Acute Fractures in Sport: Elbow

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10.1 Epidemiology of Elbow Fractures in Sport

The elbow joint is a complex hinge joint that is made up of three distinct articulations: ulno-trochlear (between the distal humerus and proximal ulna), radio-capitellar (between the distal humerus and radial head), and the proximal radio-ulnar joint (PRUJ) (between the proximal radius and ulna). Unlike the shoulder, which is a relatively unstable ball and socket joint that relies on soft tissue restraints to provide the majority of its stability, the congruity of the elbow afford this joint a significant amount of stability. Stability of the elbow is provided by both bony and soft tissue restraints, of which both account for approximately 50% of elbow stability.

Fractures about the elbow are much less common than soft tissue injuries (ulnar collateral ligament tears, triceps tendonitis, flexor-pronator tears, etc.) in athletes [1, 2]. There are two primary etiologies of fractures about the elbow in sport: macrotrauma and overuse. Macro-traumatic injuries involve a high-energy collision of the player with another object (another player, the ground, etc.) where a tremendous amount of force is placed through the elbow. This can result in an elbow dislocation, fracture, or both. The magnitude and direction of the force play a role in the ultimate injury (rotational, bending, etc.).

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10.2 Specific Elbow Fractures in Sport

10.2.1 Distal Humerus

10.2.1.1 Epidemiology

Fractures of the distal humerus are not common in athletes. While the "thrower's fracture of the humerus" (Fig. 10.1a–d) has been previously described as a spiral fracture of the mid to distal third of the humerus, there is very limited literature on distal humeral fractures in athletes [3]. These fracture typically occur from a macrotrauma with either a rotational or bending moment that causes the humerus to fail. The fracture pattern is dictated by the imparted force with spiral fractures seen in rotational injuries and transverse fractures seen following a bending moment.

10.2.1.2 Diagnosis

Diagnosis of distal humeral fractures is made from history and physical exam. The history can involve a trauma of an opponent landing on the patient's arm, the patient falling onto an outstretched arm, or the patient hearing a crack when throwing a baseball or other overhead object. Aside from associated pain, there may be paresthesia in the hand from nerve injury, especially to the radial nerve. A physical exam is undertaken, although this can be somewhat limited, due to the patient's pain. A complete neurovascular exam is performed to rule out any associated nerve injury. It is imperative to evaluate the radial nerve: this can be injured either from the trauma or swelling, or from a fracture where the nerve is interposed between the fragments (Holstein–Lewis fracture). Often there will be swelling and tenderness around the fracture site. Wrist motion should be pain free, but elbow motion is often painful. Radiographs of the elbow including an anteroposterior (AP), lateral (Fig. 10.1e, f), and oblique are ordered. These will often show the fracture. However, if there is any question of fracture extension intra-articularly, a computed tomography (CT) scan of the elbow is ordered with 3D reconstructions (Fig. 10.1g). The CT scan can also

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help with fracture pattern recognition and to look for any areas of comminution.

10.2.1.3 Classification

There are several classification systems for distal humeral fractures including Jupiter, Milch and AO/OTA. The AO/OTA is one of the most commonly utilized classification systems and classifies these fractures into 3 types: Type A—extra-articular: (supracondylar fracture); Type B—intra-articular—single column fracture; Type C—intra-articular—both medial and lateral columns are fractured (i.e. the joint is not contiguous with the shaft) [4].

10.2.1.4 Treatment

Treatment of distal third humeral fractures is based on fracture alignment and timing of return to sport (RTS). If a patient suffers a spiral distal humeral fracture that is well aligned, this fracture can often be treated effectively in a Sarmiento brace. However, if the fracture is not well aligned or the athlete needs to return to sport more expeditiously, then the fracture can be fixed with open reduction internal fixation (ORIF) (Fig. 10.1e–j). The authors will offer athletes the option of operative fixation if they wish to RTS more quickly than can be achieved with non-operative management. While a humeral nail can be used in some fracture patterns, we do not commonly treat our athletes with a nail for fear of injury to their rotator cuff and the potential for subsequent post-operative shoulder pain. When performing an ORIF for distal humeral fractures, the location of the fracture often dictates the surgical approach. If the fracture extends proximally, then an anterolateral approach is often required. However, if the fracture is isolated to the distal third of the humerus, a posterior approach is often used to gain access to the fracture. Similarly, if the fracture extends into the joint, a posterior approach is used, most commonly with an olecranon osteotomy. There are several approaches to the posterior

