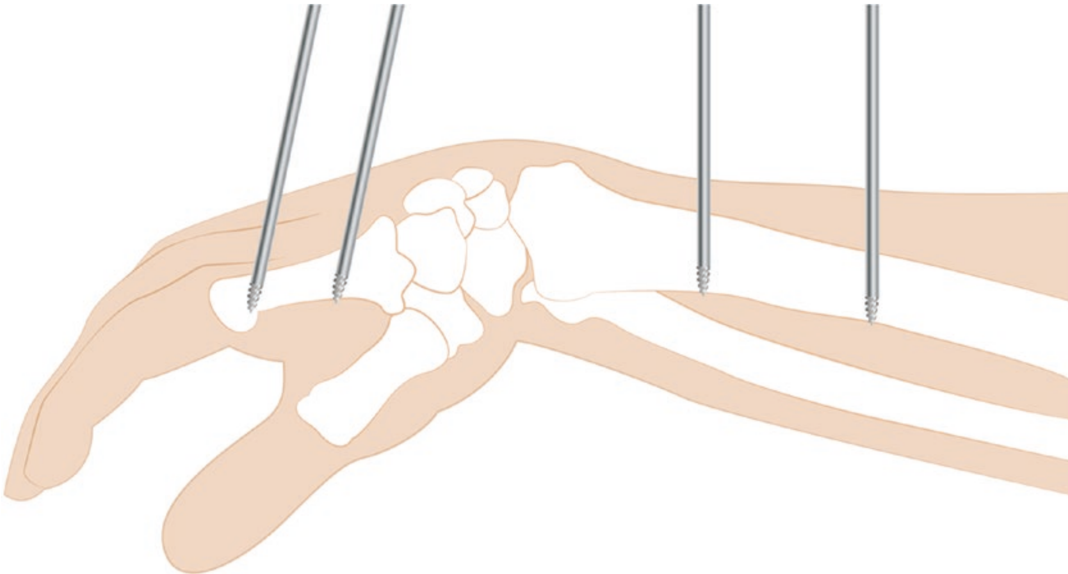

Fig. 11.2 Application of the Schanz screws for external fixation in distal radius fractures

11.5 External Fixation in Distal Radius Fractures

11.5.1 Wrist Bridging Fixator

Bridging fixation is used especially in distal radius unstable fractures. It provides reduction of fracture fragments by ligamentotaxis of distractive forces and protects the length of the radius. Ligamentotaxis is obtained by the stretching of radioscapholunate and radiolunate ligaments. Thus, forearm muscle force that depresses distal fragments is balanced, but excess or long-term (>3 weeks) stretching may lead to joint stiffness and reflex sympathetic dystrophy [3]. Again with this method, it should be kept in mind that medial die-punch fragment cannot be reduced by ligamentotaxis [4].

Although there are many bridging external fixator systems, in our clinic we commonly use the Penning fixator, in addition to percutaneous pinning.

11.5.1.1 Wrist Bridging External Fixator Application Technique

At application, four Schanz screws are delivered (two of them to the second metacarpal bone and two of them to the radius proximal diaphysis). Schanz screws are sent to the second metacarpal in parallel to each other and at an angle of 45° to vertical the horizontal plane. They may be delivered to the shaft of radius between the brachialis and extensor carpi radialis longus muscles (Fig. 11.3).

The joint part of the fixator enables reduction and distraction at desired levels. After adequate reduction, the joint part is tightened. In order to increase the stability of fixation, multiple K-wires may be delivered percutaneously (Fig. 11.4).

11.5.2 Non-bridging Fixator

In the treatment of distal radius fractures, non-bridging external fixators were reported to achieve better functional outcomes, but indications are limited when compared with bridging fixators. In fractures with sufficient space for the placement of pins in distal fragment such as Colles-like fractures, better functional outcomes may be obtained [5].

11.6 External Fixators in Elbow Fracture-Dislocations

The elbow joint is the second most common site for dislocation, following the shoulder joint. If there is no accompanying fracture, it is called *simple elbow dislocation*, whereas it is called *complex* *elbow dislocation* when there is accompanying fracture. The radial head (36%), coronoid process (13%), capitellum, trochlea, or olecranon fractures may accompany elbow dislocation [6]. These anatomic structures may be fractured together. The most common form of such a complex condition is called the terrible triad, which comprises posterior elbow dislocation, radius head fracture, and coronoid process fracture. In this section, external fixation of these unstable elbow dislocations with fracture will be discussed.

