Management of Unstable Elbows Following Complex Fracture-Dislocations the "Terrible Triad" Injury

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By Gregory J. Zeiders, DO, and Minoo K. Patel, MBBS, MS, FRACS

Introduction

Complex fracture-dislocations of the elbow can often be either irreducible or unstable, with an inability to hold the reduction or with the delayed development of subluxation or dislocation. The aim of the present study was to evaluate the etiology of the instability, both osseous and ligamentous, and the results of stabilization with a combination of internal fixation, ligament repair, radial head arthroplasty and, when necessary, hinged external fixation. Figures 1 and 2 represent our formulated protocol and treatment algorithm for elbow fracture-dislocation in this series of thirty-two patients.

The so-called terrible triad injury has a history of complicated outcomes as the surgeon attempts to maximize functional range-of-motion goals while maintaining stability[1-3]. On the basis of previous evaluations of these specific injuries and the recent evolution of surgical protocols, the restoration of congruency and stability coupled with progressive rehabilitation can reliably enhance the functional outcome[4-6].

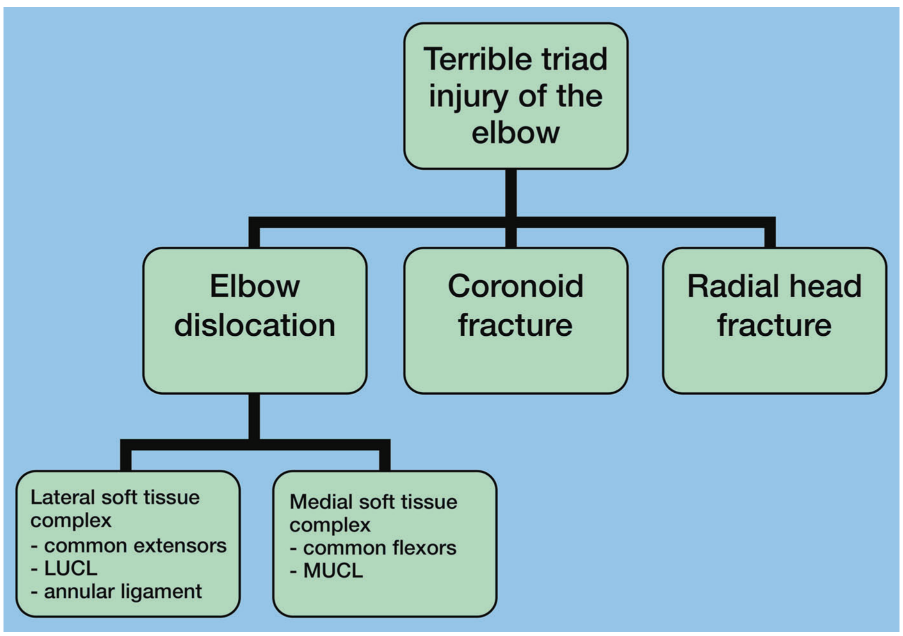

Fig. 1

Constellation of the "terrible triad" injury and the anatomic structures encountered. LUCL = lateral ulnar collateral ligament, and MUCL = medial ulnar collateral ligament.

Materials and Methods

Thirty-two consecutive patients with unstable elbow injuries who had been referred to three tertiary centers were prospectively recruited for the present study between 2001

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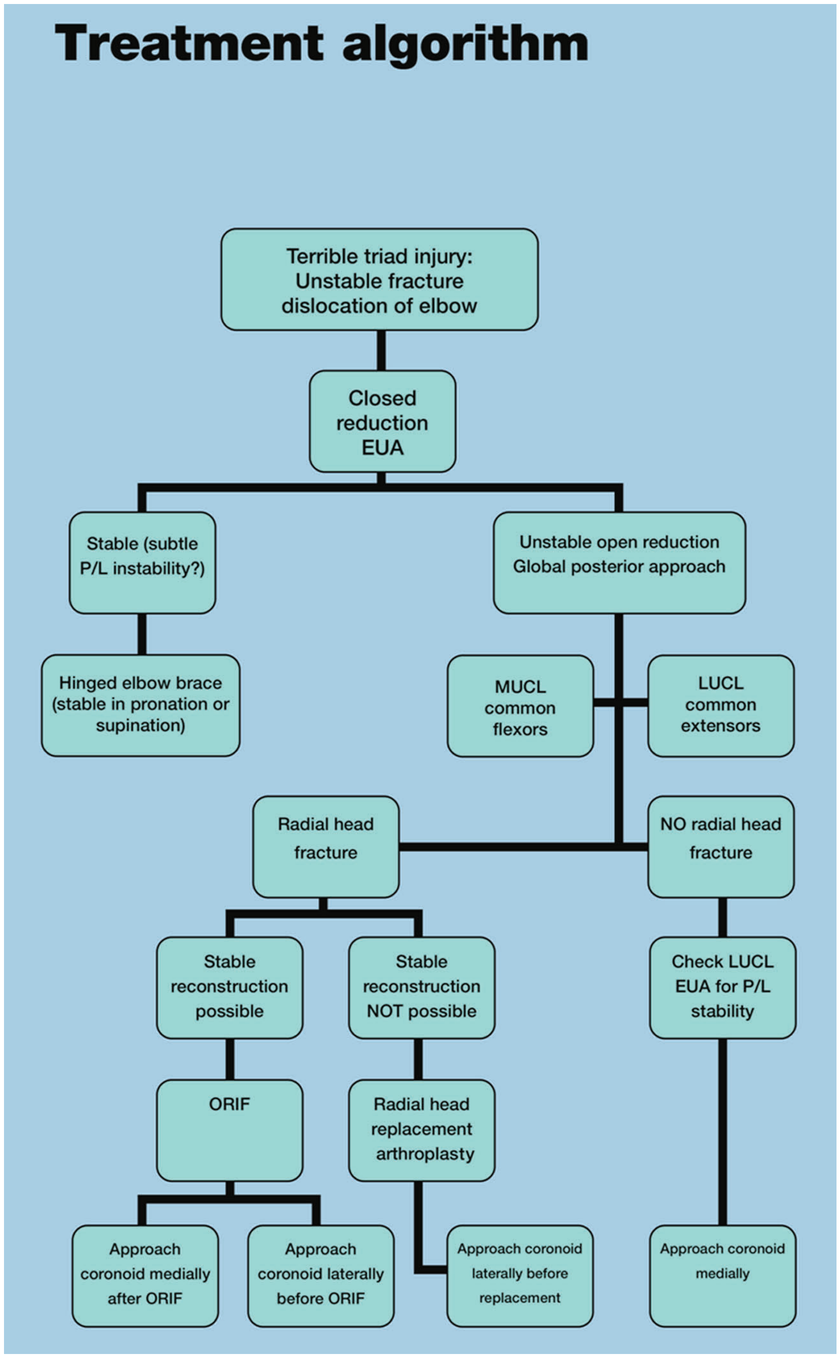