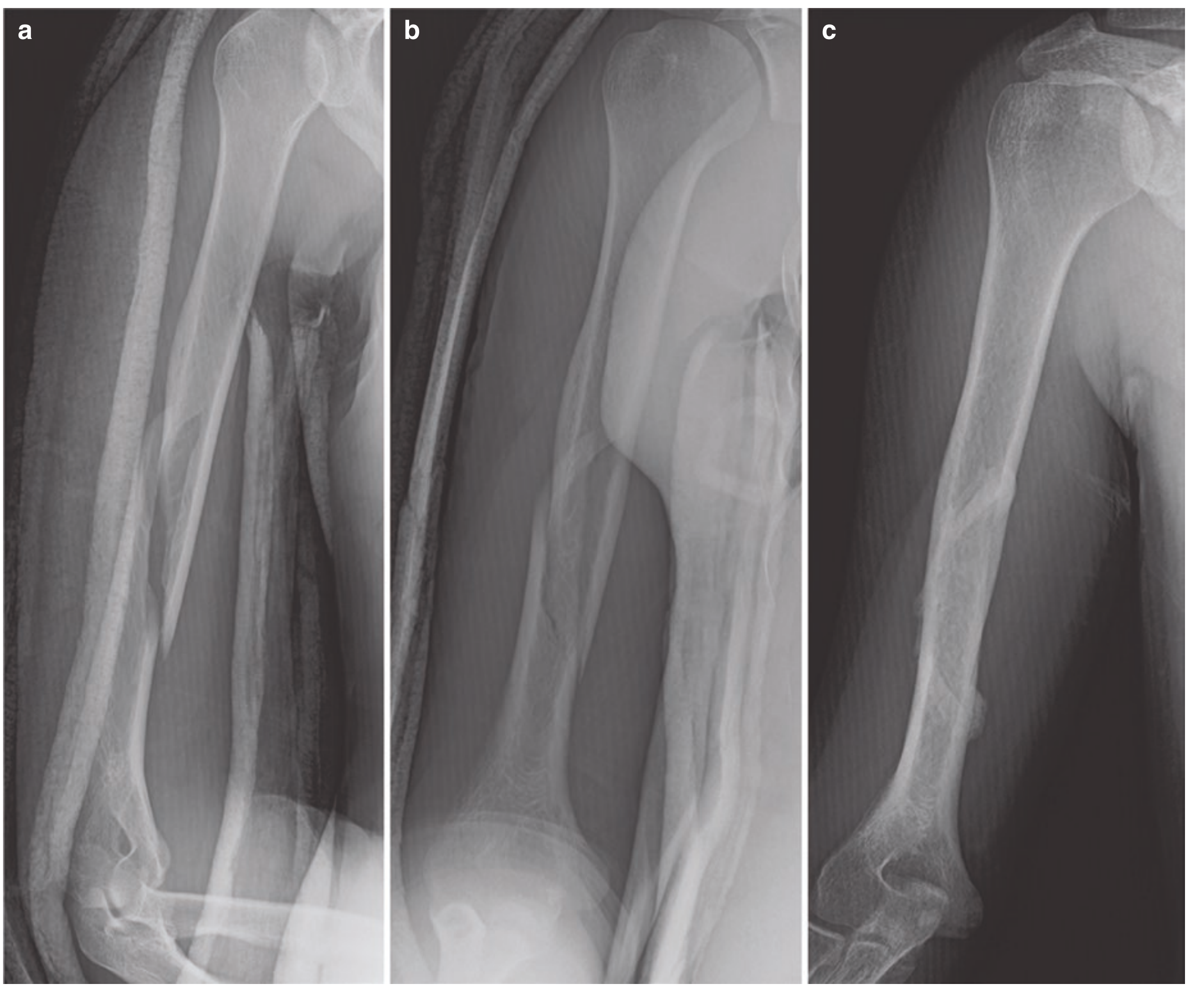

Fig. 10.1 (**a**–**d**) Radiographs of a 25 year old male who sustained a mid to distal third spiral humeral shaft fracture while throwing a baseball at initial presentation (**a**, **b**) and after 10 weeks of conservative treatment (**c**, **d**). (**e**–**j**) Images of a 16 year old male who sustained a distal humeral fracture after landing on his arm during a lacrosse game. (**e**, **f**) Are the radiographs at initial presentation that demonstrate the distal third humeral fracture, while **g** is the 3D reconstruction of the elbow CT that was obtained to ensure the fracture did not extend into the joint. Figures **h**–**j** are radiographs following open reduction internal fixation at 3 month follow-up demonstrating union of the fracture

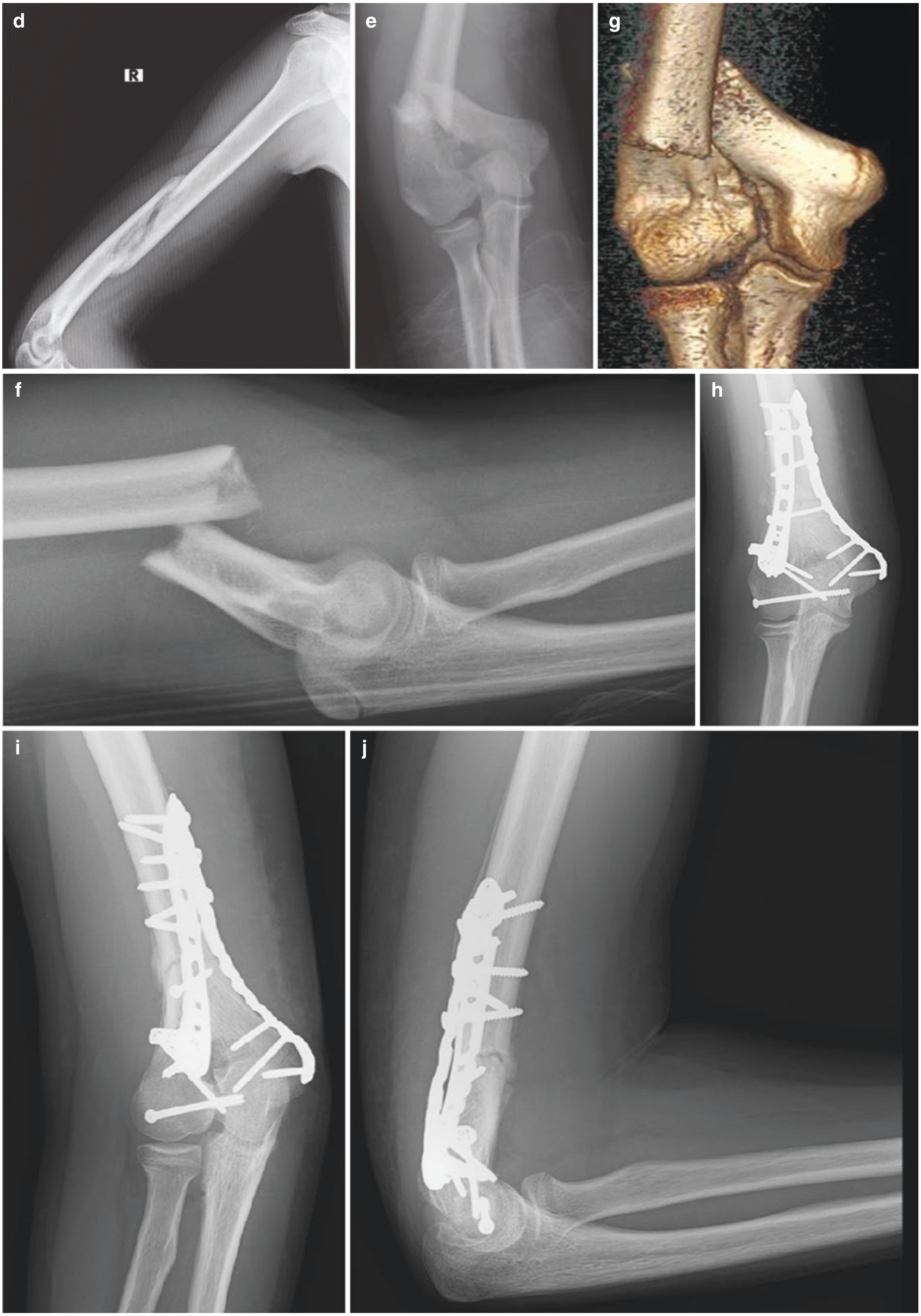

Fig. 10.1 (continued)

humerus, including a triceps split, para-tricipital and others. The surgeon should use the approach with which they are most comfortable when performing an ORIF of the distal humerus.

