Fractures of the Radial Head and Neck: Current Concepts in Management

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Abstract

Despite advances in surgical techniques, fractures of the radial head are challenging to manage. Most radial head fractures can be managed nonsurgically, with emphasis on early motion to achieve good results. Treatment of more complex radial head fractures, however, especially those associated with elbow instability, remains controversial. The choice for such injury is between open reduction and internal fixation and arthroplasty. Modern implants and techniques have led to improvements in both of these technically demanding procedures. With proper care and understanding of the mechanism of elbow function, better long-term results can be achieved. The current literature suggests that the Mason classification guides choice of the best treatment modality to achieve optimal long-term function. Fracture complexity also should be used as a guide when selecting treatment, and proper surgical technique is critical for success.

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J Am Acad Orthop Surg 2007;15:380-387

Fractures of the radial head and neck, which usually occur after a fall on the outstretched arm, account for 1.5% to 4% of all fractures and approximately 33% of all elbow fractures.[1-4] Although displaced fractures may occur in isolation, they frequently are associated with dislocation of the elbow and with injury to the medial collateral ligament (MCL) and lateral collateral ligament (LCL). Management of displaced comminuted fractures of the radial head is controversial, with conflicting evidence supporting open reduction and internal fixation (ORIF), resection, and radial head arthroplasty.[5] The radial head once was considered expendable, but now it is recognized as an important stabilizer of the elbow and forearm articulations.[6,7] Radial head resection is associated with delayed complications, including pain, joint instability, proximal radial translation, decreased strength, osteoarthrosis, and cubitus valgus.[1,7,8]

When managing unstable fracture-dislocations of the elbow and elbow injuries that affect the forearm, such as those associated with longitudinal injury of the interosseous ligament, it is important to restore radiocapitellar contact through repair or replacement of the radial head.[9] Some authors have suggested that repair or arthroplasty, rather than excision, should be considered for the healthy, active patient, even in the presence of stable elbow or forearm articulation.[10,11] With the availability of more versatile implants for internal fixation as well as a better understanding of the biomechanical role of the radial head, ORIF of displaced radial head fractures has been advocated.[5,11,12] This operation is technically demanding, however, with the possibility of complications and poor results. Interest is growing in radial head arthroplasty, especially for the MCL–deficient elbow and comminuted radial head fracture with elbow or forearm instability.[2,13-15] There is debate regarding which technique—ORIF or arthroplasty—is best for managing complex radial head fracture with associated elbow or forearm instability.

Biomechanics of the Radial Head

The radial head stabilizes the elbow and forearm in two ways. First, radiocapitellar contact resists external joint forces, preventing valgus instability. Second, the forearm and wrist are stabilized in grip activity as load is transferred from the wrist to the radiocapitellar joint. Displaced intra-articular fractures of the radial head decrease the surface area available for load transfer and decrease elbow stability as the result of loss of congruity between the articulating disk of the radial head and the capitellum.[9,16]

Valgus Stability

The radial head is an important valgus stabilizer of the elbow, particularly in the setting of an incompetent MCL, which is disrupted in most fracture-dislocations. In a cadaveric study, Morrey et al[8] demonstrated that the radial head functions as a secondary stabilizer in resisting valgus load. Retention of the radial head shifts the point of rotation in the varus-valgus plane, thus decreasing the lever arm and the relative load on the MCLs.

Lateral-side elbow stability is enhanced with a combination of tension in the posterolateral ligament complex and compression in the radiocapitellar joint.[17] In the patient with acute instability, restoring the lateral-side structures may be more critical than repair of the medial-side structures. A significant decrease in elbow stability was noted in association with radial head excision in elbows with LCL disruption.[3,18] Although elbow laxity improved following arthroplasty, these elbows were still unstable relative to elbows with intact ligaments. These findings suggest that repair of the disrupted LCL complex is essential to restore elbow stability following radial head arthroplasty.[3,18]

Longitudinal Stability

The degree of load sharing at the elbow between the radius and the ulna in regard to grip activity and lifting is not clearly described. Studies have shown that the radius bears 80% of the load at the wrist but that the load-sharing ratio equalizes at the elbow.[19,20] Morrey et al[8] studied changes in force transmission with variations in forearm rotation. They found that the most force was transmitted from the wrist to the radial head with the elbow in extension and the forearm in pronation.

The intact radial head articulating with the capitellum is the primary restraint to proximal migration of the radius. Soft-tissue structures that provide additional longitudinal stability include the interosseous membrane of the forearm and the ligaments of the distal radioulnar joint. With injury to or excision of the radial head, normal load sharing at the radiocapitellar joint no longer occurs, and all compressive loads are transferred from the distal radius to the ulna through the interosseous membrane and the distal radioulnar joint.[15] Longitudinal radioulnar dissociation may follow when radial head fracture occurs in association with damage to any of these stabilizing soft-tissue structures, particularly the interosseous membrane.