Fig. 2

Treatment algorithm proposed for the achievement of anatomic fixation and mechanical stability in patients with complex fracture-dislocations of the elbow. EUA = examination under anesthesia, MUCL = medial ulnar collateral ligament, LUCL = lateral ulnar collateral ligament, P/L = posterolateral stability, and ORIF = open reduction and internal fixation.

and 2005. Six of these patients had been unsuccessfully managed at outside facilities and had been transferred to our care. The unsuccessful treatments had included attempted closed reduction (four patients), radial head excision (one patient), and open reduction and internal fixation of the proximal part of the ulna (one patient).

All patients were evaluated with fine-cut computerized tomographic scans, including sagittal, coronal, and three-dimensional reconstructions. All elbows were approached with use of a posterior global incision[7,8]. Ulnar neurolysis was routinely performed. The medial and lateral ligament complexes were inspected and repaired by means of direct suture repair or with use of suture anchors. Internal fixation of the radial head was attempted when possible, or a radial head ar-

Fig. 3

The patient is positioned with the injured arm over a lateral arm post. The posterior global incision is shown.

throplasty was performed. The coronoid-brachialis complex was repaired with use of pull-through sutures. Elbow stability was then tested, and a hinged external fixator was used when indicated. All fixators were removed at six weeks, and indomethacin prophylaxis was administered for eight weeks to decrease the risk of heterotopic ossification.

All patients were examined clinically, radiographically, and with the Disabilities of the Arm, Shoulder and Hand (DASH) self-administered questionnaire. Range of motion, articular congruity, elbow stability, and complications were serially documented, and mean results were calculated for each treatment protocol in our algorithm.

Surgical Approach

All of the patients in the present prospective evaluation were managed by a single surgeon (M.K.P.) with use of the algorithm shown in Figure 2. The majority of patients were placed in the lateral position with the injured arm placed over a radiolucent post, and a sterile tourniquet was applied. Intraoperative image intensification was used. A posterior global incision[7,8] was preferred (Figs. 3, 4-A, and 4-B), but, alternatively, the patient was placed supine with a radiolucent extremity board[6]. With the patient in the supine position, a lateral Kocher surgical approach[7,8] was used; however, this approach is preferable only if (1) no medial abnormality is identified and (2) the surgeon is confident that the coronoid-brachialis complex can be repaired through the lateral incision. The lateral approach also facilitates radial head replacement.

Coronoid-Brachialis Capsular-Ligamentous Complex

The coronoid fracture is typically a shear fracture, not an

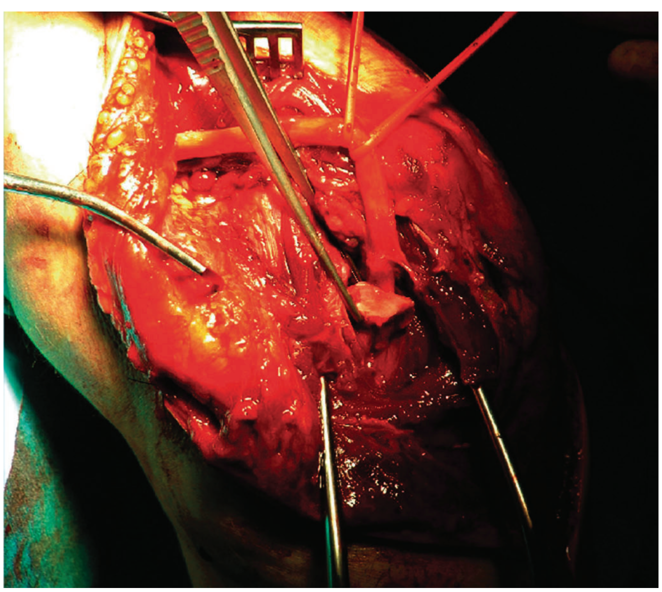

Fig. 4-A

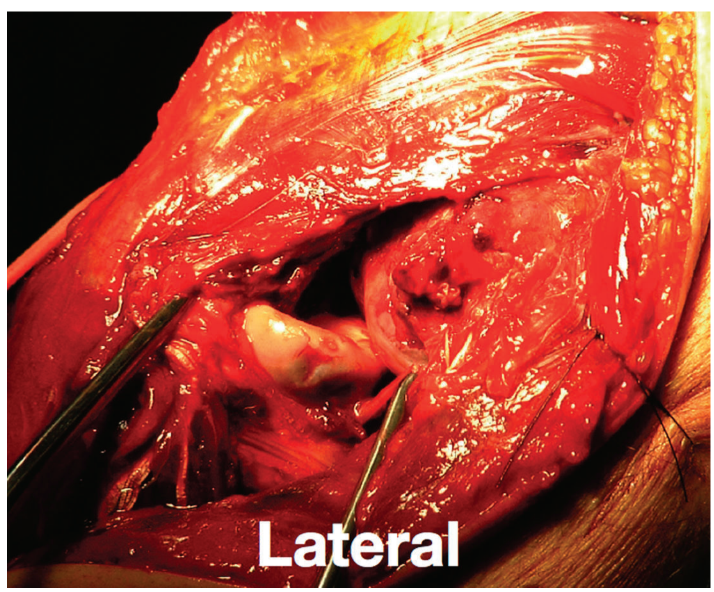

Fig. 4-B

Fig. 4-A The posterior global approach allows access to the medial side for ulnar nerve neurolysis and medial collateral ligament repair. **Fig. 4-B** A lateral window allows ligament reconstruction, coronoid repair, radial head replacement, and external fixator placement.

