



Elbow arthrodesis for post-traumatic sequelae: surgical tactics using the Ilizarov frame

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Background: Surgical arthrodesis of the elbow joint is frequently unsuccessful and rarely performed. It is the purpose of this article to evaluate tactics and different constructs to achieve elbow arthrodesis (EA) using the Ilizarov apparatus in patients with post-traumatic nonreconstructable elbow sequelae.

Methods: A consecutive series of 4 patients were treated between 2009 and 2013 (3 men and 1 woman; mean age, 46.7 [35-75] years). Two patients had late complications in total elbow replacement and developed nonunion after condylar fractures of the distal humerus. There were 3 ulnohumeral arthrodeses and 1 radiohumeral arthrodesis. The hybrid advanced Ilizarov technique was used in all cases.

Results: Complete union was obtained in 3 EAs (75%) without additional surgery at an average of 23 weeks. Fusion angles ranged from 90° to 120°. One patient required amputation above the elbow because of persistent infection and chronic pain after attempted reconstruction with distraction osteogenesis for infected total elbow replacement with humeral bone loss. The average length of follow-up after EA was 33 months (range, 18-60 months). At final follow-up, the median score of the shortened Disabilities of the Arm, Shoulder, and Hand questionnaire was 42.4 (27.3-52.2). Three patients returned to their working activities.

Conclusions: EA is not a common orthopedic procedure. Despite its difficulties and need of specific training, the Ilizarov technique provides a reproducible and reliable way of achieving solid fusion with the desired angle. Advantages include infection control, early mobilization, accurate application, convertibility and versatility compared with a monolateral fixator, and improved union rate.

Level of evidence: Level IV, Case Series, Treatment Study.

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Elbow arthrodesis (EA) is a rarely performed procedure still considered a salvage approach to be chosen in selected cases only.^{16,25,28,33,34,38,42,44} For unilateral arthrodesis of the elbow, there is no single optimal position for all

activities. Ulnohumeral arthrodesis (UHA) is difficult to perform because of the peculiar bone anatomy of the elbow. Radiohumeral arthrodesis (RHA) is even more challenging when a large ulnar defect occurs, as for failed total elbow replacement (TER).⁸ Early EA techniques involved placing bone graft around the joint without internal fixation, followed by prolonged immobilization. Later series reported new techniques based on internal fixation, external fixation, and microsurgery, although they were associated with a large number of complications. Müller and Bilic

No Ethical Committee or Institutional Review Board approval was required for this study.

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recommended combined internal and external fixation for UHA using an external compression device with a cancellous screw securing the olecranon to the distal humerus and bone graft.^{3,26} Lerner reported a case of EA with a modular hinged monolateral frame alone.²¹ RHA has been described in only a few cases in the literature by McAuliffe²² and Presnal,³³ who used plate fixation, whereas Kato¹⁷ performed such a procedure using an external fixator. There are limited data in the PubMed literature regarding the use of a circular frame according to the Ilizarov technique for EA. Gunzburg obtained a UHA using an Ilizarov external fixator in a compression setup, without major surgery to the joint.¹³ Circular frames constructed by combining half-pins with the conventional Ilizarov wires in a special multidirectional configuration provide a minimally invasive skeletal stabilization and control in all 3 planes. This configuration can provide gradual horizontal compression at the level of the EA and can be used to perform EA. The aim of this study was to describe tactics and different constructs to achieve EA using the Ilizarov apparatus in such a configuration. We evaluate a series of 4 consecutive patients treated to obtain EA by this technique. Our results are retrospectively evaluated. At the same time, we analyze the complications and the possible causes of failure.

Materials and methods

We retrospectively evaluated four consecutive patients treated with a salvage arthrodesis at our institutions between 2009 and 2013 for posttraumatic nonreconstructable elbow joint after trauma. There were 3 men and 1 woman, with a mean age of 46.7 (35-75) years (Supplementary Table 1, available on the journal's website at www.jshoulderelbow.org). The average interval between the fracture and the EA procedure was 74 months. Two patients had late complications in elbow arthroplasty, and 2 developed nonunion after condylar fractures of the distal humerus. Two developed ulnar nerve palsy after the initial trauma. The authors performed all salvage operations and follow-up.

