Radial Head Fractures

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Radial head fractures account for approximately one third of fractures about the elbow and are the most common elbow fracture in the adult population [1,2]. Radial head fractures account for 1.7% to 5.4% of all adult fractures [3]. Approximately 85% of these fractures occur in young, active individuals ranging in age from 20 to 60 years old. Radial head fractures may occur in isolation or may be part of a more extensive elbow injury. In elbow dislocations, a radial head fracture is commonly associated with other injuries including medial collateral ligament (MCL) rupture, olecranon fracture, and/or coronoid fracture. Therefore, the elbow must be carefully evaluated to rule out associated ligamentous and bony pathology.

Radial head fractures most commonly result from a fall onto the outstretched hand with the elbow slightly flexed and the forearm in a pronated position. They may also occur from direct trauma or as a component of high-energy trauma. Biomechanical studies have demonstrated the greatest amount of force is transmitted from the wrist to the radial head when the elbow and forearm are oriented in a slightly flexed and pronated position. During a fall, the body rotates internally on the elbow; the weight of the body contributes an axial load to the radius, and a valgus moment is applied to the elbow since the hand becomes laterally displaced from the body. The resultant combination of axial, valgus, and external rotatory loading mechanisms forces the anterolateral margin of the radial head to come into contact with the capitellum, resulting in a fracture of the radial head and/or capitellum.

Our ability to fix and reconstruct the fractured radial head has greatly improved over the past 2 decades. Historically, treatment consisted of radial head excision or nonoperative management with immobilization. Substantial research on the anatomy, biomechanics, and fracture management ensued. We have gained an appreciation for the role of the radial head in providing stability to the elbow, forearm, and wrist. The advent of further treatment options and management has improved patient outcomes for this common fracture.

Classification and treatment

Mason [2] provided the initial classification of proximal radius fractures. Hotchkiss [4] provided a management-based modification to Mason’s original classification (Box 1). Ultimate treatment decisions should factor fracture size, displacement, location, and block of elbow motion, bone quality, and ligamentous stability.

Type I fractures include nondisplaced or minimally displaced fractures of the head and neck, fractures with intra-articular displacement of less than 2 mm, or marginal lip fractures. There should be no mechanical block to forearm rotation; however, rotation may be limited by acute pain and swelling. To assess actual mechanical block, the elbow hemarthrosis should be aspirated and the joint injected with local anesthetic (ie, lidocaine). This will allow assessment of elbow flexion, extension, and rotation, and will improve patient comfort allowing for earlier range of motion. The mainstay of treatment of Type I fractures involves nonoperative measures that encourage early elbow and forearm range of motion. The arm is placed into a sling for comfort and the patient is instructed to begin active and...
passive range of motion as tolerated within 7 days. Protected weight bearing of the upper extremity for a period of 6 weeks is encouraged to prevent fracture displacement. Weekly radiographs are obtained to assess possible fracture displacement. If fracture displacement subsequently occurs, open reduction internal fixation (ORIF) is indicated. Good to excellent results are expected in most Type I fractures managed nonoperatively with a program of early elbow and forearm range of motion.

Type II fractures include displaced (usually >2 mm) fracture of head or neck, may have mechanical block to motion, or be incongruous, without severe comminution (technically possible to repair by open reduction and internal fixation), more than a marginal lip fracture of the radial head. Stability and range of motion can be assessed by intra-articular hematoma aspiration and anesthetic injection, followed by motion assessment or by performing elbow arthroscopy with intraoperative motion assessment under direct visualization. Controversy exists regarding the optimal treatment of Type II fractures and most would agree no single treatment is universally applicable to this fracture type. A recent retrospective review noted good to excellent results at long-term follow-up of patients with Type II radial head fractures treated nonoperatively [5]. Nonoperative management of Type II fractures can be considered if elbow stability is not dependent on fracture fixation and no block to elbow motion is present. Other data suggest that ORIF should be reserved for minimally comminuted fractures with three or fewer articular fragments [6]. The ability to fix comminuted fractures has improved with smaller plates and self-tapping cannulated screws. Therefore, some mildly comminuted fractures previously classified as Type III are now fixable and therefore considered Type II. Recently, a group described the surgical technique of comminuted fracture fixation and found improved motion and function compared with those who underwent excision [7]. Whether these comminuted fractures treated with ORIF, rather than excision and arthroplasty, will result in better outcomes remains to be investigated. Furthermore, comminuted fractures are often associated with ligamentous instability. Stable fixation must be obtained as ligamentous laxity will cause increased forces across the fracture fixation, which could lead to failure [6,8]. Another surgical option for a subset of Type II fractures is fragment excision. Fragment excision alone may be indicated when a fracture fragment blocks forearm rotation, but is too small, comminuted, or osteoporotic to adequately gain fixation. The fragment should not involve the lesser sigmoid notch or involve more than one third of the circumference of the head’s articular surface as this leads to radioulnar arthrosis and/or instability. Most elbow surgeons discourage fragment excision because of the possibility of subsequent radial head subluxation.