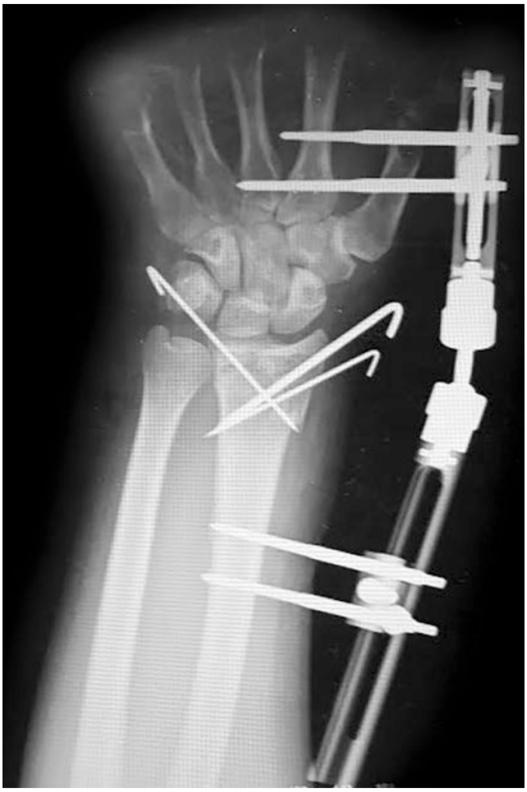

Fig. 11.3 Distal radius fracture operated with external fixator, postoperative AP X-Ray

The terrible triad is quite a complex condition that requires a systematic approach. The treatment aims at providing a stable and functional elbow. In the treatment of such injuries, surgery is required to recover stability. Osteosynthesis or repair of all anatomic structures may not be necessary. Structures that need repair or fixation may be determined based on stability at the operation. Starting from lateral structures, lateral column stabilization is obtained through osteosynthesis or radial head prosthesis together with lateral collateral ligament (LCL) repair. The coronoid process is fixed by sutures, screw, or anatomic plate according to the type of fracture and instability. Medial collateral ligament (MCL) repair is performed if necessary.

At this stage of the operation, all anatomic structures are repaired or fixed. External fixator may be applied in the presence of instability or in order to maintain the achieved stability. The biggest advantage of the external fixator is to support early joint mobility when protecting stability. Thus, stiffness due to long-term immobilization may be prevented. There are several retrospective studies with controversial results in small patient groups [7–9]. As it is a rare injury, randomized

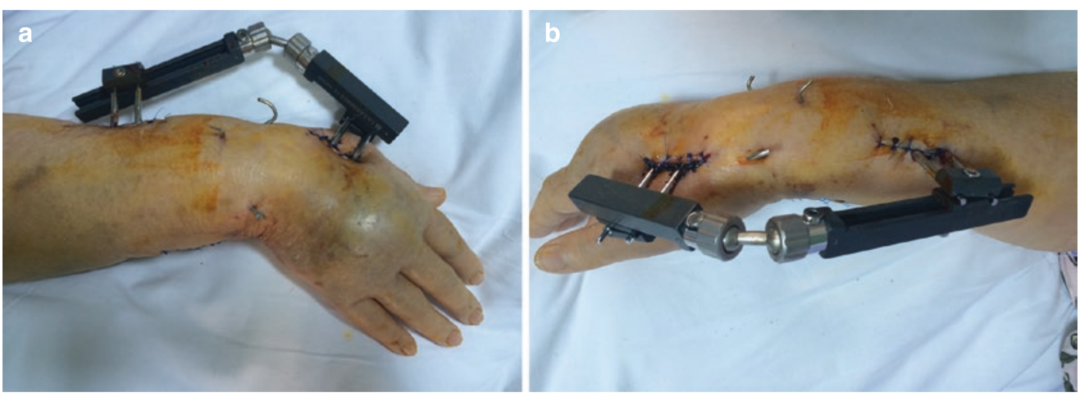

Fig. 11.4 (**a**, **b**) Distal radius fracture operated with external fixator, clinical view

controlled studies with a high level of evidence are not easy obtainable.