The radiocapitellar articulation accounts for as much as 60% of the load transfer across the elbow. Resisted isometric flexion can generate forces of up to four times body weight. Depressed fracture of the radial head decreases the surface area available for load transfer and decreases elbow stability by virtue of loss of congruity between the articulating disk of the radial head and the capitellum.[9,16]

Clinical and Radiographic Evaluation

The patient who presents with a radial head fracture should undergo clinical evaluation for elbow instability and any block to elbow motion. The examination may involve injecting the elbow joint with a local anesthetic, followed by range of motion (ROM) evaluation at the elbow (ie, flexion, extension) and at the proximal radioulnar joint (ie, supination, pronation). Elbow stability also should be confirmed, including varus-valgus laxity.

Anteroposterior and lateral radiographs should be obtained. A Greenspan view may aid in delineating the radial head fracture. This modified lateral view, taken with the beam angled 45° toward the radial head, allows visualization of the radial head without coronoid overlap.[21]

Computed tomography may be used to help identify the fracture pattern and associated injuries in complex elbow fracture-dislocations. It also may be useful in planning surgical technique and identifying fractures not visualized or appreciated on plain radiographs. The Mason classification of fracture of the radial head, as modified by Hotchkiss,[19] greatly assists in determining treatment options (Table 1). Mason types III and IV require ORIF or replacement arthroplasty of the radial head.

Surgical Treatment

The surgical options for radial head fracture include ORIF, excision, and arthroplasty. The primary pitfall in managing such fractures is underes-

Table 1

Mason Classification*

Type I	Minimally displaced fracture, no mechanical block to forearm rotation, intra-articular displacement <2 mm
Type II	Fracture displaced >2 mm or angulated, possible mechanical block to forearm rotation
Type III	Severely comminuted fracture, mechanical block to motion
Type IV[22]	Radial fracture with associated elbow dislocation

* As modified by Hotchkiss.[19]

timating the importance of elbow stability. Comminuted fracture of the radial head is part of the spectrum of elbow instability, and optimal management of the radial head fracture should maintain elbow stability. However, with comminuted fracture, there is also a high likelihood of associated osseous and ligamentous injury.[10] It is imperative that the surgeon understand and treat these associated injuries to prevent persistent instability. Fixation of the displaced coronoid process provides one aspect of improvement in elbow stability. Small type I and II coronoid fractures can be repaired and fixed using sutures, while larger type III fractures are fixed with screws. When a "global" approach is utilized, a plate can be used to fix this fracture from the medial aspect.

Ligamentous injuries must be addressed simultaneously with the radial head fracture to restore balance and stability. Repair of the LCL, which must be performed when addressing the radial head fracture, may be done by passing sutures through the ligament and fixing the LCL to the lateral epicondyle using suture anchors or drill holes. MCL repair usually is not required unless elbow instability persists after coronoid and lateral repair. For the joint that continues to be unstable after bony fixation and ligament repair, a supplemental hinged external fixator may be required.

Surgical Exposure

Either the lateral (Kocher) or the global approach is commonly used to treat radial head fracture. Both use the same deep muscular interval to approach the radial head.

With the Kocher approach, the incision is begun at the lateral epicondyle and extends distally toward the ulna. The interval for the Kocher approach is best identified distally between the anconeus muscle and the extensor carpi ulnaris tendon. The deep fascia at this interval is incised, and the muscles are retracted to expose the LCL complex. Care is required to separate the capsule from the muscular layer. The posterior interosseous nerve is protected by pronating the forearm, which moves the nerve away from the radial neck. When the capsule is intact, it is incised anterior to the lateral ulnar collateral ligament, and anterior and posterior flaps are created. The anterior capsular flap is released from the epicondyle, exposing the anterolateral aspect of the joint without violating the lateral ulnar collateral ligament. At this stage, the posterior capsular flap is left intact to maintain joint stability.

The Kocher approach allows good visualization of the radial head fracture, and ORIF or arthroplasty can be performed via this approach. A Z-shaped incision of the annular ligament is used when distal extended exposure is required. This ensures stable repair of the annular ligament following the procedure. With a delayed procedure, the patient may have a fixed flexion deformity, which can be corrected by releasing the capsule from the anterior aspect of the humerus.