10.2.1.5 Rehabilitation

This involves a brief period of protection and immobilisation followed by elbow and shoulder ROM. Stiffness can be a problem in these athletes, so a balance between immobilisation to allow fracture healing and mobilization to prevent stiffness is extremely important. No lifting with the injured upper extremity is permitted for the first 6 weeks while the fracture unites. During this period the athlete is encouraged to work out their legs as well as work on their shoulder and hip range of motion and core strength. Once the fracture has healed, a gentle strengthening program is begun followed by a sport-specific return to play program. Athletes who compete in contact or collision sports (American football, rugby) are often able to RTS faster than overhead athletes as the stress placed on the elbow by an overhead athlete is more significant than that of a contact athlete.

10.2.1.6 Complications

Depending on the fracture pattern and treatment, patients with distal humeral fractures are at risk for non-union, malunion, nerve injury (either from the fracture or iatrogenically at the time of surgery), or elbow stiffness depending on the exact fracture. Hardware here is typically not symptomatic unless it encroaches into the joint, or in the case of plating the olecranon for an olecranon osteotomy. If symptomatic, this hardware can be removed after a minimum of 6 months if the fracture has successfully united. However, the athlete must be held out of competition following hardware removal, to prevent a fracture through one of the screw holes while these consolidate.

10.2.2 Medial Epicondyle Fractures

10.2.2.1 Epidemiology

Medial epicondyle fractures are most commonly seen in overhead athletes (typically pitchers) and gymnasts, as the amount of stress placed across the medial epicondyle with activities in these sports is significant [5, 6]. These injuries can often be separated based on the status of the medial epicondylar growth plate, which commonly fuses around age 14–18, and is typically the last growth plate of the elbow to fuse. The growth plate commonly fuses at an earlier age in females than males, as females often reach skeletal maturity at a younger age. Athletes who are still growing, and whose medial epicondyle growth plate has not yet closed, are susceptible to apophysitis and avulsion injures of the medial epicondyle, with repeated valgus stress of the elbow. Skeletally mature athletes, however, can injure the medial epicondyle with an elbow subluxation/dislocation or following surgery (medial epicondyle fracture following ulnar collateral ligament reconstruction (UCLR)) [7–10]. Medial epicondyle fractures account for approximately 10–20% of all elbow fractures in adolesscents and adults [11].

10.2.2.2 Diagnosis

Athletes who present with a medial epicondyle fracture will often complain of pain in and around the medial elbow, that is exacerbated by passive wrist extension and forearm supination, and active wrist flexion and forearm pronation. The injury often occurs as an acute, traumatic event in which the player felt a “pop”: report of increasing pain around the medial epicondyle secondary to repetitive valgus loads over time, should raise the suspicion of a medial epicondylar stress fracture. It is important to ask the patient if they have any ulnar nerve symptoms such as numbness/tingling on the pinky or ulnar half of the ring finger, or weakness of their hand. This can indicate involvement of the ulnar nerve, which will influence how these injuries are treated. On inspection there may or may not be bruising present around the medial elbow depending on the chronicity of the injury. On palpation, pain should be located to the medial elbow, specifically on the medial epicondyle. The elbow should be meticulously palpated to ensure there are no other sites of tenderness, such as along the course of the ulnar collateral ligament. Range of motion of the elbow is first assessed including flexion/extension and forearm supination/pronation. Stress placed across the medial epicondyle will cause pain, so exam maneuvers that stretch or activate the common flexor-pronator mass will be uncomfortable for the patient. Similarly, a moving valgus stress test or ‘milking’ maneuver will often cause pain in these athletes as these maneuvers impart significant stress on the medial elbow. A neurovascular exam, focused on the ulnar nerve, including ulnar nerve compression test at the elbow, Tinel’s testing at the elbow, ulnar nerve instability assessment, and testing for weakness of the first dorsal interosseous is critical to document any ulnar nerve deficit.

10.2.2.3 Classification

Once the exam is complete, radiographs of the elbow including an anteroposterior (AP), oblique, and lateral views are obtained (Fig. 10.2a–c). In skeletally immature individuals it is helpful to X-ray the contralateral, uninjured elbow as a baseline to determine the normal radiographic anatomy for that particular patient’s elbow. Depending on the severity of injury, the radiographs can be normal, can show widening of

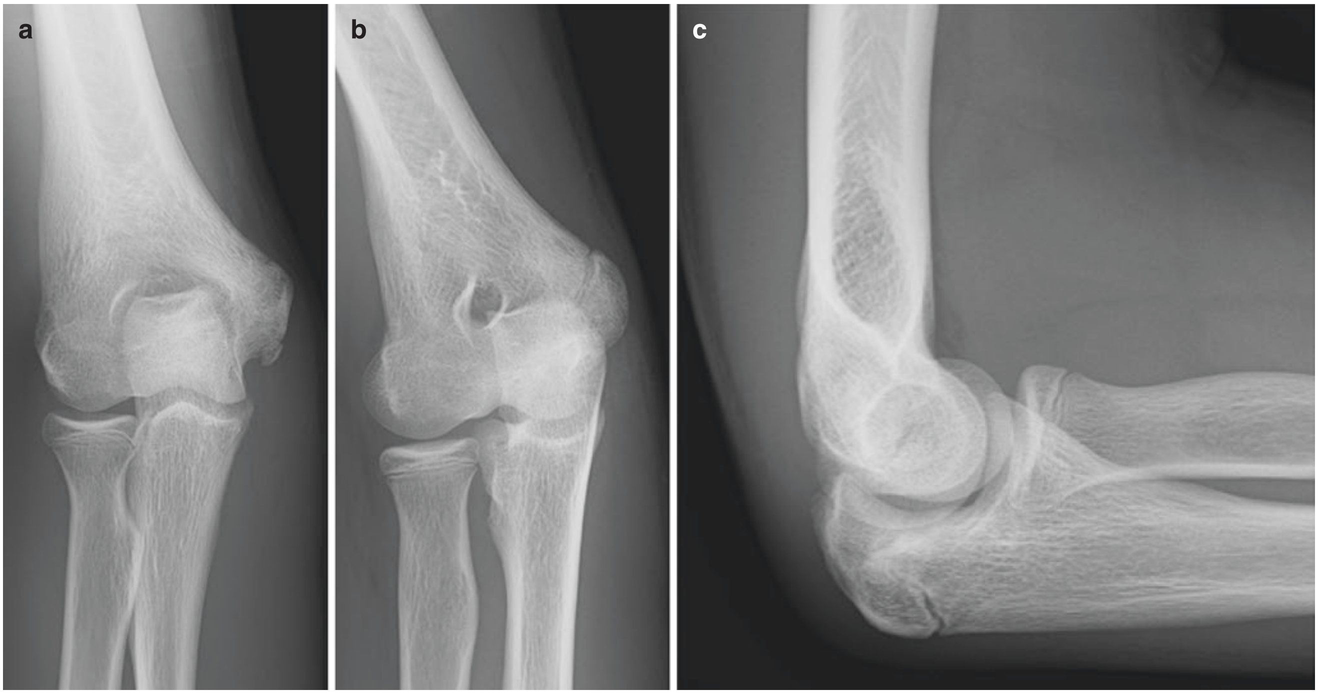

Fig. 10.2 (**a**–**c**) Anteroposterior (**a**), oblique (**b**), and lateral (**c**) radiographs of the elbow of a 15 year old male. Several of the growth plates are still open. There is also evidence of a calcification within the proximal aspect of the ulnar collateral ligament