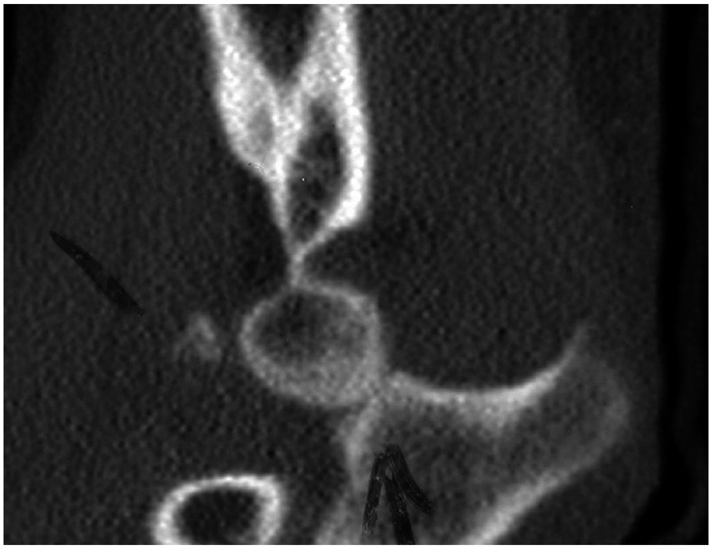

Fig. 5-A

Fig. 5-A Preoperative sagittal computerized tomographic scan showing a small coronoid fragment with frank dislocation of the ulnohumeral joint. **Figs. 5-B and 5-C** The coronoid-brachialis capsular-ligamentous complex is repaired through the lateral window of the posterior approach. Note the brachialis "ledge" or fragment (white arrows in Figures 5-B and 5-C) and the pull-through suture (blue arrow in Figure 5-C).

