Treatment of the Chronically Subluxated Elbow (Persistent Elbow Instability)

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Background

Despite our growing understanding of elbow biomechanics and the various patterns of instability, there still remain unanswered questions. One such challenge for the elbow surgeon is persistent elbow instability after a complex dislocation, which has been defined by Papandrea [1] as evidence of continuous dislocation or subluxation after initial treatment for the elbow dislocation with a coronoid fracture. The time period included in this definition is not well established, but most authors agree that 8–12 weeks from the injury might be the minimum time limit to consider an elbow chronically unstable.

At the end of this chapter, the authors hope to improve the reader's understanding of the various causes of persistent instability, develop a systematic and comprehensive approach to diagnosis, and a treatment algorithm to guide the surgeon's decision making process.

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Evaluation

In the initial evaluation of persistent elbow instability, it is necessary to identify and analyze each structure that provides primary or secondary stability. Evaluation begins with the history and physical examination of the elbow. One should note the mechanism of the original injury, symptoms that the patient is currently experiencing and what treatment has already been provided, including previous operative reports and progress notes. Physical examination of the elbow should be systematic, starting with inspection (Is there swelling or deformity? Where are the previous surgical scars?), palpation (Is there point tenderness?), range of motion (Is it painful? Is the elbow stiff? Is there clicking, popping, or crepitance?), and finally, appropriate provocative maneuvers (such as varus and valgus stress and the elbow pivot shift test). It is important to understand that the majority of patients presenting with persistent instability complain of stiffness and pain, and have already a variable degree of cartilage damage in the joint.

Imaging is truly part of the physical exam and should start with plain X-rays with multiple

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Fig. 14.1 Lateral X-ray of a 71-year-old patient 3 weeks alter a radial head fracture dislocation of the elbow treated with cast immobilization. There is obvious subluxation of the joint the joint

Fig. 14.2 CT scan of a patient presenting with persistent instability after an attempt to reconstruct the coronoid and resection of the radial head

views, including AP, true lateral, radiocapitellar lateral (also known as Greenspan view) and oblique views (Fig. 14.1). Acute injury radiographs should be reviewed in addition to current films. Finally, computed tomography (CT) with three-dimensional reconstructions can provide important details about the injury pattern and inform preoperative planning (Fig. 14.2).

A critical feature of elbow stability is the ulnohumeral congruence. The congruent reduction is maintained by various structures: the bony articulation (olecranon and coronoid), the articular capsule, the lateral ulnar and medial collateral ligaments (LUCL and MCL, respectively) and the muscles crossing the elbow. Morrey et al. [2] experimentally demonstrated that the load carried by the radial head under a valgus force is minimal when the medial collateral ligament is intact, suggesting that stability is not significantly compromised after radial head excision with a functionally intact MCL. However, it provided secondary stabilization when the medial collateral ligament was insufficient. Due to the complexity of these injuries and extent of concomitant soft tissue damage, we believe that the standard of care in the acute setting should be to either fix the radial head fracture or replace it when it is irreparable, in order to restore its role as a secondary stabilizer.

Other experimental studies have shown that the instability is directly proportional to the percentage of bony deficiency affecting the ulnohumeral joint; it is necessary that at least 30 % of the olecranon [2, 3] and at least 50 % of the coronoid [4] be preserved in order to maintain articular reduction and stability. It is useful to remember these values when planning surgical treatment.

Understanding the pathology of a persistent unstable elbow involves evaluation of all potential causes and consequences of joint incongruence: coronoid deficiency, ligament insufficiency, absence or malunion of the radial head, cartilage damage, nerve involvement and capsular contracture. A global view of the problem and a clear plan to restore ulnohumeral congruence and stability is necessary to pursue a good clinical outcome.

Treatment

A common problem in the chronically subluxated elbow is the coexistence of stiffness and instability; in those cases, treatment should prioritize correcting incongruence and restoring stability to avoid the development of potentially debilitating ulnohumeral osteoarthritis.

Treatment ranges from nonoperative strategies with physical therapy regimens to a wide spectrum of surgical options. The first step is to recognize the injury pattern and remember the objective: restore ulnohumeral congruence, reduce the radiocapitellar joint and restore elbow stability. While a functional range of motion is desired (Morrey et al. [5] established 30–130° as a functional range of motion), stability is of primary significance and should take priority. A stiff elbow is easier to manage than a chronically unstable one.