the medial epicondyle physis, or can show a discrete fracture through the medial epicondyle with displacement. A magnetic resonance imaging (MRI) can be obtained in patients with normal X-Rays who have a suspected medial epicondyle fracture. If positive, the MRI will show edema within the medial epicondyle and possibly a discrete fracture line. The MRI is also useful to rule out other pathologies within the elbow including injuries to the flexor pronator mass, ulnar collateral ligament (UCL), cartilage, and others.

10.2.2.4 Treatment

Treatment of these injuries is based on the severity of the injury as well as the athlete's activity level and sport. For skeletally immature patients with a minimally displaced fracture of the medial epicondyle on MRI, but no significant (<5 mm) widening of the physis on X-Ray, conservative management with a period of rest and immobilisation followed by regaining range of motion (ROM) and strength, and finally a RTS program [12, 13]. These injuries are most common in baseball players, and a 4–6 week shutdown period with no throwing followed by a return to throwing program once the elbow is asymptomatic is often effective in allowing these athletes to RTS. When there is more than 10 mm of widening of the medial epicondyle physis in an overhead athlete, these players often benefit from open reduction internal fixation (ORIF) of the fracture [14]. There are several techniques for fixation of the fracture fragment, including cannulated screws, tension band, suture anchors, and others (Fig. 10.3a–d). The fracture often translates anterior and distal, so fluoroscopy is helpful to evaluate and confirm the reduction before the fracture is fixed. We typically use one or two cannulated screws provided the fracture fragment is large enough to afford fixation without splintering. It is imperative to identify and protect the ulnar nerve when preforming this surgery, to prevent any damage to this critical structure.

Finally, in older athletes who have a history of an UCLR, a fracture through the humeral drill tunnel can occur, especially if the tunnel was created too medial (close to the medial cortex). These injuries are significant and often warrant surgical intervention with ORIF using a cannulated screw or suture anchors.

A recent study evaluated medial epicondyle fractures in professional baseball players using the major league baseball (MLB) injury tracking system [9]. In total, 15 professional baseball pitchers underwent open reduction internal fixation for a medial epicondyle fracture between 2010–2016. All of these players had a history of UCLR and the majority of these players were starting pitchers (80%). Overall 55% were able to RTS at the same or higher level, and for players who were able to RTS, their performance upon RTS was not significantly different from that of a matched control group or compared to their own pre-operative performance.

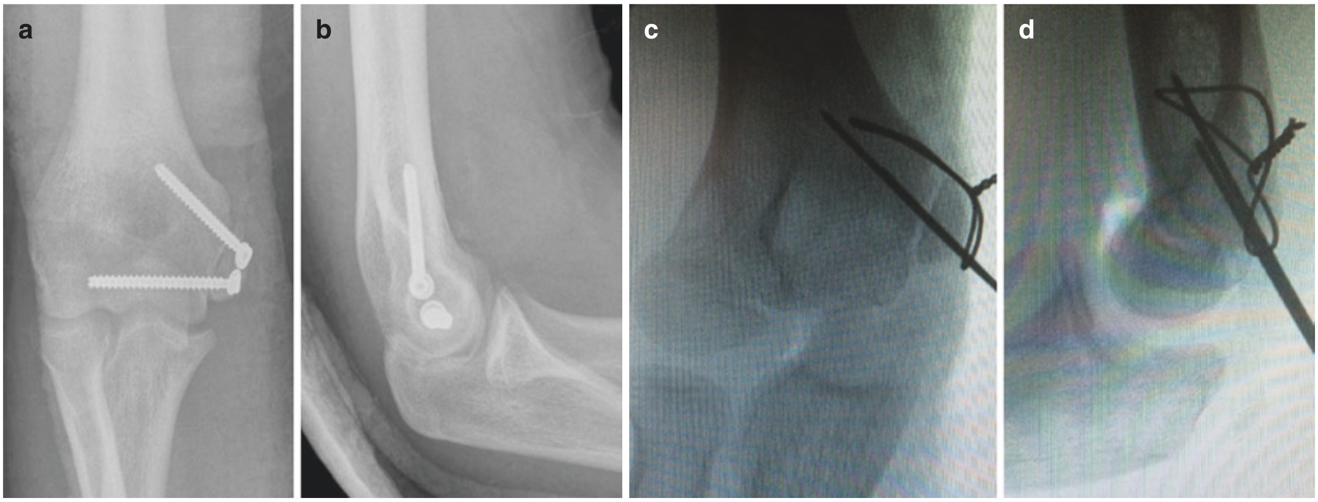

Fig. 10.3 (**a**–**d**) Anteroposterior (**a**) ad lateral (**b**) radiograph following open reduction internal fixation of a displaced medial epicondyle fracture in a skeletally immature adolescent baseball player using a two screw construct. Anteroposterior (**c**) and lateral (**d**) radiograph following open reduction internal fixation of a medial epicondyle fracture in a skeletally immature baseball player using a tension band construct

10.2.2.5 Rehabilitation

Rehabilitation following non-operative and operative treatment of medial epicondyle fractures is specific to each patient. A brief period of immobilisation is typically afforded (7–10 days) followed by controlled elbow movement. Strengthening is started after fracture healing has occurred and timing of return to sport is based on the particular sport (shorter time for contact athletes, longer time for overhead athletes).

10.2.2.6 Complications

While patients who undergo ORIF of the medial epicondyle fracture typically do well, there are several complications that can occur. Non-union or mal-union of the fracture, infection, hardware irritation, failure of the construct, and ulnar nerve irritation are all potential complications following ORIF of the medial epicondyle. Treatment of each complication is on an individual basis.

10.2.3 Isolated Elbow Dislocations

10.2.3.1 Epidemiology

Simple or isolated elbow dislocations make up approximately 10–25% of elbow injuries [15]. Simple elbow dislocations involve a dislocation of the ulnohumeral and radiocapitellar joint without an associated fracture. These injuries are commonly seen from a fall onto an outstretched hand, with a load placed on the athlete while falling. There is often a valgus load with some hyperextension, that causes the elbow to dislocate. This causes varying degrees of injury to the lateral ulnar collateral ligament (LUCL), elbow capsule, medial ulnar collateral ligament (UCL), and other structures. While isolated elbow dislocations do not involve an associated fractures, studies have found that nearly 100% of elbow dislocations result in some form of osteochondral injury [16].