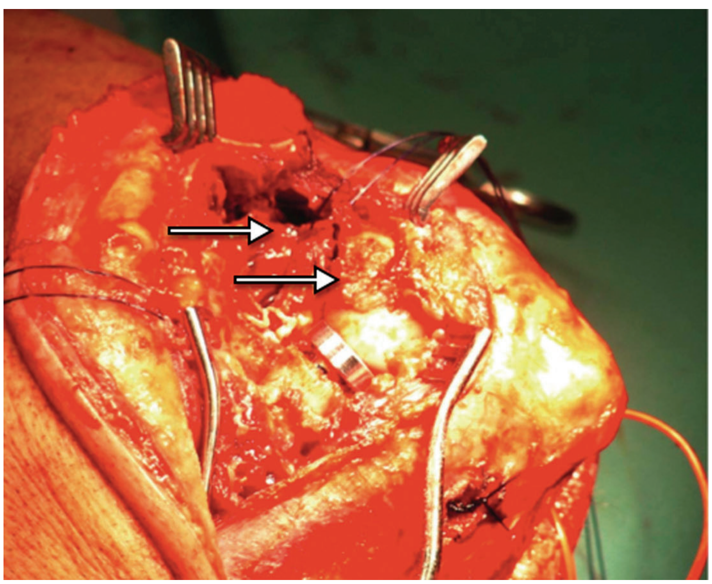

Fig. 5-B

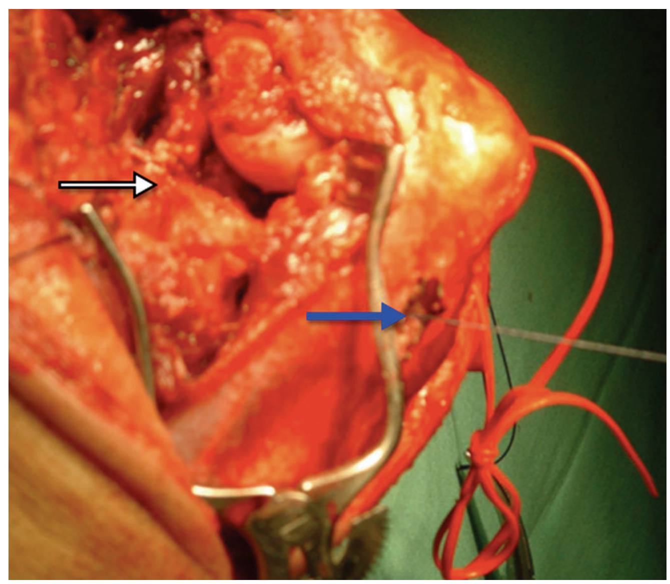

Fig. 5-C

avulsion fracture[9]. The coronoid-brachialis complex, with the attached capsular-ligamentous structures, forms the anterior restraint to dislocation. It is inevitably damaged when the ulna is dislocated posteriorly and the distal part of the humerus is translated anteriorly. Type-1 coronoid fractures are often associated with this injury. The bone fragments are often comminuted and not amenable to internal fixation. In these cases, repair of the coronoid-brachialis capsular-ligamentous complex is as important as the fixation of a type-2 or type-3 coronoid base fracture. Repair is performed with use of a pull-through suture technique devised by the senior author (M.K.P.) as shown in Figures 5-A through 5-E. A locking stitch is placed in the cartilaginous ledge at the soft-tissue attachment to the brachialis with use of a heavy number-2 braided nonabsorbable suture. Bone fragments are ignored or incorporated in the locking stitch. A 2.3-mm passing pin with an oval eye, commonly used for anterior cruciate ligament reconstructions (Smith and Nephew, Memphis, Tennessee), is used to drill, by hand, a hole from the subcutaneous border of the ulna, exiting at the coronoid tip. The passing pin is then reversed to allow the eye of the pin to be delivered into the wound to pull the locking stitch through the subcutaneous border of the ulna. Two strands of sutures are pulled through two separate holes, which are placed at least 7 mm apart at the coronoid exit point. The sutures are then pulled tight to reduce the coronoid-brachialis capsular-ligamentous complex to the bone and are tied over the subcutaneous border of the ulna, with the elbow flexed at 90°. The anteromedial facet of the coronoid, if fractured, requires fixation as described by O'Driscoll et al.[3].

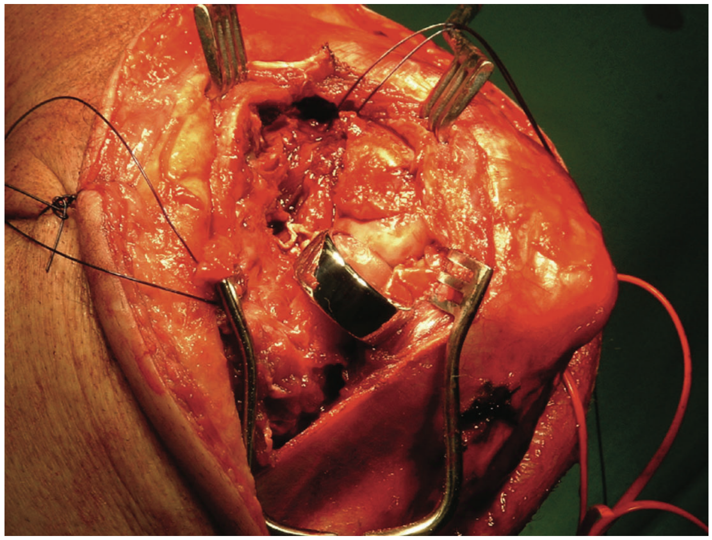

Fig. 5-D

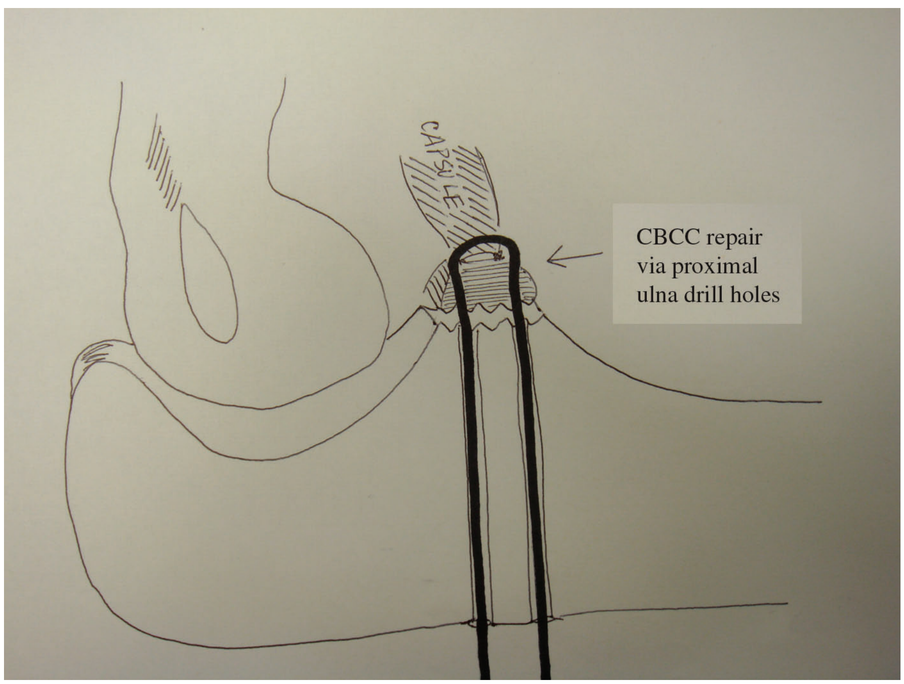

Fig. 5-E

Figs. 5-D and 5-E Photograph and illustration depicting the anatomic repair of the coronoid-brachialis capsular-ligamentous complex (CBCC) before the placement of a radial head implant.

Radial Head Reconstruction or Replacement

The decision to replace or repair the radial head is based on a preoperative evaluation of the radiographic studies and careful intraoperative assessment of the degree of comminution, fracture displacement, and fragment size. Specifically, fractures that involve more than one-third the articular surface of the radial head with >2 mm of displacement and any sizeable comminution are replaced. Reconstruction is performed with use of tissue-sparing plate fixation (Acumed, Hillsboro, Oregon). Replacement is usually performed with a monopolar modular implant (EVOLVE; Wright Medical Technology, Arlington, Tennessee) (Figs. 6-A through 7-B). Occasionally, a cemented bipolar implant (CRF II; Tornier, Grenoble, France) is used to compensate for bone loss (Figs. 8-A through 8-D). The modularity of this device makes it easier to implant the stem initially and to repair the coronoid-brachialis capsular-ligamentous complex prior to implantation of the head component.