Nonoperative Strategies and Therapy Protocols

In select cases of residual elbow subluxation, nonoperative treatment with exercises that focus on strengthening the dynamic stabilizers and avoidance of varus stress is a reasonable alternative. In 2008, Duckworth [6] suggested that this strategy be employed only in those cases of slight subluxation, defined by an ulnohumeral joint space between 4 and 7 mm, and only in cooperative patients. They studied 23 patients with 20 fracture-dislocations and three simple dislocations. Five were initially treated nonoperatively and the rest underwent surgery. The mean age was 43 years old, and average follow up was 24 months. All patients achieved stability. The mean ROM was 113°. All had concentric reductions at final follow up except one, who was reportedly asymptomatic. The mean Broberg-Morrey elbow score was 90 points. Four patients ultimately underwent surgery: two ulnar nerve transpositions, two heterotopic ossification excisions, one elbow contracture release, one skin graft, and one compartment syndrome. In general, nonoperative management should be reserved only for those patients with minimal instability and minimal loss of congruence.

Surgical Management

Surgical planning of a persistent subluxed elbow includes assessment of all osseous and ligamentous structures around the elbow. All efforts should be aimed to restore as many stabilizers as possible.

Radial Head Fracture

The Mason Classification for radial head fractures may be the most widely used [7]. Type 1 fractures are nondisplaced marginal fractures. Type 2 fractures are marginal fractures with displacement and type 3 fractures are comminuted fractures of the entire head [7]. In his original paper, Mason proposed nonoperative treatment for type 1 fractures and operative treatment for type 3 fractures [7]. Recent studies have validated that nonoperative treatment of isolated type 1 radial head fractures is reasonable, with 95 % of patients in one large series obtaining excellent or good outcomes [8]. In the setting of elbow instability with a type 1 fracture, nonoperative treatment may still be considered as long as there is a concentric reduction and a stable range of motion with no evidence of subluxation with flexion and extension. Type 3 fractures continue to be treated operatively with general consensus. The optimal treatment of type 2 fractures remains controversial. Some authors have reported excellent results after nonoperative treatment of certain isolated type 2 fractures [8] while others have reported very good results with operative treatment [9]. In the setting of complex dislocations, operative repair of type 2 fractures should be performed to maintain its role as a secondary stabilizer in the setting of an injured MCL.

In type 3 fractures, radial head arthroplasty offers better outcomes when it is made in the acute phase. Morrey [10] reported 92 % good outcome in the acute phase and 48 % good outcome when it is made in chronic phase. The worst result is seen in cases of delayed radial head arthroplasty. The use of allograft for reconstruction is unpredictable and in our opinion, should be avoided.

If the radial head is absent in the subacute setting due to a prior resection, it commonly needs to be replaced in order to help maintaining posterolateral and valgus stability in cases of chronic subluxation or instability. It is unclear which type of radial head arthroplasty is superior. However, the surgeon should not believe that radial head replacement alone solves the problem of an unstable elbow if the rest of anatomical structures involved are not addressed (Fig. 14.3).

Ligamentous Injury

In a concentrically reduced ulnohumeral joint, one can expect ligamentous healing. In acute ligamentous injury with associated complex instability, primary repair is often feasible. However, in delayed cases, the surgeon should prepare for ligament reconstruction. Repair and

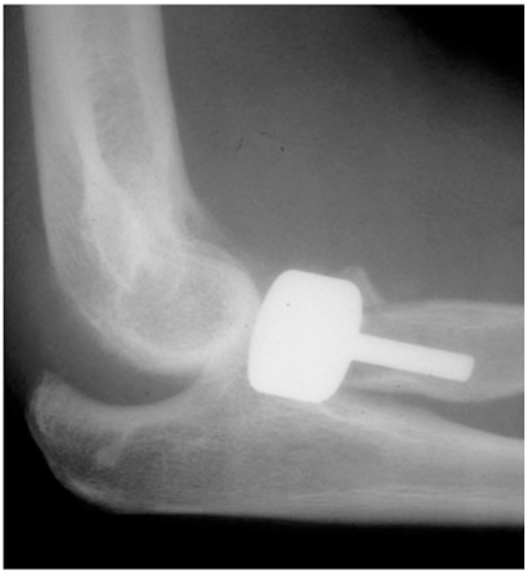

Fig. 14.3 Patient with persistent instability after a radial head fracture associated with elbow instability in whom the radial head was replaced but the rest of stabilizers were not adequately addressed

reconstruction techniques are described in previous chapters, and we encourage the reader to review them. Occasionally, especially when there has been an associated neurologic injury, one may find significant heterotopic ossification that needs to be removed and compels the surgeon to undergo a ligament reconstruction (Fig. 14.4).