Iordens et al. [10], in their multicenter study, reported good functional outcomes and stable elbow joints with open reduction and internal fixation in 27 unstable elbow dislocations with fracture. They applied hinged external fixator to prevent instability [10].

11.7 Hinged External Fixator Application Technique in Elbow Joint

In our clinical practice, if stability is not achieved with open reduction and internal fixation in complex elbow dislocation, the joint is stabilized using a MAYO-type hinged unilateral external fixator.

In order to place the fixator properly, the joint rotation axis should be defined. To do this, the trochlea and capitellum should be superposed, and a perfect circle should be obtained on lateral fluoroscopic image when the elbow is at 90° flexion. Rotation centers of the joint and fixator are superposed by delivering a K-wire through the midpoint of this circle parallel to the joint (Fig. 11.5a, b).

If this is not achieved, concentric joint movement cannot be obtained. The central hole of the fixator is delivered through the K-wire; from the lateral side, two Schanz screws are sent to the ulna and two screws are sent to the distal humerus. When delivering Schanz screws to the distal humerus, a 4–5-cm incision should be made, the radial nerve should be found without exploration, and screws should be visualized on the bone. After mounting the fixator using Schanz screws, joint movement should be controlled for any change in the range of motion. If joint movement is adequate, the K-wire should be removed to finish the procedure.

Complication rates are not low even in reports with successful outcomes [10]. It should be kept in mind that redo surgery may be necessary if the rotation centers are not correct. Complications with this method include radial and ulnar nerve damage or pin bottom infection as in all external fixators.

11.8 External Fixator for Salvage Procedures in the Upper Extremity

11.8.1 Distraction Interposition Arthroplasty

In a patient with limited elbow motion due to pain or intrinsic reasons, elbow prosthesis may be a treatment option, but it is not preferred in a young, active

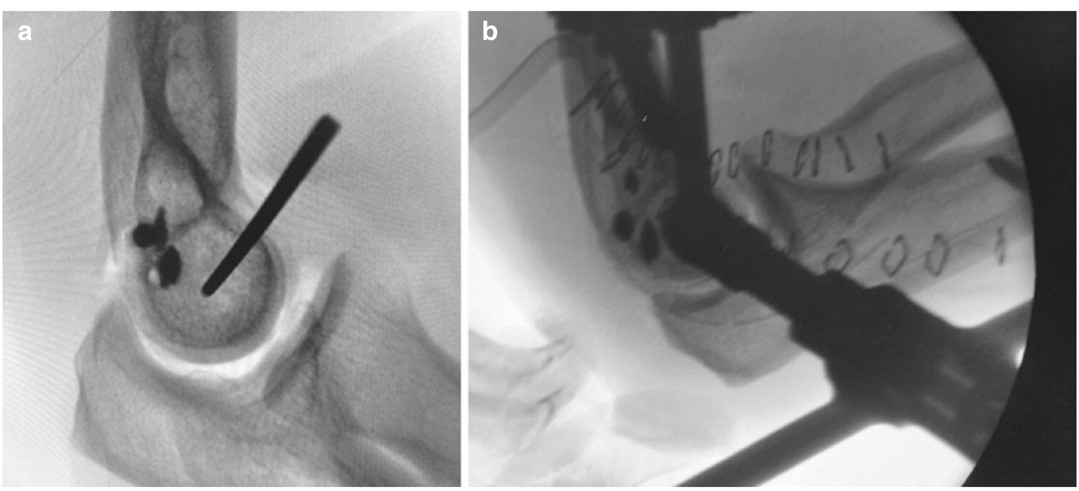

Fig. 11.5 (**a**, **b**) Application of the hinged external fixator in elbow joint

patient with the potential use of the elbow in heavy activities. In such cases, distraction interposition arthroplasty is one of the salvage methods that can be preferred [11]. In our clinic, Achilles tendon allograft is preferred for interposition. Following interposition, a hinged elbow fixator is used for distraction to protect interposition during healing for 6 weeks. There are studies with reported long-term successful results with this method [12, 13]. We performed this method on five patients, the mean range of motion was increased from 24 to 81°, and no revision or prosthesis operation was necessary during a 7-year follow-up period (Fig. 11.6a–c) [14].