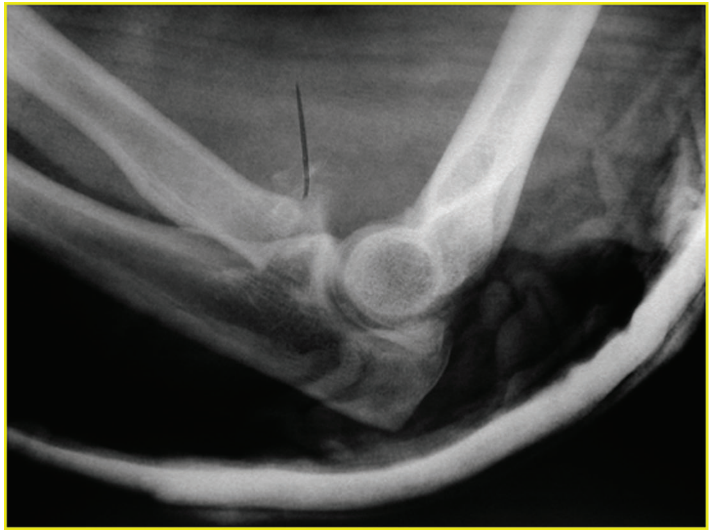

Fig. 6-A

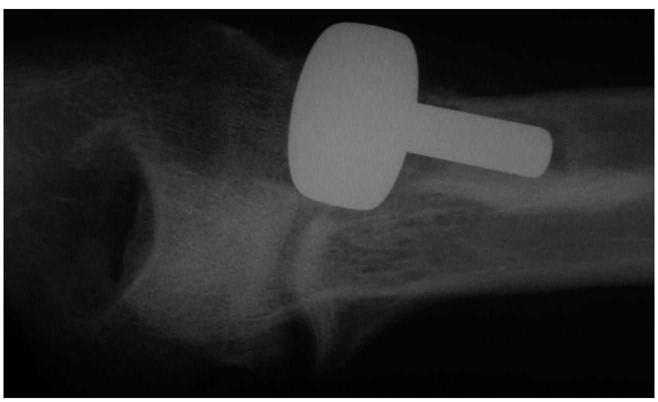

Fig. 6-B

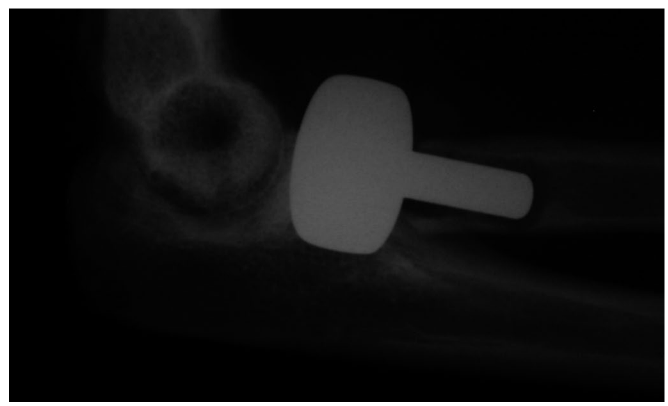

Fig. 6-C

Fig. 6-A Preoperative radiograph showing a comminuted radial head fracture with a stable metaphyseal neck. **Figs. 6-B and 6-C** Radiographs made after replacement of the radial head with a monopolar head device.

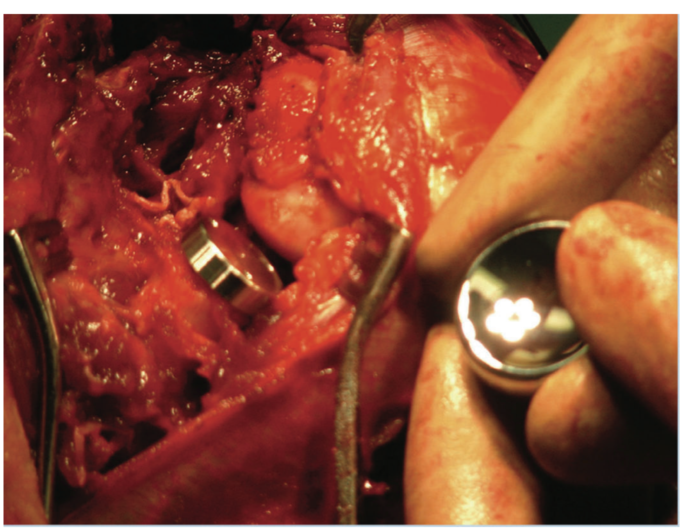

Fig. 7-A

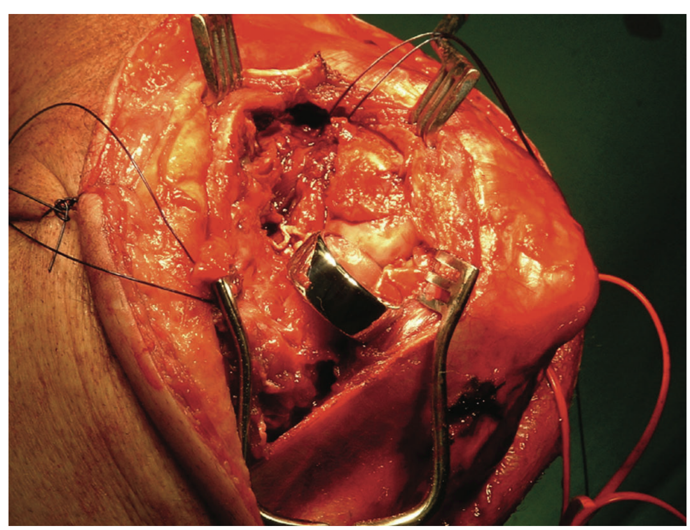

Fig. 7-B

Intraoperative photographs showing radial head placement onto a modular monopolar neck (Fig. 7-A) and a reduced radiocapitellar joint (Fig. 7-B).