Coronoid Fracture

Regan and Morrey [11] described three types of coronoid fracture. Type I fractures involve the tip of the coronoid, type II fractures involve more than the tip and less than 50 % of the coronoid, and type III fractures involve greater than 50 %. O'Driscoll et al. [4] described an alternative classification system involving three fracture types. Type 1 is a tip fracture, type 2 is an anteromedial facet fracture, and type 3 is a fracture through the

Fig. 14.4 (**a**) Radiographs of a patient with a persistent elbow dislocation 6 weeks after high-energy trauma with central neurological injury. There is significant heterotopic ossification. (**b**) The elbow presents with severe stiffness

base of the coronoid process. This classification stresses the importance of identifying fractures of the anteromedial facet of the coronoid caused by a varus force, leading to posteromedial rotatory instability.

Classical recommendations have been to fix all Regan-Morrey type II and III coronoid fractures as well as any type I fractures associated with instability. In type I fractures, many authors feel that there is not enough evidence of instability associated with this particular fracture type. Therefore, some authors do not feel there is enough evidence supporting the importance of their repair of this fracture type. The coronoid process has three significant soft tissue insertions: the anterior joint capsule, the brachialis muscle and the ulnar collateral ligament. Anatomic evidence demonstrates that the capsule usually attaches below the tip of the coronoid process and the anterior band of the MCL attaches more distal [12, 13]. Repair of fractures, depending on size, will also incorporate some or all of these soft tissue insertions playing an important role in elbow stability.

Josefsson [14] reported four cases in a series of patients that experienced recurrent instability after an initial elbow dislocation. All patients that redislocated had an associated fracture of coronoid that was not repaired at the time of initial treatment. Terada [15] demonstrated that repair of type I fractures could improve stability. Clinical evidence reported by Pugh [16] corroborates that finding, stating that type I injuries usually represent a capsular injury. Although in the acute setting fixation of small coronoid fragments may not be necessary, all these clinical findings stress the importance of addressing all possible stabilizers when dealing with persistent instability.

The coronoid fracture in the setting of elbow dislocations remains a significant cause of persistent instability, and it remains incompletely solved. It is still unknown what percentage of the coronoid is necessary to maintain elbow stability. However, it is rather clear that in type I fractures the issue is not the bone, but the anterior capsule.

In 2004, Schneeberger [17] demonstrated that elbows with a defect of 50 or 70 % of the coronoid, loss of the radial head, and intact ligaments could not be stabilized by radial head replacement alone; however, additional coronoid reconstruction was able to restore stability.

Because of its critical role in rendering stability, we try to fix all acute Type 3 fractures when possible and reconstruct it in those fractures that are not amenable to repair, such as those with extensive comminution. Type II fractures may be treated nonoperatively if the radiocapitellar joint can be reconstructed, the lateral ligament is repaired and the elbow is found to be stable through a full arc of motion. However, if the radial head is not amenable to fixation, a type II coronoid fracture may need to be fixed in addition to radial head replacement.

Coronoid Fracture Repair

Repair alternatives include suture lasso technique, screw fixation (anterior to posterior or posterior to anterior) and plate fixation. Grant et al. [18] reported that the suture lasso technique was more stable than the other techniques intraoperatively, both before and after LUCL repair, and at final follow-up. Open reduction internal fixation (ORIF) was associated with a higher prevalence of implant failure, and suture anchors were associated with a higher prevalence of malunion and nonunion. Greater stability with fewer complications can be achieved with the use of the suture lasso technique for fixation of small coronoid fractures (Fig. 14.5). If the fracture is big enough, screw or plate fixation is probably the optimal technique (Fig. 14.6)

Coronoid Fracture Reconstruction

The most common scenario in the subluxed elbow presenting 3–6 weeks after the initial injury involves absence of a competent coronoid. In this situation there are several reconstruction options. Esser [19] in 1997 described reconstruction with radial head autograft. Moritomo [20] in 1998 published reconstruction with olecranon autograft; and Kohls-Gatzoulis [21] in 2004 and Chung [22] in 2007 reported good outcomes with iliac crest bone autograft.

In 2014, Kataoka et al. [23] compared the three types of osteochondral autografts that have been employed for coronoid process reconstruction: olecranon tip, lateral radial head, or proximal radial head. They concluded that an olecranon graft was most suitable for defects of the coronoid process involving the tip, and a proximal radial head graft was most suitable for defects of the coronoid process involving the anteromedial rim. The olecranon graft seems to provide the highest "covering rate" and reconstruction of 50 % of the height of the coronoid process only required harvest of about 14 % of the olecranon tip and does not seem to cause gross elbow instability secondary to the donor site defect.