11.8.2 Diaphyseal Humeral Nonunion

Even if conservative methods are frequently used in the treatment of diaphyseal humeral fractures, the frequency of surgical treatment has been increasing. Nonunion rate varies between 2 and 30% following conservative treatments, whereas it varies between 2.5 and 13% following surgery (Fig. 11.7a, b) [15–17].

There are various alternatives for treatment of nonunion, but each method has its own advantages and disadvantages [18]. The goal of treatment is to establish a structure that is firm enough to allow the adequate range of motion of shoulder and elbow joints. Plate–screw and internal fixation is a proven treatment method for nonunions after conservative treatment, but it is not a choice with infection or bone defects after surgical treatment. Thus, external fixation comes forward in such cases [19]. Circular external fixation seems to be a successful treatment in diaphyseal humeral nonunions, because it corrects surgical deformities and it enables bone transport after segment resection in infected patients. However, circular fixation of the humerus is not easy in terms of application, and patient comfort is low. Thus, it is

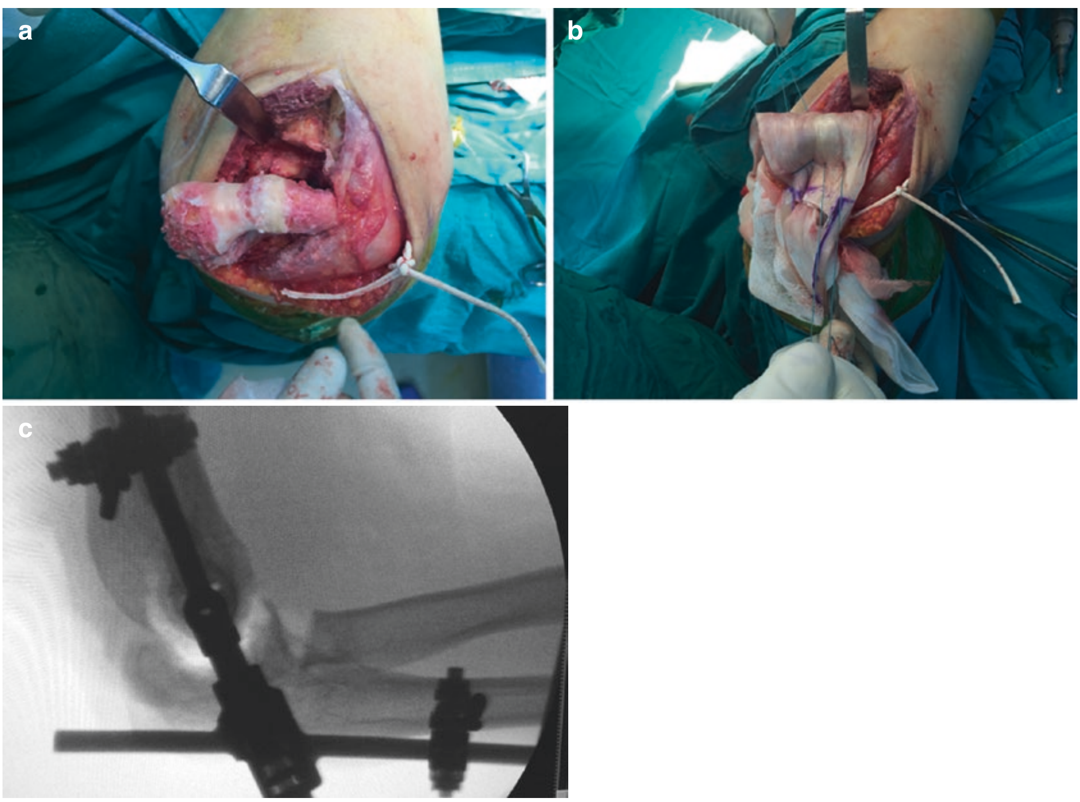

Fig. 11.6 (**a–c**) Intraoperative pictures of the external fixator application to the elbow joint with the hinge positioning