Fig. 8-A

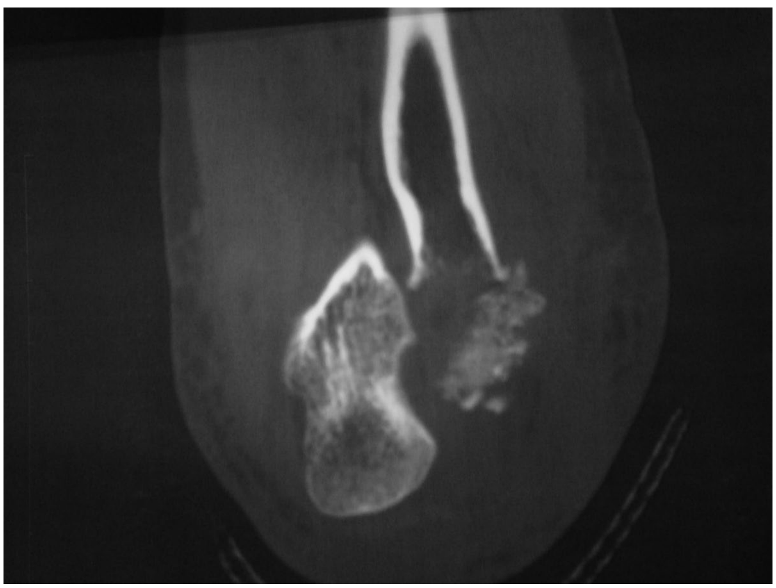

Fig. 8-B

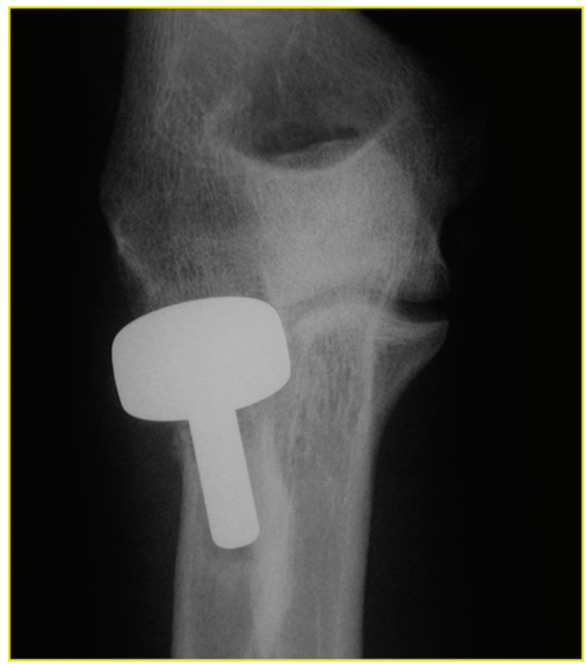

Fig. 8-C

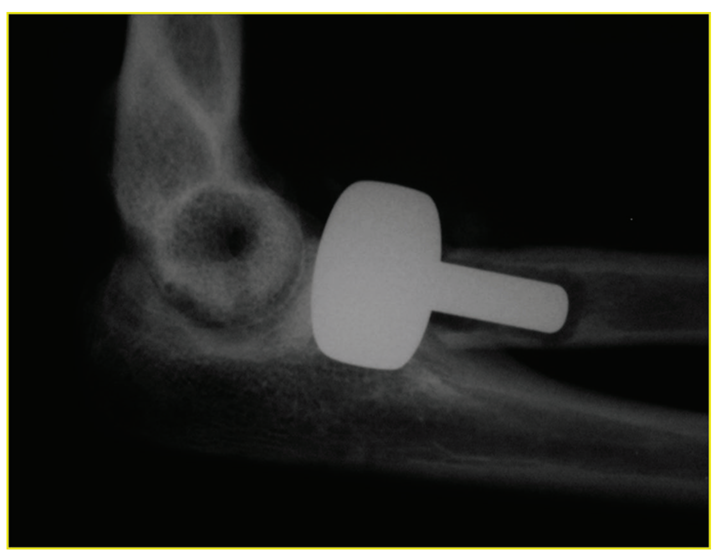

Fig. 8-D

Figs. 8-A and 8-B Preoperative radiograph (Fig. 8-A) and computerized tomographic scan (Fig. 8-B) illustrating a comminuted radial head-neck injury. **Figs. 8-C and 8-D** Postoperative radiographs showing stable fixation with a bipolar radial head replacement system.

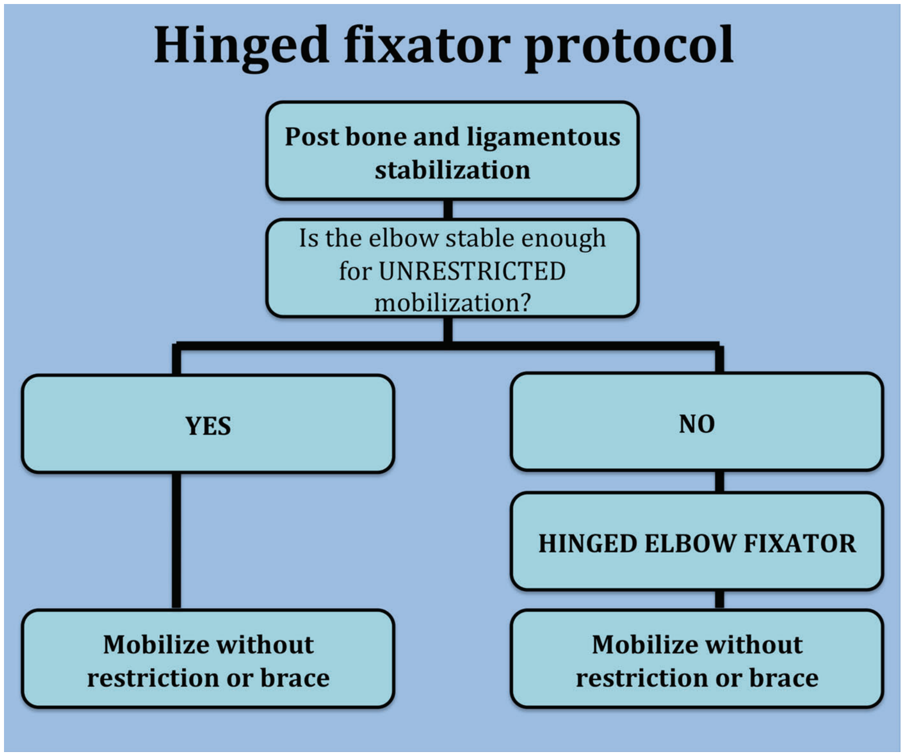

Fig. 9

External fixation protocol for achieving stability in patients with complex fracture-dislocation elbow injuries.