Type III fractures include severely comminuted radial head or neck fractures that are deemed unreconstructible based on radiographic and/or intraoperative appearance (Fig. 3). Surgical options include radial head excision with or without radial head replacement arthroplasty. Radial head excision alone provides reliable pain relief and good range of motion. The potential

Box 1. Hotchkiss modification of Mason classification of proximal radius fractures [4]

Type I
- Nondisplaced or minimally displaced fracture of head or neck
- No mechanical block to rotation
- Displacement less than 2 mm or a marginal lip fracture

Type II
- Displaced (usually >2 mm) fracture of head or neck (angulated)
- May have mechanical block to motion or be incongruous
- Without severe comminution (technically possible to repair by open reduction and internal fixation)
- More than a marginal lip fracture of the radial head

Type III
- Severely comminuted fracture of the radial head or neck
- Judged not reconstructible on basis of radiographic or intraoperative appearance
- Usually requires excision for movement

disadvantages of head excision include decreased grip strength, weak forearm rotation, and radial shortening with resultant wrist pain [7]. Altered load transfer at the elbow joint may also lead to the development of early ulnotrochlear arthrosis and elbow pain. Elderly, low-demand patients without ligamentous instability are possible candidates for radial head excision. Otherwise, comminuted fractures where a stable, anatomic reduction cannot be obtained with ORIF should be treated with a metallic radial head replacement. Multiple biomechanics studies have confirmed the role of the radial head as an important elbow stabilizer. During valgus stress, the anterior band of the medial collateral ligament acts the primary elbow stabilizer, while the radial head performs a secondary role [9–11]. In the setting of ulnar collateral ligament rupture, Essex-Lopresti lesion, olecranon fracture, and/or coronoid fracture, the radial head becomes the main stabilizer to valgus stress and longitudinal compressive forces. Even when these structures are intact, recent studies demonstrate that the kinematics and stability of the elbow are altered by radial head excision [11,12]. After metallic radial head replacement, the kinematics and stability of the elbow are similar to that of a native radial head [13]. Compared with head excision alone, results after metallic radial head replacement show similar range of motion, better clinical scores, decreased radial shortening, and decreased ulnotrochlear arthritis.