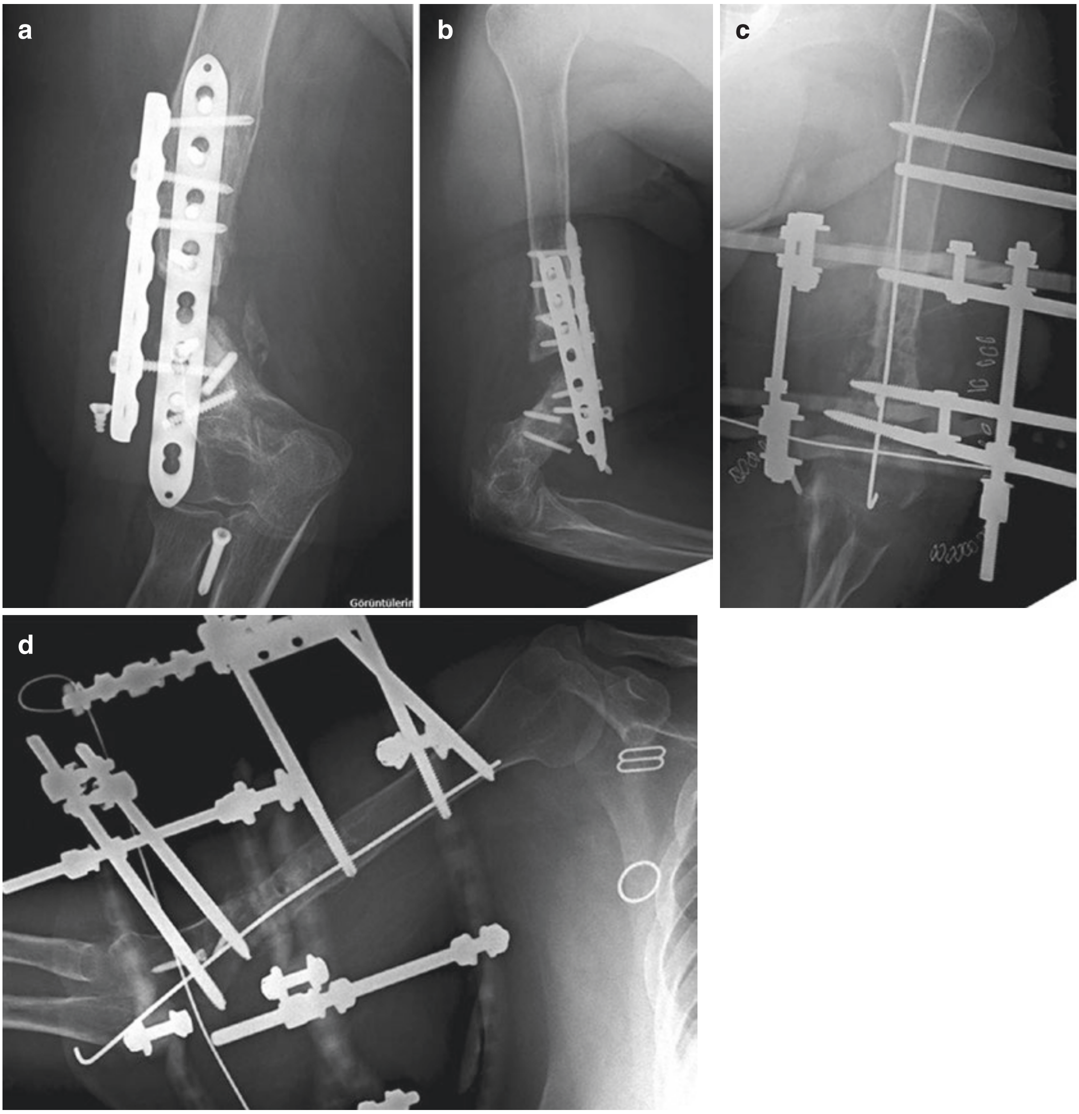

Fig. 11.7 (**a**, **b**) Pseudoarthrosis at the elbow joint and implant failure, mechanical instability is the main reason for this nonunion. (**c**, **d**) Circular external fixator application to the patient of humerus pseudoarthrosis at figures **a**, **b**

preferred in patients who have undergone many operations and/or infected (Fig. 11.7c, d) [20].