In cases in which the radial head is not reconstructable, replacement is required. Once the remnants have been excised, the coronoid-brachialis capsular-ligamentous complex is easily accessible through the lateral window and should be repaired before the radial head is replaced. Similarly, displaced radial head fragments can be set aside for later reconstruction after the coronoid-brachialis capsular-ligamentous complex is repaired. Even if the radial head is intact, disruption of the lateral ulnar collateral ligament makes the coronoid-brachialis capsular-ligamentous complex easily accessible from the lateral soft-tissue window.

Application of External Fixation

External fixation was applied to supplement stability at the time of surgery on the basis of our protocol (Figs. 9, 10-A, 10-B, and 11). A hinged external fixator positioned over the center of rotation of the elbow allows for early mobilization without the danger of anterior subluxation. The center of rotation of the elbow is the center of the trochlear and capitellar "spool," which can be seen clearly as a circle on the true-lateral radiographic projection.

Two types of fixators were used in the present study, depending on availability at the time of surgical intervention (Compass Universal Hinge [Smith and Nephew] and OptiROM Elbow Hinged Fixator [EBI, Biomet Trauma, Parsippany, New Jersey]). The Compass hinge has the advantage of being a circular fixator and offers multiaxial fixation. The OptiROM hinge is the only currently available elbow hinge fixator in which the central hinge has been expanded, providing a virtual hinge through which radiographs of the elbow can be made to give a true-lateral image of the elbow without metal interference (Fig. 10-A). The hinge must be tested intraoperatively to allow for full frictionless range of motion without soft-tissue resistance. The humeral fixation pins can be placed in the lateral plane or posteriorly (posteromedially and posterolaterally) through the triceps. The former can endanger the radial nerve, whereas the latter can cause triceps tethering that restricts elbow flexion. It is imperative not to insert the radial pins percutaneously. We prefer to make a formal incision and to dissect down to bone, carefully watching for and avoiding the radial nerve. This is best done as the last step of the operation after removal of the sterile tourniquet. A zone within 2 to 3 cm from the deltoid insertion is the safest area for the insertion of humeral pins in the lateral plane.

Postoperative Care and Rehabilitation

Early mobilization is encouraged if a hinge fixator is used. If external fixation is not utilized, a well-padded hinged brace is applied with the elbow at 90° of flexion. The forearm is rested in pronation to protect any lateral ligament repair. If both collateral ligaments are repaired or no ligament repair is performed, the forearm is placed in neutral rotation.

Protected mobilization is commenced at ten to fifteen days. Indomethacin (25 mg, administered orally three times per day) is used for a period of three weeks for prophylaxis against heterotopic ossification.

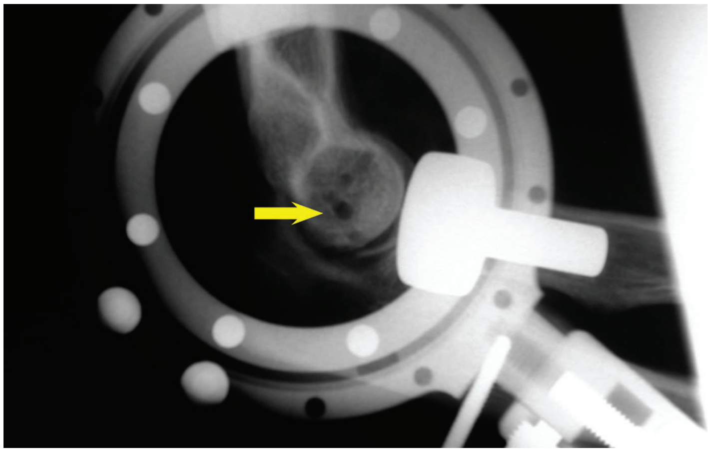

Fig. 10-A

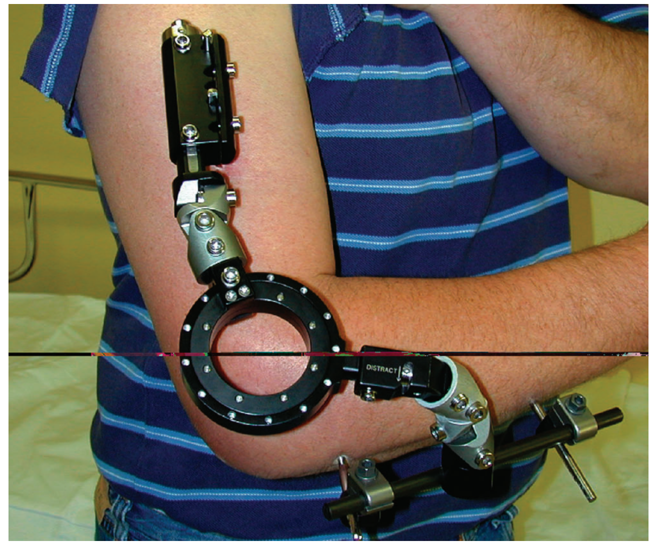

Fig. 10-B

Figs. 10-A and 10-B Intraoperative radiograph (Fig. 10-A) and postoperative photograph (Fig. 10-B) showing the OptiROM external fixation device (EBI, Biomet Trauma). The yellow arrow in Figure 10-B marks the center of rotation of the external fixator.