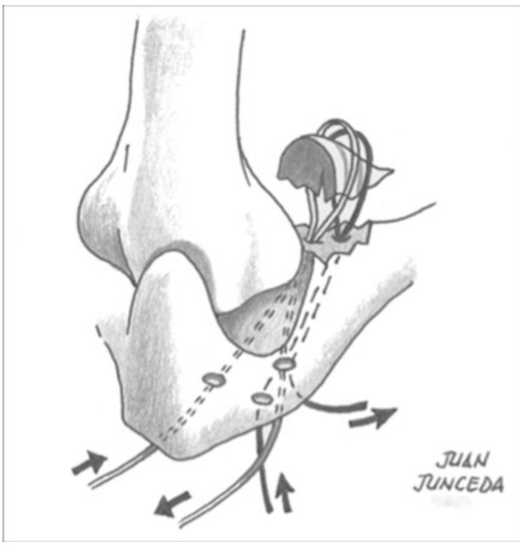

Fig. 14.5 Suture fixation of small coronoid fractures is seldom required in the acute setting but can be an additional help in subacute cases

Allograft options have also been reported. In 2005, Karlstad [24] published the failure of fresh-frozen radial head allografts in the treatment of Essex-Lopresti injury. This result suggests that allograft reconstruction options may result in less optimal outcomes than autograft. Van Riet et al. reported on six cases of coronoid process reconstruction, three cases using radial head allograft and three cases using radial head autograft [25]. Two of three allograft cases had a poor results based upon the MEPS with mild pain in two cases and severe pain in one. The authors reported that reconstruction of the coronoid process is an option but results are unpredictable.

Time since injury is important in deciding between repair and reconstruction. Ring and others [26] consider repair of the coronoid process 4 weeks after injury as difficult if not impossible in a dislocated or subluxated terrible triad elbow. Papandrea [1] recommends that reconstruction (after a coronoid fracture dislocation) should be done as soon as possible; a delay beyond 7 or 8 weeks is uniformly associated with an unsuccessful outcome (Fig. 14.7).

Preferred Coronoid Reconstruction Technique

When the coronoid fracture is deemed not reparable, and radial head is available, we prefer to use it for coronoid reconstruction. If radial head

Fig. 14.6 Radiographs of a 54-year-old patient presenting 10 days after an elbow injury with a subluxed elbow associated with a type II coronoid fracture and a complex radial head fracture. The coronoid was fixed with screws and the radial head was replaced

Fig. 14.7 Persistent elbow instability after an attempt to reconstruct the deficient coronoid with an autograft from the radial head

is not available, as in those patients who may have had radial head replacement in a previous operation or in whom the radial head is severely comminuted, we prefer to use the olecranon tip. We consider allograft to be a reasonable option when neither radial head nor olecranon tip is available, recognizing concerns expressed by Karlstad [24] and van Reit et al. [25].

We generally use a utilitarian posterior incision for skin and lift full thickness flaps. This allows us access to the medial side if it is deemed necessary intraoperatively. It also facilitates posterior-anterior screw placement and/or suture fixation of coronoid fractures and grafting.

Technique: Radial Head

We enter the radiocapitellar joint laterally through the traumatic rent or through a Kaplan interval, but Kocher is reasonable as well. In cases of delayed presentation and radial head fracture that is in three fragments or more, we resect the radial head with the intention of replacing it "on the way out." This typically gives adequate exposure of the coronoid fracture. Once the decision is made to reconstruct based on the status of the fracture fragment, we assess the radial head fragments. We recognize the findings of Kataoka et al. [23] which suggest using the lateral rim of the radial head to recreate the convexity of the coronoid process and the proximal, concave radial head to reconstruct anteromedial facet fractures; however, we find that in practice we do not have the choice of what part of the radial head we have available to use. Therefore, we seek to recreate the bony buttress and orient articular cartilage toward the trochlea as much as possible.

In a manner similar to Ring et al. [27], we prepare the coronoid fracture bed by creating a flat surface with exposed cancellous bone (callous, hematoma are debrided). We then fashion the radial head graft to have a matching flat surface on which to sit and try to retain at least 50 % of the native radial head width. The proximal radial head (or the lateral radial head) is then oriented toward the trochlea. While holding the graft in place with a dental pick (or large pointed reduction clamp), a k-wire is placed posterior-anterior to hold it provisionally. We then use fluoroscopy and visual inspection to confirm placement. Once it is satisfactory, we place a 2.7 or 3.5 mm screw in a posterior-anterior manner. Suture augmentation through bone tunnels can also be used as needed.