10.2.3.2 Diagnosis

The diagnosis of a simple elbow dislocation is often made by history, physical exam, and radiographic imaging. If the physician is covering a game and a player dislocates his or her elbow, or the physician is called to the emergency department to review a player because of an elbow deformity, the diagnosis is often obvious. There will be a deformity to the elbow, with significant pain on any attempted elbow movement. It is extremely important to assess neurovascular status of the extremity both before and after reduction. Radiographs confirm the diagnosis and the elbow is reduced in a timely manner. If the athlete presents to the office, the elbow has typically already been reduced and the diagnosis is made by history as well as prior radiographs. Physical exam following reduction of an elbow dislocation should determine the position of stability for the elbow (the amount of extension where the elbow becomes unstable), as the elbow should be protected from this range of motion initially. Finally, the physician should also examine the shoulder and wrist for any concomitant pathology.

10.2.3.3 Classification

As simple elbow dislocations do not involve a fracture, these injures are classified based on the direction of the elbow dislocation. Posterolateral dislocations are the most common direction of dislocation.

10.2.3.4 Treatment

The mainstay of treatment for isolated elbow dislocations is brief immobilisation followed by early range of motion. Prolonged immobilisation has been shown to have poor outcomes [15]. The elbow is most stable in flexion and least stable in extension, so the elbow should be splinted in 90° of flexion to begin with for approximately 10 days. The splint can be changed to a hinged elbow brace or removable splint that allows complete flexion but prevents extension to the point of instability for the next 2–3 weeks. Once the elbow has become stable, full extension can be allowed, as long as there is no evidence of instability. Full ROM should be achieved at the 4–6 week mark. While surgery is uncommon in these patients, if the elbow does not remain concentrically reduced, or if the elbow is not stable at 50° of extension or less, repair of the UCL and LUCL is recommended.

10.2.3.5 Rehabilitation

Rehabilitation following simple elbow dislocations is based on the stability of the joint. The more stable the joint, the more aggressive the rehabilitation can be. Following the initial period of immobilisation, therapy is initiated to help the patient regain full ROM while avoiding any positions of instability. Once ROM is achieved at the 4- to 6-week mark, gentle strengthening is begun with the elbow at the side. Varus and valgus stress on the elbow is avoided for at least 8–10 weeks.

10.2.3.6 Complications

Elbow stiffness is the most common complication that occurs following elbow dislocation. This may necessitate an arthroscopic or open elbow release, if a functional ROM cannot be achieved. Persistent elbow instability requiring UCL or LUCL repair is a possible complication as well. Finally, delayed instability, such as posterolateral rotatory instability, is a potential complication. This may require a LUCL reconstruction in the future, if the athlete complains of persistent elbow discomfort or a sense of instability.

10.2.4 Fracture Dislocations of the Elbow

10.2.4.1 Epidemiology

Elbow instability injuries have been reported to occur at an incidence of 0.04 per 10,000 athlete exposures (i.e. one athlete participating in one game or practice session, regardless of time duration, within which they are exposed to a risk of sport-related injury) [17]. While most of these are simple dislocations (i.e. do not involve a concomitant fracture), an associated fracture is seen with elbow dislocations in approximately 26% of cases [18, 19]. The treatment of complex elbow dislocations varies greatly from simple dislocations.

10.2.4.2 Diagnosis

Similar to a simple elbow dislocation, the diagnosis is made via history, exam, and radiographs. Acutely there will be a significant deformity present, with radiographic evidence of the dislocation. However, unlike simple elbow dislocations, an associated fracture about the elbow is often appreciated. The mechanism of injury (axial load, valgus stress, direct impact, etc.) will often determine the associated fracture. While the associated fracture may not be clearly visible on initial radiographs, advanced imaging in the form of a CT scan can be useful to identify and characterize the fracture. As before, a thorough exam of the entire upper extremity is necessary including a complete neurovascular exam and an exam of the shoulder and wrist to rule out concomitant pathology.

10.2.4.3 Classification

Complex elbow dislocations are classified by the direction of the dislocation as well as the associated fracture. The associated fracture of the proximal radius or proximal ulna can be further classified using the AO classification system. Fractures of the radial head and neck region can be classified as complete articular, partial articular, or extra-articular. The extra-articular radial fractures can be divided into avulsion of the bicipital tuberosity, simple radial neck, multi-fragmentary radial neck. The partial articular radial fractures can be divided into simple and fragmentary. The complete articular radial fractures can be divided into simple and multi-fragmentary. The extra-articular proximal ulnar fractures can be divided into avulsion of the triceps insertion, metaphyseal simple fracture, and metaphyseal fragmentary fracture. The partial articular proximal ulnar fractures can be further divided into olecranon and coronoid fractures. The complete articular fractures are divided into coronoid and olecranon fractures, that are simple, multi-fragmentary involving the olecranon, or multi-fragmentary involving coronoid process. Finally, coronoid fractures can be classified based on the size of the fragment where a type I involves avulsion of the tip of the coronoid, type II involves a single or comminuted fragment of 50% of the process or less, and type III involves a single or comminuted fragment involving more than 50% of the coronoid process [20, 21].

10.2.4.4 Treatment

Treatment of complex elbow dislocations is based on the associated fracture pattern. A complex elbow dislocation with an isolated non-displaced radial head fracture or isolated small coronoid fracture can be managed non-operatively. However, this injury pattern is rare. More commonly these injuries involve olecranon fractures, communited radial head fractures, or large coronoid fractures. In these cases, surgical intervention is required for reduction and stabilization of the fracture and repair of the lateral collateral ligament (LCL).

The elbow is commonly approached from the lateral side, unless there is a concomitant olecranon fracture. The olecranon is often reduced and plated with a posterior plate, while treatment for the coronoid and radial head is more variable. Coronoid fractures can be treated with suture lasso fixation or lag screws depending on the size of the fragment [22]. Radial head fractures can be treated with ORIF or radial head replacement, with radial head replacement reserved for older individuals or in the setting of significant comminution (more than 3–4 fracture fragments) [23–25].