Unilateral external fixator application can be preferred as it is easier to apply than circular fixation with a higher patient comfort. It provides sufficient stabilization and enables compression-distraction [21]. In our clinic, 80 patients with diaphyseal humeral nonunion underwent further treatment. Of these, 35 had a circular external fixator and 24 had a unilateral external fixator. Both external fixation methods resulted in successful union without loss of functional elbow range of motion (Fig. 11.8a, b) [22].

11.9 Humeral External Fixator Application Technique

Safe planes should be known during humeral external fixator applications because there are neurovascular structures close to the bone; the surgeon should stick to these planes when delivering pins.

Again, in order to protect neurovascular structures, a Schanz screw is preferred rather than a K-wire.

In general, the pinning of the proximal humerus is accepted as safe. A pin can be delivered from anterolateral to posteromedial by staying lateral to the bicipital groove in the 5-cm area from the acromial lateral rim, which is safe for the axillary nerve. When going to the distal, the anterolateral region in the proximal metaphyseal region is feasible for pinning. Around the mid-diaphyseal region, the radial nerve extends through the posterior part of the bone; therefore, lateral and anterolateral application is accepted as safe.

The radial nerve turns from posterior to anterior in the distal diaphyseal and metaphyseal regions; therefore, a small incision should be made, and the radial nerve should be exposed before delivering a pin in this region (Fig. 11.9a, b).

Pinning should be performed after protecting the nerve. In the distal supracondylar region, a Schanz screw should be delivered from lateral to medial, whereas a K-wire should be delivered from medial to lateral to protect the ulnar nerve. It is also possible to deliver 2 K-wires from the medial side (Fig. 11.10a, b).

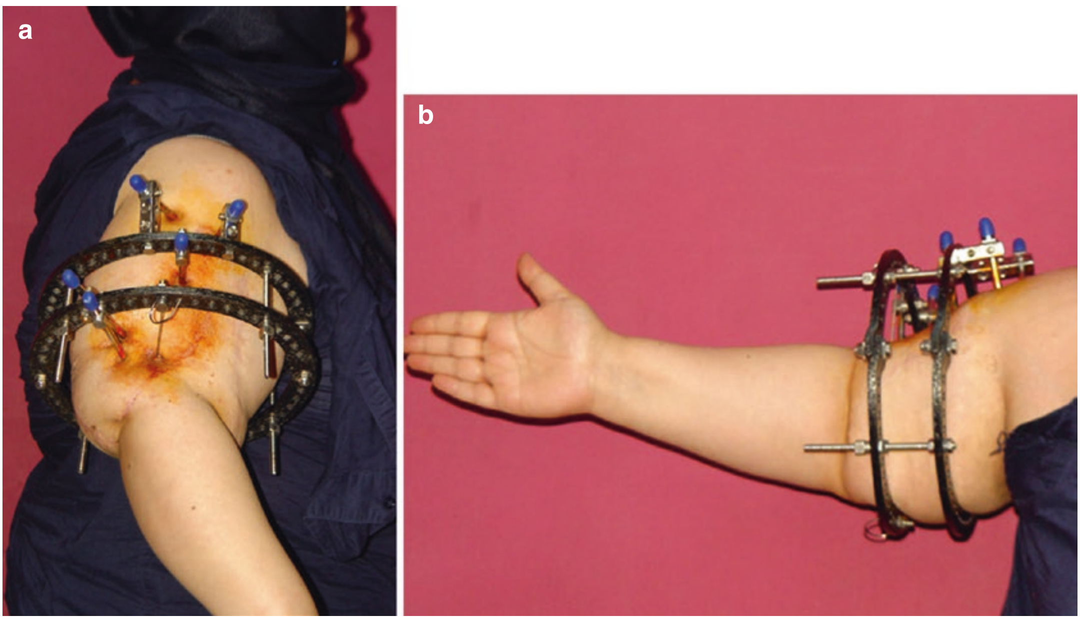

Fig. 11.8 (**a**, **b**) Postoperative clinical photos of the patient in Fig. 11.7