Technique: Olecranon Tip

If radial head is not available, we prefer to use olecranon tip. An et al. [28] and Bell et al. [29], who found that excision of up to 50 % of the olecranon may not cause gross instability, to determine how much olecranon tip can be harvested. Based on the work of Kataoka et al. [23], only about 14 % is required to replace coronoid fractures of 50 %.

The olecranon tip is approached through a utilitarian posterior approach. The triceps is split from about 2–3 cm proximal to about 1–2 cm distal to the tip. The amount of olecranon harvested depends on the amount require as estimated by visual and radiographic inspection. This is usually about 1.5 cm. A straight osteotome is used to osteotomize the tip, remaining perpendicular to the articular surface. The triceps rent is repaired with a non-absorbable suture.

The bed of the coronoid fracture is prepared as described above. A flat surface is obtained to match the base of the graft. Two holes, approximately 1 cm apart, are made with a 1.0 mm drill in the graft on the back table. Two 1.5 mm holes are drilled approximately 2 cm apart, from the posterior surface of the ulnar through the bed of the coronoid fracture. A heavy, non-absorbable suture is passed through the graft to serve as supplemental fixation and to use as "tow sutures." The graft is oriented such that the articular surface faces the trochlea. The sutures are passed through the holes through the bed of the coronoid fracture to the posterior aspect of the proximal ulna.

While the sutures are pulled tightly, and while holding the graft in place with a dental pick (or large pointed reduction clamp), a provisional K-wire is placed posterior to anterior. Fluoroscopy and gross inspection confirm proper placement, and a 3.5 mm cortical screw is placed in lag fashion. Alternatively, a cannulated screw may be placed over a guide-wire. The suture is then tied over the bony bridge (Fig. 14.8).

After reconstruction of the coronoid with either radial head or olecranon tip, the resected radial head is replaced in a standard manner, the LUCL is repaired and stability is assessed and confirmed with gross inspection and fluoroscopy. If the reduction and fixation are judged to be stable, the patient is placed into a posterior mold splint for 3–5 days to allow for wound healing; the patient is then placed into a hinged elbow brace to begin early, protected ROM. We prefer that exercises be performed while supine to avoid varus and valgus stress on the elbow.

We have a low threshold for placing a hinged external fixator in cases of tenuous fixation or questionable stability. It remains in place for 4–6 weeks, and we encourage early, protected ROM.

Coronoid Prosthesis

Coronoid prostheses have been described for those injuries in which repair or reconstruction are not achievable. In 2013, Gray [30] demonstrated favorable biomechanics with an anatomic prosthesis compared to the native elbow in a cadaveric model of elbow instability due to coronoid deficiency. More studies are required for in vivo outcomes. Currently there are no coronoid