10.2.4.5 Rehabilitation

Rehabilitation following surgical intervention is often dictated by the type of surgery performed. If an ORIF of the olecranon or radial head was performed, these structures must be protected in the initial rehabilitation phase. Conversely, if a radial head replacement was performed, the rehabilitation program can be slightly more aggressive with ROM. Regardless, rehabilitation is a balance between allowing the surgically repaired structures to heal, while attempting to minimize concomitant stiffness of the elbow. Once the patient has regained full ROM, a strengthening program is regularly initiated at the 8-week mark, followed by sport specific training.

10.2.4.6 Complications

The most common complications following major trauma to the elbow are stiffness and post-traumatic arthritis [26, 27]. Symptomatic hardware, infection, and wound issues can also be seen in the patient population. Specific complications are often dictated by the fracture pattern and are discussed in the individual sections of the text involving isolated fractures.

10.2.5 Olecranon Fractures

10.2.5.1 Epidemiology

Olecranon fractures are relatively uncommon injuries in the overall athletic population and can occur from acute, traumatic injuries or, more commonly, from repetitive overload leading to a stress fracture. In the athlete, acute olecranon fractures most commonly occur following a fall onto the elbow [28]. Acute sport-related olecranon fractures have an incidence of 0.01 per 1000 general population [29].

10.2.5.2 Diagnosis

Athletes presenting with acute olecranon fractures will complain of pain and swelling in the elbow, with possible numbness in their hand, depending on nerve compression from the swelling, and pain with elbow movement. These injuries will often occur from either a direct blow to the posterior elbow or a fall on an outstretched hand. The acute event is often accompanied by a "pop" or "crack" and significant pain. On examination, the patient will have pain with elbow flexion/extension accompanied by bruising and swelling. A detailed neurovascular exam of the injured limb is mandatory.

10.2.5.3 Classification

Radiographic evaluation begins with the standard elbow series. Acute, traumatic olecranon fractures can be classified using several different systems including the Mayo classification system, AO classification system, and many others [30]. The Mayo classification system can be divide into 3 types: Type 1: non-displaced; Type II: displaced but with a stable elbow (A = non-communited; B = communited); Type III: displaced with an unstable elbow (A = non-communited; B = communited). The AO classification system divides these fractures into three types: Type A: extra-articular; Type B intra-articular; Type C intra-articular fractures of both the radial head and olecranon [30]. In acute fractures, a computed tomography (CT) scan may be necessary to better characterize the fracture and any associated comminution.

10.2.5.4 Treatment

Treatment of olecranon fractures is dictated by patient age, type of fracture, and activity level. Acute, traumatic, displaced olecranon fractures are treated with ORIF using either a tension band or plate and screw construct. The authors typically use an olecranon specific plate to minimize hardware irritation, although in some athletes the plate is symptomatic and needs to be removed in the off-season. This is followed by a brief period of immobilisation after which supervised passive ROM is begun in an effort to prevent stiffness. Patients with non-displaced olecranon fractures, where the joint is well-aligned, can be trialed with non-operative management. This involves a posterior splint with the elbow in 45–60° for 10–14 days, followed by transition to a hinged elbow brace, with passive elbow extension and active elbow flexion. Full motion is obtained by 4 weeks, but the elbow is not loaded until 6–8 weeks depending on healing. One can consider obtaining advanced imaging with either a CT or magnetic resonance image (MRI) to verify fracture union before allowing these athletes to RTS.

A recent study evaluated 52 olecranon fractures treated with ORIF in professional baseball players between 2010 and 2016 [31]. To note, the majority of these were primary olecranon stress fractures (73%) and were treated with a single screw (60%). The authors reported an overall RTS rate of 67.5% (57.9% returned to the same or higher level of play) with no significant decline in performance upon RTS compared to a group of matched controls and to the player's individual preoperative performance. Interestingly, it took players an average of 314 days to return to their same level of play.

10.2.5.5 Rehabilitation

Following ORIF of olecranon fractures, patients are typically immobilized in a posterior moulded spin for 7–10 days. Passive elbow extension and active elbow flexion are then begun, with care taken to avoid passively hyperflexing the elbow or forcefully extending the elbow, in the immediate post-operative period. This minimizes stress on the fracture fixation. Once the fracture has healed and the patient has regained their elbow motion, a strengthening program is begun. This is followed by a sport specific rehabilitation protocol and gradual RTS. Those patients with non-displaced olecranon fractures that are managed non-operatively will remain in the splint longer as there is no hardware in place. Once ROM is regained at 4 weeks, flexor pronator strengthening is begun but no triceps strengthening is undertaken for 6–8 weeks to prevent distraction of the fracture. Once the patient has reached the 6–8 week mark, they are typically cleared to begin a RTS program.

10.2.5.6 Complications

The skin around the posterior elbow does not have a robust blood supply and there is minimal sub-cutaneous fat to protect the hardware. Hence, skin breakdown and hardware irritation are two of the most common complications following olecranon ORIF. Other complications include non-union, mal-union, loss of reduction, ulnar nerve irritation, elbow stiffness, and continued pain. Each complication is managed on a case by case basis.

10.2.6 Proximal Radius Fractures

10.2.6.1 Epidemiology

Fractures of the proximal radius are relatively common, occurring in an athlete following significant trauma. The proximal radius includes the articular surface of the radial head, the radial neck, and up to the bicipital tuberosity. The significant majority of these injuries occur at the radial head and neck region. The radial head is a component of the elbow joint, and comprises the radio-capitellar articulation. The radial head has a major role in elbow pronation and supination, and affords bony stability to the lateral aspect of the elbow joint. Injury to the radial head and neck can occur as a result of two mechanisms. The first is from an instability pattern. The radial head fracture is a component to the terrible triad injury pattern (radial head fracture, elbow dislocation, and coronoid process fracture of the ulna). The second mechanism is a direct injury with a fall or blunt trauma to the proximal radius.

10.2.6.2 Diagnosis

Patients who sustain a proximal radius fracture often present with pain and swelling at the elbow. Range of motion of the elbow is typically reduced, secondary to pain in flexion/extension, as well as supination/pronation. Often, patients are focally tender over the proximal radius. There can be associated neurological deficit on exam if there was significant trauma or substantial subsequent swelling; however, most patients who sustain these injuries are neurovascularly intact.

Radiographs of the elbow will commonly demonstrate a posterior fat pad sign, indicating intra-articular swelling. However, secondary to displacement, they do not always demonstrate the radial head/neck fracture clearly. If the radiographs are non-diagnostic and the patient demonstrates a block to motion, a CT scan is obtained to better characterize the bony anatomy of the radial head/neck region.

10.2.6.3 Classification

The Mason classification, used to classify radial head fractures, is divided into four types: Type I: Nondisplaced or minimally displaced (<2 mm), no mechanical block to rotation; Type II: Displaced >2 mm or angulated, possible mechanical block to forearm rotation; Type III: Comminuted and displaced, mechanical block to motion; Type IV: Radial head fracture with associated elbow dislocation [32].