The global approach begins with a 20- to 25-cm posterior midline incision centered on the olecranon. Full-thickness fasciocutaneous flaps are elevated to expose the lateral and medial side of the elbow, as required.[23] Once these flaps are raised, the approach continues using the same lateral interval as for the Kocher approach. The advantage of the global approach is the ability to address problems on both the medial and lateral sides. It also allows fixation of associated proximal ulna fracture. The disadvantages are the long incision and the creation of large flaps on either side for visualization.

Surgical Technique

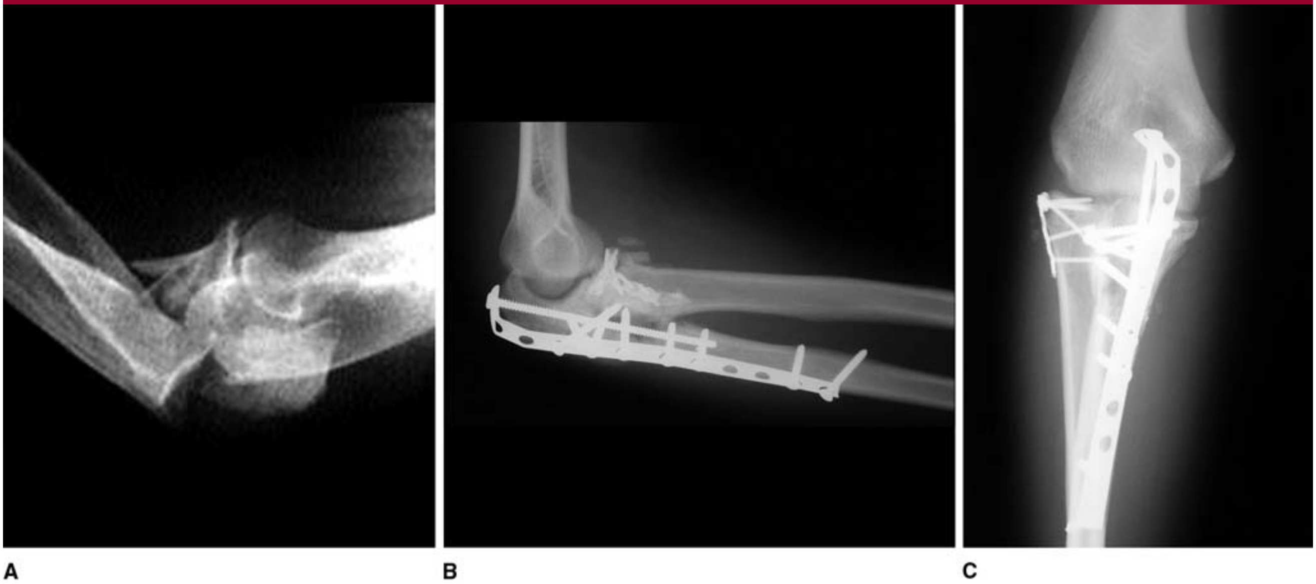
Open Reduction and Internal Fixation

Internal fixation of the radial head, when technically possible, is the preferred treatment. The radial head with three or fewer fragments usually can be reconstructed and fixed internally.

Before undertaking surgery, a comprehensive array of devices should be laid out, including Kirschner wires (K-wires) for temporary fixation, and a mini-fragment internal fixation set with reconstruction plates, including mini-condylar plates and mini-fragment screws (1.5- or 2.0-mm), Herbert miniscrews (Zimmer, Warsaw, IN), variable pitch mini-Accutrak screws, and the Mayo Clinic precontoured radial head plate (Acumed, Beaverton, OR).

The articular surface is reduced under direct visualization and held temporarily with K-wires. For the radial head with a partial articular fracture, mini-fragment screws may provide sufficient fixation. We typically use the Kocher approach and reduce the fracture under direct visualization. After reduction, provisional fixation is achieved with K-wires (usually 0.035 in) and confirmed visually and with fluorosco-

Figure 1



A, Lateral radiograph of a radial head in two large pieces, with comminution at the periphery and the neck. Lateral **(B)** and anteroposterior **(C)** views taken after fixation with a mini-fragment T-plate. One of the screws appeared to be in the radiocapitellar joint, but was confirmed intraoperatively to be extra-articular.

py. Definitive fixation is achieved using either 1.5- or 2.0-mm mini-fragment screws or headless screws with differential pitch to allow compression across the fracture site. The surgeon must be cognizant of the convex surface of the radial head to avoid intra-articular penetration of the screws. The results for internal fixation of these types of radial head fractures are predictable and typically good.