Surgical techniques

Preparation and planning are essential in the surgical management of radial head fractures. A full selection of internal fixation and reconstructive options should be available for each case as final treatment is often dictated by intraoperative findings. Options for internal fixation include various combinations of threaded K-wires (for
Fig. 2. (A, B) Three-dimensional computed tomography reconstructions of the right elbow showing an impaction, splitting fracture of the radial head. The fragments are displaced anterior and posterior radial head fragments. (C) The patient underwent open reduction and internal screw fixation with an attempt to restore radial height. (D, E) After failure of internal screw fixation, photographs of the fragments were obtained during revision operation. (F, G) The patient then underwent radial head replacement with good result.
provisional fixation), screws (bioabsorbable, Ac-cutrak, Herbert, or Minifragment screws), and plates (T-plate, L-plate, condylar blade plate, modular hand set). The ultimate goal of these hardware devices is to obtain rigid fixation and, hence, allow early postoperative range of motion. The surgeon should be prepared to replace the radial head if indicated, preferably with a metallic prosthesis. The patient is positioned supine on the operating table and general or regional anesthesia is administered. A sandbag is placed under the ipsilateral scapula to facilitate positioning of the upper extremity across the chest. Prophylactic antibiotics are administered 30 minutes before making the incision. An examination under anesthesia is performed before prepping and draping the involved extremity. Examination under anesthesia is absolutely essential in evaluating elbow and forearm stability and range of motion before proceeding. This examination should be performed with fluoroscopy to assess any fracture of displacement. A posterior elbow incision just lateral to the tip of the olecranon is preferred to create a skin flap, which is raised over the lateral side (Fig. 4). This will also allow access to the medial side, if needed, by raising a medial flap. Full-thickness flaps are developed down to the level of the fascia. The classic approach to the radial head uses Kocher’s [14] interval between the anconeus and extensor carpi ulnaris. This approach is disadvantageous for two reasons. First, the approach tends to expose the radial head too posteriorly, making internal fixation of the commonly fractured anterolateral head difficult. Second, iatrogenic injury to the lateral ulnar collateral ligament is difficult to avoid, and may lead to posterolateral rotatory instability. Additionally, if a metallic radial head is needed, it is difficult to place it without displacement of the lateral collateral ligament. An alternative approach that splits the extensor digitorum comminus is the preferred approach. This direct approach is more anterior and hence avoids disruption of the posterolateral collateral ligamentous complex. This approach is centered directly over the radial head and allows excellent exposure. If great exposure is needed, the extensor carpi radialis longus is elevated off the humerus to gain access to the joint. The forearm should be fully pronated. To avoid placing the posterior interosseous nerve at risk, distal dissection should be done with caution more than two fingerbreadths distal from the radiocapitellar joint. If the location of the posterior interosseous nerve is in doubt, definitive identification of the nerve may be required. Once sufficient exposure is obtained, the character of the fracture is thoroughly assessed. The capitellum is also visually assessed for the presence of an associated chondral injury or osteochondral fracture. The decision to proceed with fragment excision, head excision, ORIF, or radial head replacement arthroplasty can be made at this point. The fascial layer over the common extensor group is closed to augment lateral elbow stability. Elbow and forearm range
of motion and stability are carefully assessed and recorded.

Open reduction internal fixation

The concept of an anatomic “safe zone” must be understood when attempting hardware placement into the radial head. The safe zone is defined by a 110-degree arc centered superolaterally over the equator of the radial head with the forearm in neutral rotation [15]. Hardware may be placed into this zone without causing impingement of the proximal radioulnar joint. Alternatively, one may identify the safe zone as a 90-degree arc defined by the right angle from the radial styloid to Lister’s tubercle. Surface anatomy can also help to identify the proper location for hardware placement. Once the fracture has been reduced, K-wires may be used for provisional fixation. K-wires should be absolutely avoided for definitive fixation given their tendency for migration postoperatively. For fractures that do not involve the radial neck, definitive fixation is typically obtained by using small screws such as Herbert mini-screws, mini-Acutrak screws, mini-fragment screws (sizes 1.5, 2.0, or 2.7 mm), and 3.0-mm cannulated screws (see Fig. 1C, D). Screws should be countersunk beneath the articular surface, but not protrude through the opposite cortex. Fractures involving the radial neck are often impacted and require bone grafting to elevate the radial head. These fractures may be amenable to screw and/or plate fixation. One technique that has been successful in the authors’ experience avoids the inherent problems associated with plate fixation for impacted neck fractures. In this technique, the radial head is first elevated to its anatomic position and temporarily secured using threaded K-wires. Screws are then placed obliquely from the radial head proximally to the opposite cortex of the radial neck distally (see Fig. 2C; Fig. 5). This arrangement may be likened to a bar stool in which the seat (the radial head) is supported by the eccentrically arranged legs (the screws). The resultant bony defect in the radial neck secondary to impaction is filled with autologous bone graft or bone graft substitute. This technique has several advantages over plate fixation for radial neck fractures. First, screws are less bulky than plates and may decrease annular ligament impingement. Second, placement of screws generally requires less dissection and periosteal stripping, which may lessen the amount of blood supply disruption to the neck and decrease risk of injury to the posterior interosseous nerve. These advantages should theoretically result in decreased postoperative stiffness, painful hardware, heterotopic ossification, proximal radioulnar synostosis, and nonunion rates. If plate fixation is chosen, low-profile plates are necessary given the close proximity of the annular ligament and paucity of overlying soft tissues. Mini-condylar L-plates, T-plates, and fixed-angled blade plates are all available for radial head and neck fixation. There are few studies comparing internal fixation devices. A biomechanical study compared the average stiffness of several radial neck fracture plate fixation constructs axially loaded in compression [16]. The study demonstrated statistically greater stiffness with a 2.7-mm T-plate modified with a fixed angle blade when compared with a 2.0-mm T-plate and 2.0-mm fixed angle blade. The investigators also noted increased proximal screw hole toggle when a fixed-angle device was not used. Contouring of the plate to the radius was observed to be the most important factor affecting overall construct stiffness. In another biomechanical study, investigators found no statistically