Operative technique

Preoperative planning involved a careful clinical examination including previous surgical incisions and post-traumatic skin damage. The supine positioning allowed us to operate on the circumference of the elbow and to obtain intraoperative fluoroscopic imaging. The hybrid advanced Ilizarov technique was used in all cases.⁹ This technique was developed to achieve more frame stability by combining half-pins with the conventional Ilizarov wires in a special configuration following safe corridors for wire and half-pin insertion.⁷ The proximal humeral half-pins were placed laterally. The safe areas for the diaphyseal region were situated anterolateral, whereas pin insertion in the distal metaphyseal and epiphyseal region was performed through a narrow safe skin area above the lateral epicondyle. The distal humerus is predominantly cortical and is flattened anteroposteriorly; therefore, the half-pins can be replaced by wires. In UHA, the assembly on the forearm was made by rings and

half-rings fixed with wires and pins to the ulna. The bars of the distal component of the fixator were aligned parallel to the long axis, adjacent to the subcutaneous border of the ulna, to facilitate half-pin placement perpendicular to the long axis. In RHA, bone screw placement varied on the basis of the clinical scenario. A temporary fixation with K-wires was placed to secure the elbow flexed at 100° to 120° in a neutral pronation-supination position. Autologous iliac crest bone grafting (ICBG) was placed around the fusion site in the noninfected cases, and the frame was applied and slowly compressed. One case with extensive bone loss required bone transport. Shoulder, wrist, and hand mobilization, active and passive, started on the first day postoperatively. Standard pin care with showering and application of dry gauze around the pins were recommended, following a standard protocol. Three patients were followed up until radiographic and clinical union was achieved or until recovery from amputation. Dynamization was performed before removal of the frame. Such a procedure is performed by releasing the nuts on the threaded bars at the nonunion site, one by one for a few seconds, followed by relocking to progressively relieve the frame tension. The decision to remove the fixator was based on the quality of the EA docking site on radiographs together with quality of the regenerated bone, when present. The fixator was removed either in the outpatient department or under anesthesia in the operating room according to the surgeon's opinion and the patient's wishes. Complications and reoperation rates were also recorded. A shortened Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) questionnaire was administered before and after surgery to measure the ability of a patient to perform upper extremity activities as well as severity of symptoms.¹² The score ranges from 0 (no disability) to 100 (most severe disability). The average length of follow-up was 39 months.

Case 1

A 75-year-old woman sustained a "terrible triad" injury with a right elbow dislocation associated with radial head and coronoid fracture. After multiple surgical procedures, including internal fixation, primary TER, and 2 revisions with allograft, she developed a large bone loss around the elbow, preventing another revision TER. A circular external fixator RRS (Dial Medicali Srl, Milan, Italy) was customized to achieve an elbow-spanning construct (Fig. 1). The external fixator was removed after 26 weeks with clinical and radiographic signs of EA fusion. Seven months later, she sustained a fracture of the homolateral radius after a fall. A circular frame with an intramedullary Steinmann pin and ICBG were reapplied. Six months later, the fixator was removed with the fracture healed. After 2 months from the removal of the fixator, the patient, lifting a weight with the right forearm, fractured the radius distally to the tip of the pin. The new radial fracture was fixed, replacing the Steinmann pin with a longer titanium elastic nail and protecting the forearm in plaster for 3 months. At 3 months of follow-up, signs of complete radiographic and clinical fusion were present. The final Quick-DASH score was 52.3 vs. 81.8 points preoperatively. The patient is satisfied despite the lack of pronosupination at the forearm (Fig. 2).

Case 2

A 36-year-old man involved in a motorcycle accident sustained an open, complex elbow fracture with humeral, radial, and ulnar

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