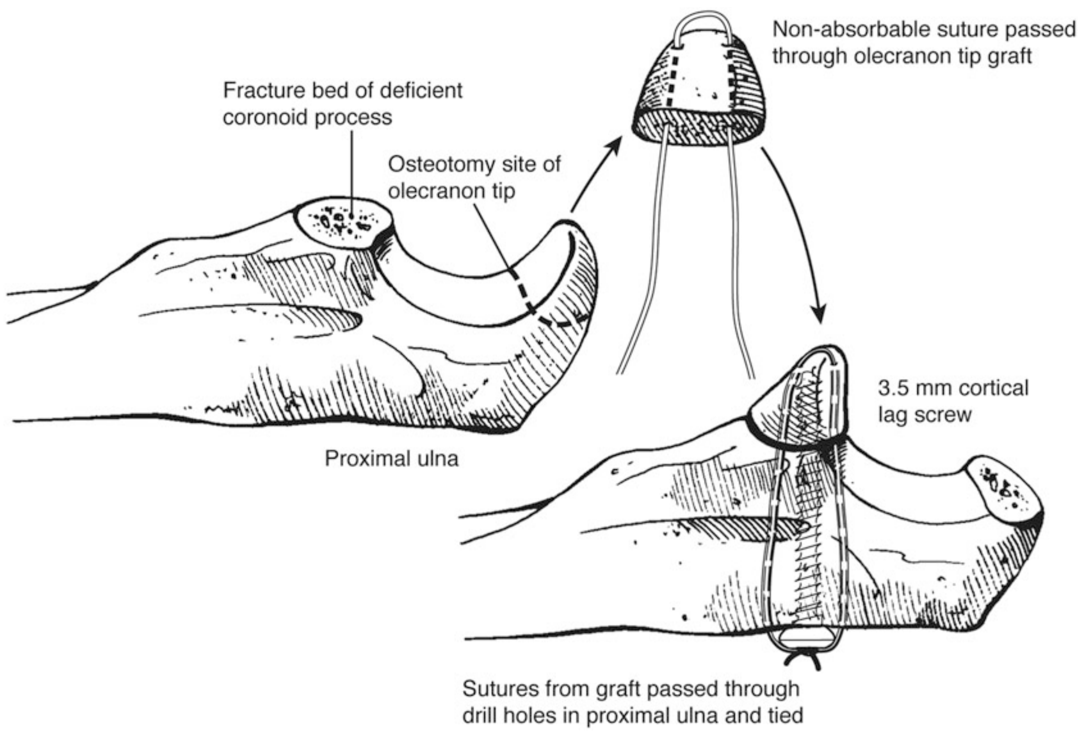

Fig. 14.8 Coronoid reconstruction utilizing the ipsilateral olecranon tip for a graft source

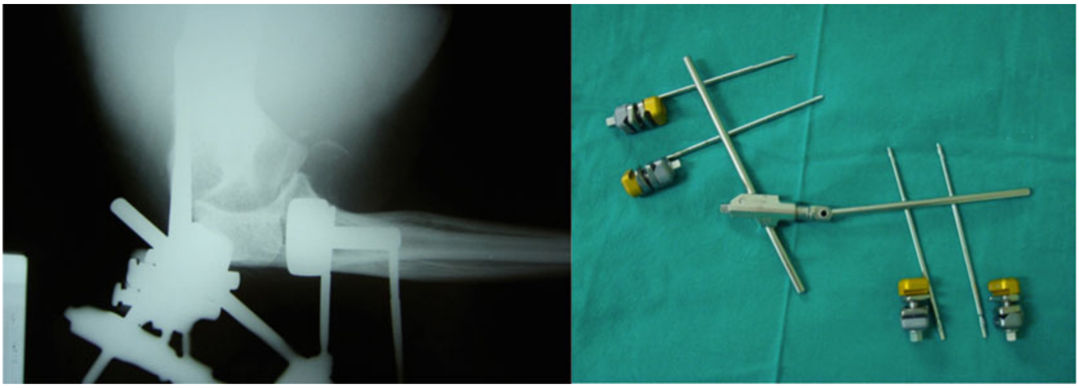

Fig. 14.9 Patient with persistent elbow instability in Fig. 14.7 treated with radial head replacement, and ligament repair. Intraoperatively the elbow would not be completely stabilized and a static external fixation was placed for 2 weeks. After 2 weeks the external fixator was dynamized to allow motion and kept for 6 weeks

prostheses available for clinical use although reports of custom implants have been made in few case reports.

External Fixation

Hinged external fixation is useful to maintain a concentric reduction in difficult cases. It allows concentric reduction during active or passive range of movement. It is indicated in cases with poor internal fixation and in cases that may require capsulotomy (Fig. 14.9). The most common complications are pin tract infection and pin failure. We recommend using the hinged external fixation in light distraction and to allow progressive ROM in an effort to balance stiffness and stability with mobility. Static external fixation can also be utilized in cases of tenuous fixation where stability is at risk. Static external fixators allow early healing in a reduced position and are typically removed at 4–6 weeks to then allow therapy to restore range of motion.

Published Outcomes and Complications

In 1998, McKee et al. [31] reported 16 cases of unstable fracture-dislocations after previous treatment. They performed ligament reconstruction and hinged external fixation with an average 5 weeks elapsed between date of primary injury and reconstruction. The mean Mayo Elbow Performance Score (MEPS) was 84 and average ROM was 105°. They had one patient with residual instability. One patient had and infection, and another had pin failure with infection.

In 2004, Ring et al. [26] reported 13 cases of persistent ulnohumeral instability after a fracture-dislocation of the elbow with adequate articular surfaces and stable alignment of the olecranon. The patients were treated with a hinged external fixator, reconstruction of the coronoid process and radiocapitellar joint and lateral collateral ligament repair. Seven patients had a terrible triad injury pattern and six had a posterior Monteggia injury pattern. The average time to surgery after index injury was 11 weeks. They performed radial head arthroplasty in 11 patients, reconstruction of the coronoid with radial head autograft in six patients and lateral soft tissue repair in 11 patients. All required hinged external fixation. The mean MEPS was 89 and flexion-extension ROM was 99°. Complications included four pin tract infections and three contractures that needed release. Two elbows remained unstable.