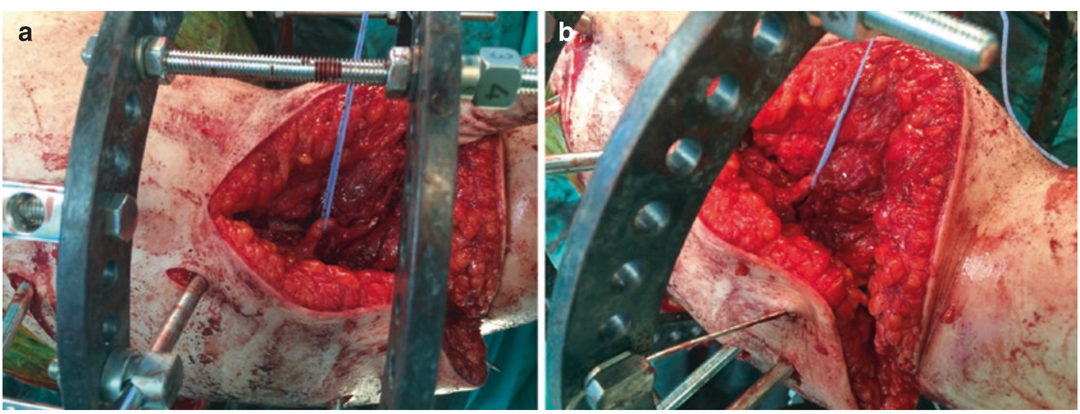

Fig. 11.9 (**a**, **b**) Radial nerve exploration at the circular external fixator application because of a nonunion

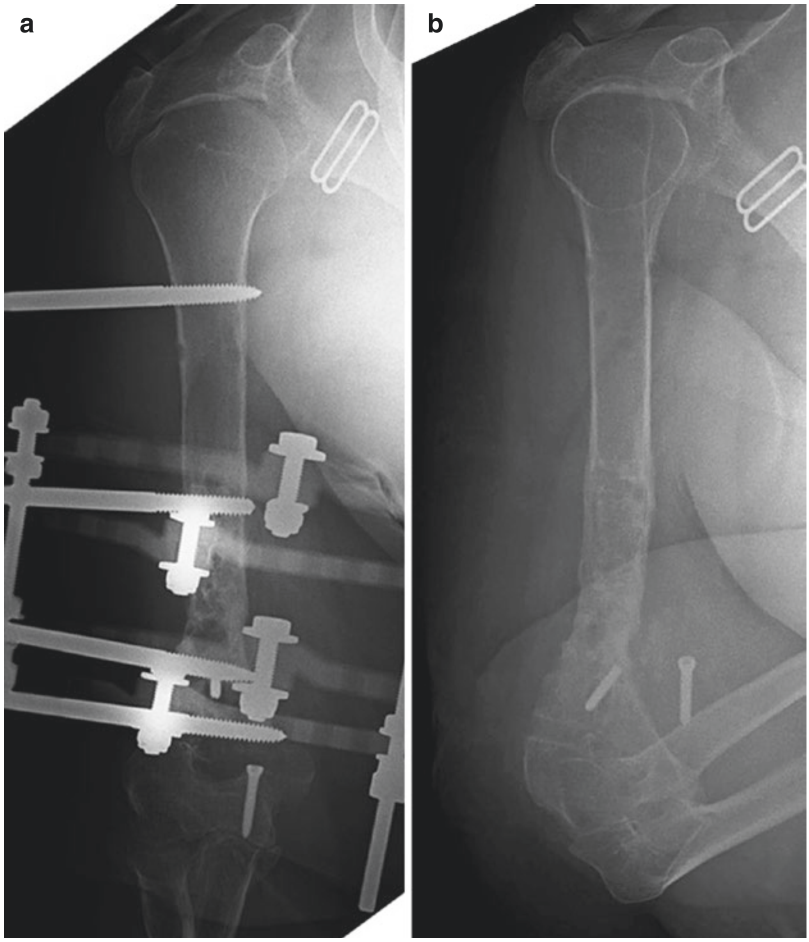

Fig. 11.10 (**a**, **b**) Union after 2 months

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