Fig. 4. (A) Healing posterior incision. This is the preferred approach of the authors for cosmetic reasons. (B) Lateral view of the healing incision.
significant difference in fixation stiffness when a low-profile blade plate and 3.0-mm cannulated screws were compared, but both constructs were statistically stiffer when compared with a 2.7-mm T-plate [17].

Radial head replacement arthroplasty

For all practical purposes, metal radial head prostheses have replaced silicone radial heads as the implant of choice in radial head replacement arthroplasty. When compared with metal radial heads, silicone implants are associated with worse clinical scores, increased elbow arthritis, and increased radial shortening. Furthermore, silicone implants are associated with increased failure secondary to fracture, fragmentation, and production of silicone synovitis. Both monoblock and modular radial head prostheses are now available. Anthropometric studies of cadaver proximal radii demonstrate that the head is inconsistently elliptical in shape, the head is variably offset from the axis of the neck, and the head diameter correlates poorly with the diameter of medullary canal of the neck [18]. These findings may support the use of modular implants that allow improved sizing options that more closely approximate the anatomy of the proximal radius.

The radial head is approached in the manner previously described. The annular ligament is incised transversely to expose the radial head. The appropriate radial head resection guide is used to determine proper alignment and resection level. The neck should be osteotomized proximal to the bicipital tuberosity. The medullary canal of the proximal radius is then prepared with a starter

Fig. 5. (A) Type II radial neck fracture. (B, C) Treated with crisscrossing barstool formation to restore and maintain radial head height.
awl, burrs, and broaches to accept the implant (see Fig. 3B). Exposure may be improved by applying varus stress and placing the forearm in supination. Serial-sized broaches are used until a snug fit is obtained in the canal at the appropriate depth, taking care to restore accurate radial length as understuffing or overstuffing can result in instability [19]. The appropriate-sized trial stem is inserted ensuring that the collar of the prosthesis is flush with the resected neck. In modular designs, the trial head is secured to the trial stem, and the elbow and forearm are placed through a full arc of motion. Tracking as well as the relationship between the prosthesis and the capitellum is carefully assessed. Once acceptable alignment and tracking are determined, the trial components are removed, and the final prosthesis is inserted. The stem may be press-fit or cemented in place depending on the design and stability of the stem in the medullary canal. The head is inserted over the taper of the stem and secured using an impactor. Final assessment of motion and stability of the elbow and forearm is performed.

Tips

The most common complication associated with surgical treatment of radial head fractures is postoperative stiffness. In the elbow, loss of terminal extension is more common than loss of forearm rotation, whereas, in the forearm, supination is more difficult to regain than pronation. Poor results are directly related to immobilization periods longer than 3 to 4 weeks. Rigid internal fixation is a prerequisite for beginning a program of early postoperative range of motion. Plate fixation may provide a more stable construct compared with screws alone, but requires more dissection for adequate placement. Excessive dissection and periosteal stripping lead to increased postoperative stiffness. A balance must be obtained between achieving rigid internal fixation to facilitate early range of motion and avoiding hardware constructs that require excessive dissection.

Summary

Radial head and neck fractures are common injuries that require a thorough understanding of elbow anatomy and biomechanics for proper management. The goals of current management are aimed at restoring the normal anatomical and biomechanical relationships of the elbow in an effort to prevent the development of elbow stiffness, instability, and arthritis. Preservation of the radial head should be attempted in fractures that are amenable to internal fixation. Severely comminuted fractures that are not salvageable should be managed with radial head replacement. Regardless of the type of fracture and chosen method of management, a program of early range of motion should be incorporated.

References