10.2.6.4 Treatment

The treatment of radial head and neck fractures is based upon the number of articular fragments, presence of a block to motion, and overall stability of the elbow joint. Isolated radial neck fractures, and radial head fractures that are minimally displaced without a block to motion, can be treated with an early active motion protocol. Typically, these patients are placed into a sling for 2–3 days followed by immediate active and passive assisted-motion with structured physical therapy [33]. Regular flexion, extension, pronation, and supination exercises are encouraged immediately to prevent long-term stiffness.

Fractures, with a subsequent block to motion, and those that are comprised of multiple fragments can be treated with either open reduction and internal fixation or radial head arthroplasty. Ring and Jupiter have simplified treatment planning, recommending that fractures involving three or less fragments are amenable to fixation with osteosynthesis, while fractures with more than three fragments are better treated with arthroplasty [34]. Fractures of the proximal radius that occur from instability patterns of injury, such as terrible triad injuries, are commonly amenable to radial head arthroplasty. It is imperative to evaluate and treat any injuries to the LCL, as there is often an associated injury. In the athletic population there is no data to dictate whether an ORIF or radial head replacement is the preferred method of treatment. One concern with a radial head replacement is earlier wear in the athlete population and the possibility for implant loosening given the stresses they place on their elbow. It is for this reason the authors typically favor ORIF over radial head replacement, for the athletic patient, when possible.

10.2.6.5 Rehabilitation

For isolated radial head or neck fractures, rehabilitation begins with a brief period of immobilisation followed by regaining elbow ROM. Strengthening of the elbow is avoided until full elbow ROM has been achieved. The timing of RTS is based on how quickly patients regain their motion and strength, and is typically longer for overhead athletes than contact athletes.

10.2.6.6 Complications

One of the most important complications of proximal radius fractures is an acute block to elbow rotation for these patients. Many of these fractures can be managed non-operatively, but if they develop a mechanical block to motion they often necessitate surgical intervention. Patients can also develop stiffness, continued pain, or iatrogenic posterolateral rotator instability (PLRI) if they undergo an ORIF and the LUCL is damaged. The posterior interosseous nerve (PIN) is at risk during ORIF, and as such can be damaged during surgery. Furthermore, there can be post-traumatic arthritis associated with this injury pattern.

10.2.7 Radial Diaphyseal Fractures

10.2.7.1 Epidemiology

Fractures of the radial shaft are known as the "fracture of necessity" as proper length and rotation of the bone is critical for elbow and wrist function. The mechanism of injury is typically a direct blow to the forearm causing fracture of both the radius and ulna (Fig. 10.4a, b), or the radius in isolation. Due to the importance of the radial bow, and its critical involvement with forearm rotation, anatomic alignment is

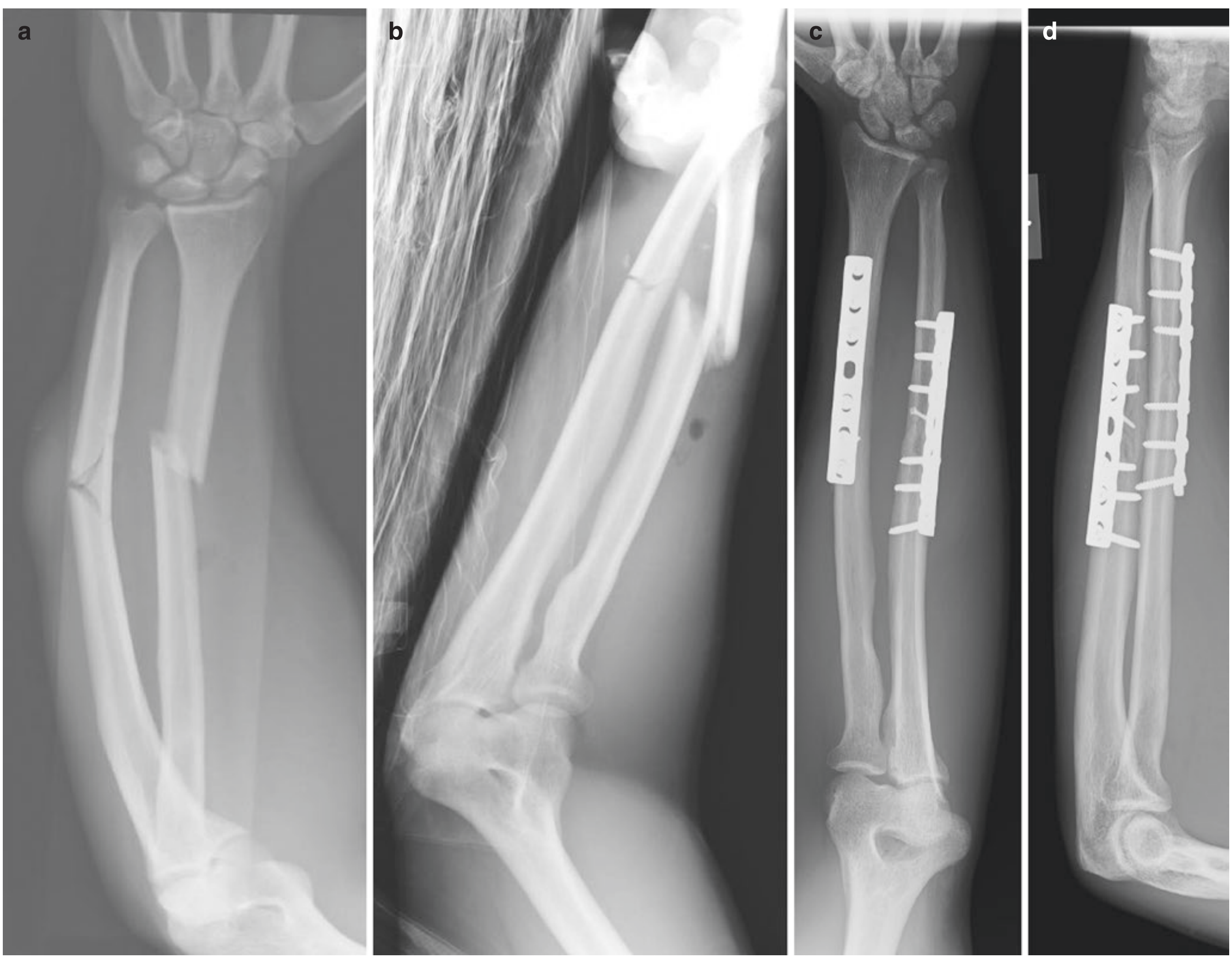

Fig. 10.4 (**a**, **b**) Anteroposterior (**a**) and lateral (**b**) views of a displaced both bone forearm fracture sustained from a sporting injury. (**c**, **d**) Anteroposterior (**c**) and lateral (**d**) views following open reduction internal fixation of a both bone forearm fracture

paramount. In addition to the bony fracture, it is important to consider the soft tissue injuries as well. Profound swelling can lead to compartment syndrome necessitating immediate release.