Papandrea et al. in 2007 [1] reported 21 cases of coronoid fracture-dislocations that remained unstable after prior treatment. The mean time since previous injury was 11 weeks. They performed nine coronoid reconstructions, ten LUCL repairs and external fixation in 16 cases. The mean MEPS was 71, and the flexion-extension ROM was 96°. Five elbows remained dislocated and three subluxated. The complication rate was 71 %: eight cases of instability, two infections and five contractures.

Authors' Preferred Treatment

Persistent elbow instability is a challenging problem. Achieving congruence and stability during the index procedure could prevent it. Surgery for persistent elbow instability is a complex procedure requiring wide surgical exposure, comprehensive understanding of elbow pathology and restoration of congruency and stability (Fig. 14.10).

If treatment is unsuccessful, we approach persistent instability as outlined in Fig. 14.11. If the duration of time from the injury to treatment is less than 4 weeks, repair of all bony and ligamentous injuries should be attempted. The coronoid process is repaired using a suture lasso technique, plate or screw fixation. The radial head is either repaired or replaced based upon fracture severity and ability to achieve stable fixation. Finally, the lateral collateral ligament complex is repaired with suture anchors or bone tunnels. If the time from injury is greater than 4 weeks, typically a lateral collateral ligament reconstruction is performed. The coronoid process fracture repair should be attempted but if irreparable then reconstruction with autograft or allograft is performed. The radial head fracture typically needs an arthroplasty at this point in time to maintain

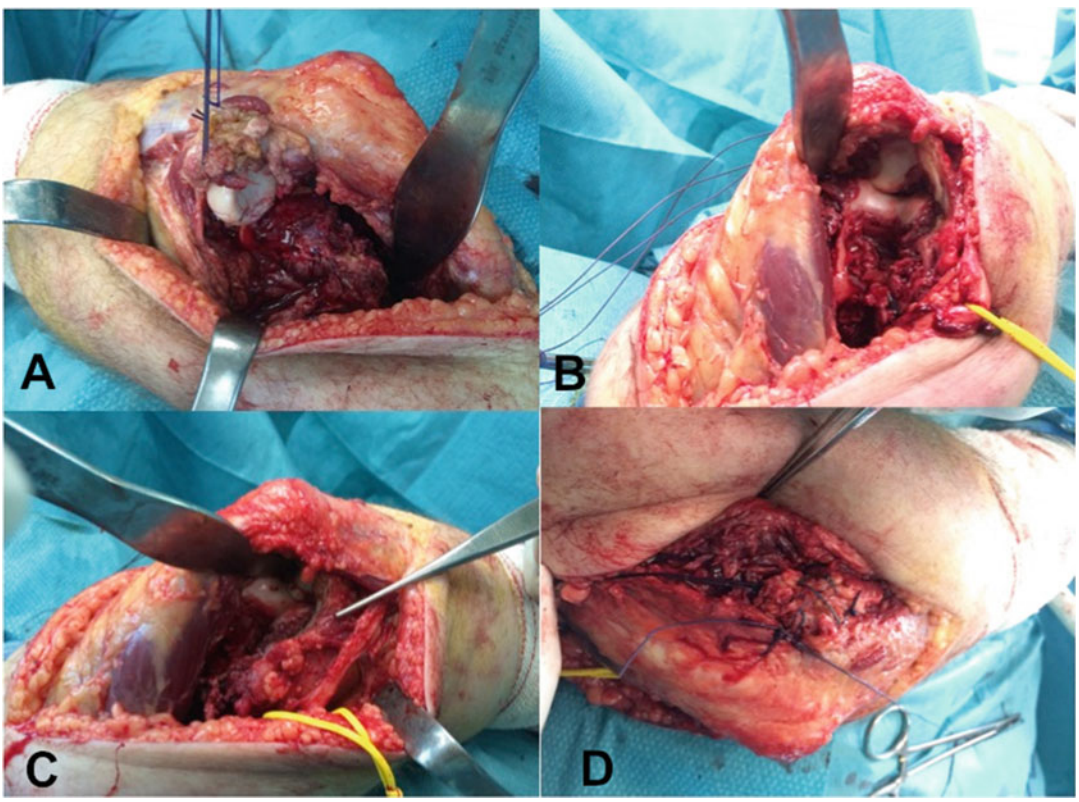

Fig. 14.10 Intraoperative pictures of a patient with a dislocated elbow treated 8 weeks after the initial injury. (**a**) The lateral compartment is seen dislocated after the lateral collateral ligament is released form the humerus and tagged for further repair. (**b**) Dislocation of the ulnohumeral joint is obvious after triceps reflection. (**c**) The medial collateral ligament is ossified and needs to be released in other to allow reduction. (**d**) After the elbow was reduced and both ligaments repaired, the joint could be stable and no further surgical treatments were necessary