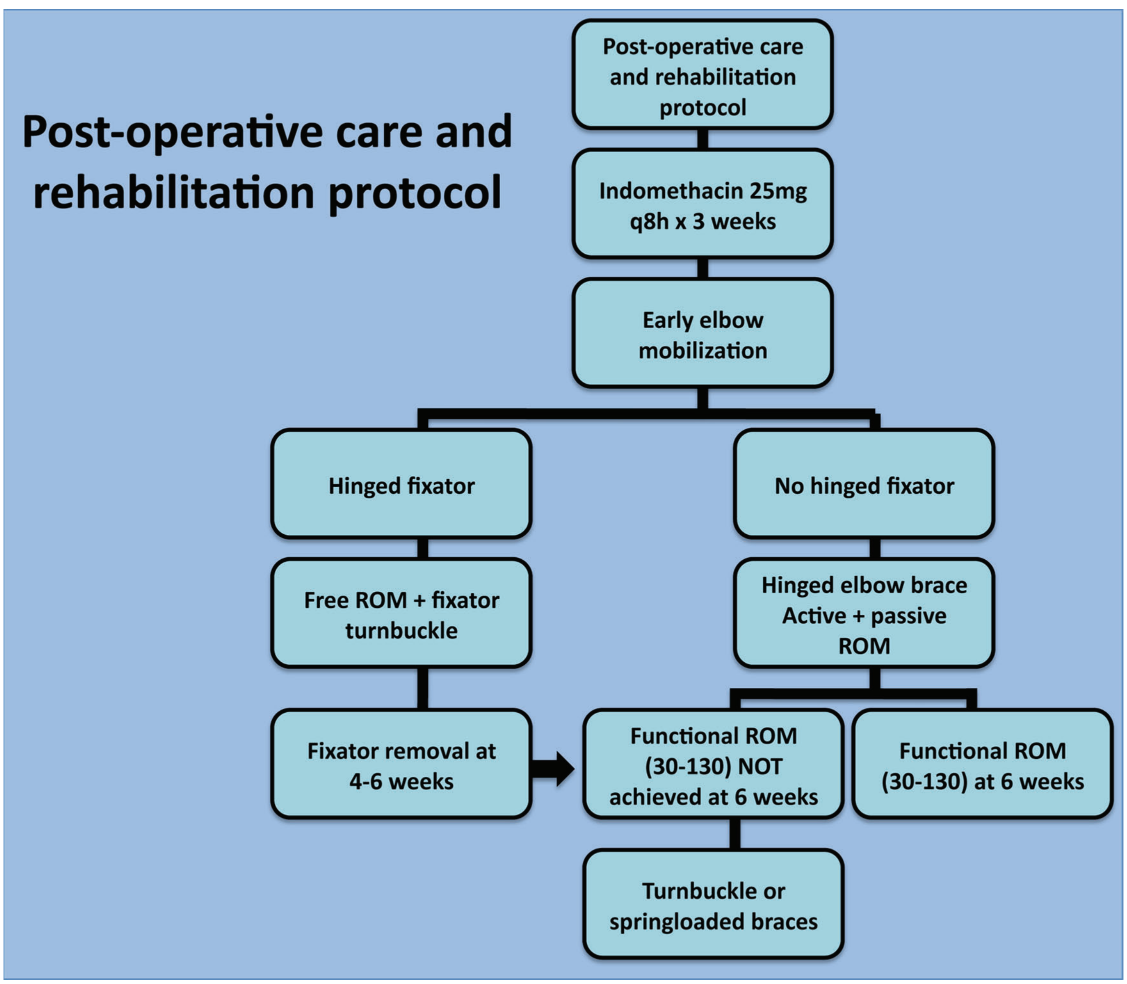

Fig. 11

Postoperative care and rehabilitation protocol. ROM = range of motion, and q8h = every eight hours.

The hinged fixator is removed six weeks after surgery, and physiotherapy is pursued to achieve maximum range of motion.

Results

All thirty-two patients underwent a repair of the coronoid-brachialis complex. The radial head was noted to be intact in six elbows. It was able to be reconstructed in seven of thirteen cases in which reconstruction was attempted, and it was replaced in nineteen cases. A lateral repair alone was performed in eighteen cases, a medial repair alone was performed in two cases, and a combined medial and lateral repair was performed in twelve cases. Twenty-one elbows required protection in a hinged external fixator; the Compass hinged fixator was used in nine elbows, and the OptiROM hinged fixator was used in twelve.

After a mean duration of follow-up of three years (range, one to five years), all thirty-two elbows had a functional arc of motion from 30° to 130°. The mean extension loss was 12° (range, 0° to 20°), the mean flexion loss was 14° (range, 0° to 20°), and a full range of motion was exhibited by three patients. The average DASH score was 23 (range, 19 to 28).

Despite having received indomethacin prophylaxis, three patients had development of minor heterotopic ossification, which did not affect the final outcome. The patients who had been managed with radial head arthroplasty exhibited no intermediate-term problems such as loosening or capitellar wear.

Discussion

Reconstruction of complex elbow fracture-dislocations represents one of the most troublesome and unpredictable procedures that orthopaedic surgeons face. We have found that three-dimensional computerized tomographic reconstructions are very useful to facilitate preoperative planning and to stage the treatment. The algorithm that we have developed (Fig. 2) represents a systematic approach to achieve the goals of reestablishing stability and functional motion. Our goal was prompt surgical stabilization once the acute swelling had subsided. Adequate stability must be achieved intraoperatively. In our limited experience, patients with a complex elbow dislocation who had a hinged elbow fixator had an earlier return of mobility. Our preference now is to use the OptiROM external fixator (EBI, Biomet Trauma) as it provides the ability to make lateral radiographs of the elbow joint and intraoperative fluoroscopy through the central hole in the expanded hinge. ■

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