10.2.7.2 Diagnosis

Patients who have sustained acute radial diaphyseal fractures will present with pain and swelling in the forearm. This can be accompanied neurological symptoms in the patient's hand, secondary to the swelling. There will be tenderness around the fracture site and significant pain with forearm rotation.

It is important to consider the wrist and elbow joints when evaluating radial shaft fractures. A distal third radial shaft fracture may cause a dislocation of the distal radioulnar joint (DRUJ), known as a Galeazzi fracture-dislocation. It is important to obtain anatomic reduction and stable fixation of the fracture to establish reduction and stability of the DRUJ.

Routine x-ray assessment should image the forearm, the wrist and the elbow, to assess for concomitant proximal or distal injuries.

10.2.7.3 Classification

Classification of these fractures is largely descriptive, and should include any concomitant injuries to the elbow and/or wrist. The AO classification of radial diaphysis fractures divides these fractures into proximal, middle, and distal fractures as well as fracture type (simple, wedge, multi-fragmentary). Simple fractures can be further classified as spiral, oblique, or transverse. Wedge fractures can be further classified as intact or fragmentary wedge. Finally, multi-fragmentary fractures can be further classified as an intact segmental or fragmentary segmental fractures.

10.2.7.4 Treatment

A fracture of the radial shaft should be treated with surgical stabilization. Fixation for radial shaft fractures is typically done through plate and screw fixation using 3.5 mm compression plating systems (Fig. 10.4c, d). Other techniques do include flexible nailing in length stable fractures [35]. It is important to start early motion to avoid stiffness and contracture. The DRUJ must be evaluated at the time of surgery after the radial fracture is fixed to ensure stability. If the DRUJ is unstable, this may require temporary screw or K-Wire fixation.

10.2.7.5 Rehabilitation

Similar to previous protocols, rehabilitation comprises of an initial period of fracture immobilisation, followed by progressive ROM of the elbow, wrist and hand. This is followed by forearm strengthening and gradual RTS.

10.2.7.6 Complications

Complications include non-union, mal-union, nerve injury (specifically to the PIN and the superficial branch of the radial nerve), elbow or wrist stiffness, or hardware issues.

10.2.8 Ulnar Diaphyseal Fractures

10.2.8.1 Epidemiology

The ulnar shaft is a cutaneous bone that is palpable on the dorsal and ulnar aspect of the forearm. It is at risk to fracture when forces are aimed directly to this region. While ulnar shaft fractures are rare in the contact athlete, this patient population is at higher risk than the general population for such injuries. Some term this fracture the "nightstick" injury as this injury can occur from a direct blow to the ulna (such as when a person raises their forearm to block someone who is trying to hit them with a nightstick).

10.2.8.2 Diagnosis

Patients presenting with acute ulnar diaphyseal fractures will complain of pain and swelling in the forearm. This can be accompanied by paresthesia in the patient's hand, secondary to the swelling. There will be tenderness around the fracture site and significant pain with forearm rotation. Wrist and elbow motion may or may not be painful. X-Rays of the forearm are reviewed, and if there is any question for concomitant proximal or distal injuries, elbow and wrist films should be ordered.

10.2.8.3 Classification

Classification of these fractures is largely descriptive, and should include any concomitant injuries to the elbow and/or wrist. The AO classification for ulnar diaphysis fractures divides these fractures into proximal, middle, and distal fractures as well as fracture type (simple, wedge, multi-fragmentary). Simple fractures can be further classified as spiral, oblique, or transverse. Wedge fractures can be further classified as intact or fragmentary wedge. Finally, multi-fragmentary fractures can be further classified as an intact segmental or fragmentary segmental fractures.

10.2.8.4 Treatment

Since the ulna is a fixed structure, and remains relatively stable during pronation and supination of the forearm, not all ulnar diaphyseal fractures require operative treatment. If satisfactory fracture length, translational alignment, and rotational alignment are noted on clinical and radiological assessment (i.e. $<50\%$ translational displacement and $<10°$ of angulation), short arm splinting, short arm casting or long arm casting are acceptable means of treatment. Short arm splinting can facilitate an accelerated rehabilitation over both short and long arm casting, and should be considered. However, in the athletic population, these fractures are often fixed to allow earlier RTS. This is a shared decision between the athlete and surgeon, but if the player wished to RTS as quickly as possible, an ORIF is typically offered. If the fracture is not length stable, or significantly displaced, fracture fixation using a 3.5 mm compression technique should be performed, often with excellent results [36]. Finally, injuries to the radius and ulna can occur concomitantly with one another. When the athlete has a radius and ulna fracture, this is typically treated with open reduction and internal fixation of both fractures. The careful management of concomitant soft tissue injuries, when present, is also paramount.

10.2.8.5 Rehabilitation

The fracture is immobilized initially to allow appropriate healing. For both non-operative and operative management, short arm splinting is preferable, with gentle elbow and wrist motion exercises commenced, as early as possible to prevent stiffness. Graduated progression is then made towards strengthening as fracture healing permits. This is followed by sport-specific rehabilitation exercises with a gradual RTS.

10.2.8.6 Complications

Patients with operatively-managed ulna fractures are at risk for non-union, mal-union, construct failure, fracture proximal or distal to the plate, hardware irritation (necessitating future hardware removal) or tendon irritation from the plate. Those patients treated conservatively are at risk for loss of reduction, non-union, and mal-union. Typically, ulnar shaft fractures are treated conservatively if there is<50% displacement and <10° of angulation. Hence, if subsequent X-rays demonstrate an increase in angulation or displacement, these fractures may need operative intervention, as their risk of non-union or mal-union, with secondary displacement, is significantly increased.

10.3 Preventative Measures

Prevention of fractures about the elbow in sport is difficult. There are many sports where fractures about the elbow occur from a macro-traumatic events. In these instances, the injuries cannot usually be prevented. Maintaining a proper strengthening program in these athletes and encouraging a complete diet to augment bone health is the mainstay for prevention. Proprioceptive training programs in which the players learn how to take a hit, and how to properly land once they are hit, may be beneficial although further studies are needed in this area. There is no evidence to recommend the use of protective equipment for the athlete to reduce the incidence of fractures about the elbow.

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