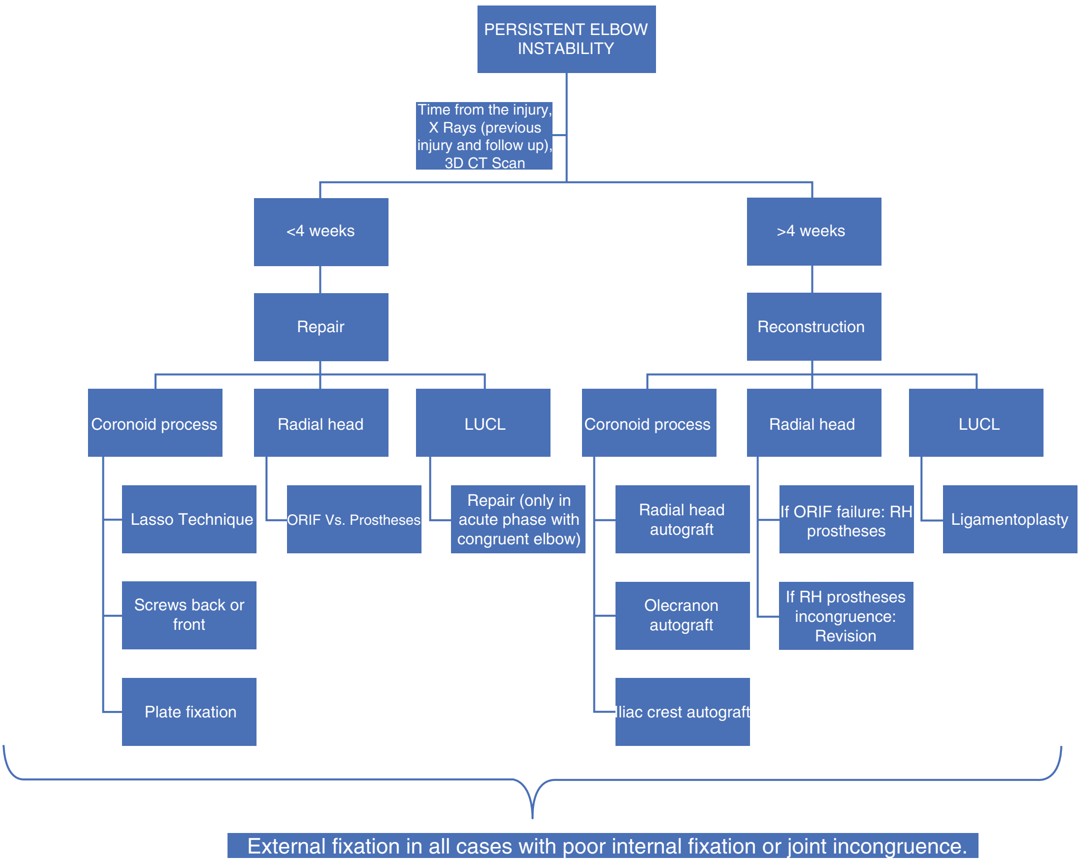

Fig. 14.11 Treatment algorithm for persistent instability

radiocapitellar joint stability. If a prior ORIF of the radial head has been performed or there is incongruence of a prior radial head arthroplasty, revision radial head arthroplasty achieving a congruent radiocapitellar joint is recommended. Finally, lateral collateral ligament reconstruction is typically required in the setting of a ligament injury older than 4–6 weeks. In both early (<4 weeks) and delayed (>4 weeks) treatment if internal fixation is tenuous or there is persistent subluxation, an external fixator should be placed to restore stability.

Conclusions

The management of the persistent elbow instability is challenging. The best treatment is an index procedure that addresses the instability and ensures a congruent joint. In cases of persistent instability, a systematic approach is critical. Workup always begins with a detailed history and physical exam, appropriate diagnostic imaging, including X-rays and CT. Finally, treatment should address both bony and ligamentous anatomy to restore stability and a congruent joint to prevent advancement to posttraumatic arthritis.

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