The fracture that extends into the radial neck requires plate fixation with a mini-fragment T-plate or a blade plate. The technical challenges to obtaining stable fixation are greater and the results less predictable for this fracture type (Figure 1). The plate is placed in the safe zone, that is, the area that does not articulate with the proximal radioulnar joint and thus will not impinge during forearm rotation. This 45° arc should be confirmed by testing forearm rotation after temporarily fixing the plate with K-wires. This fixation is challenging and requires the use of multiple screws through the plate, including a "triangulating" screw. This screw is inserted through the distal portion of the plate (distal to the head) and is angled proximally into the head to allow supplemental fixation and to increase the construct strength. For optimal fixation, it is important to get purchase in the subchondral bone; however, the surgeon must be careful to ensure extra-articular screw placement. This requires direct visualization of the articular surface and multiple fluoroscopic views.

The plate length typically needed for a radial head and/or neck fracture is one that allows placement of at least three screws distal to the fracture site. The bicipital tuberosity is the distal limit of the plate placement. Anything distal to that structure endangers the posterior interosseous nerve. A Z-shaped incision is used for distal exposure of the annular ligament. This incision must be made under direct visualization.

Internal fixation of the radial head can be challenging, especially with a comminuted fracture. It is difficult to maintain length and alignment during the fixation process. Typically, the fracture is malreduced into valgus and has shortening. This may be due to inability to recreate the medial buttress of the radial neck. The surgeon should always have radial head replacements available in case the fracture is more comminuted than expected or attempts at internal fixation are unsuccessful.

Radial Head Excision

Management of the displaced radial head fracture that is not amenable to ORIF is controversial. Injury that is isolated to the radial head (Mason types I and II) may be managed with early or delayed excision. There are conflicting reports regarding long-term outcomes.[1,7]

Acute excision of the radial head without replacement is contraindicated in the presence of concomitant disruption of the MCL or the interosseous membrane. Even in the absence of associated soft-tissue injuries (eg, tears of the MCL), radial

Figure 2

A B C D

Lateral **(A)** and anteroposterior **(B)** radiographs of an ulna fracture with radial head fracture-dislocation (Monteggia variant). Lateral **(C)** and anteroposterior **(D)** radiographs following radial head replacement and ulna fracture fixation. Intraoperatively, this radial head fracture was determined to be unreconstructible, and a radial head prosthesis was implanted.

head resection may be associated with delayed complications, including pain, joint instability, proximal radial translation, decreased strength, osteoarthritis, and cubitus valgus.[1,7,8] However, Herbertsson et al[1] reported successful results with satisfactory outcomes in 54 of the 61 patients included in their study of long-term outcomes of radial head excision.

Radial Head Arthroplasty

Arthroplasty is indicated for the displaced, comminuted radial head fracture when stable internal fixation is not possible and the fracture involves more than one third of the radial head.[13,24] In particular, arthroplasty is indicated for the fracture with associated ligament injury (elbow dislocation or distal radioulnar joint injury [Mason types III and IV]) or associated fracture (coronoid or olecranon fracture that is displaced or comminuted and unstable). The controversy is in deciding exactly which fractures of the radial head meet these criteria.

Available Implant Options Multiple studies over the past decade have reported good results with metallic radial head devices.[13,14,25] Newer prostheses, including the Evolve radial head (Wright Medical Technology, Arlington, TN), the Seitz radial head implant system (Kapp Surgical, Cleveland, OH), and the rHead radial implant system (Small Bone Innovations, New York, NY), allow surgeons the advantage of modularity.

Technical Considerations The metallic prosthesis should replicate as closely as possible the native radial head (Figure 2). Multiple biomechanical studies have shown that optimal sizing of the radial head is important.[16,20,26-28] A prosthesis with a too-large diameter will load the margins of the sigmoid notch, whereas a too-small prosthesis will point load on the sigmoid notch. Additionally, a radial head with an incorrect diameter has a cam effect, producing abnormal loading on the capitellum.[29] The correct diameter of the radial head prosthesis is selected by comparing the excised radial head fragments with the trial prosthesis. The prosthesis should be congruent and have smooth motion with the capitellum throughout the full ROM.[13,30]

The height of the prosthesis is also important. Fortunately, most fractures occur at the head-neck junction; once the head is excised, insertion of a prosthesis that corresponds in height with the native head is adequate. Care is required to ensure that the appropriate neck length has been excised to create a stable rim of neck on which to seat the prosthesis. The surgeon must ensure that the radial head is loading the capitellum but that the joint is not "overstuffed." Overstuffing, which occurs when a radial head is too long or too large, may lead to pain on the lateral side of the elbow. A radial head prosthesis that is too short will not load the capitellum, thus increasing joint instability.[28,31] To ensure a normal articulation with the proximal radioulnar joint, the height of the prosthesis must be the same as that of the trochlear notch. Proper fit is confirmed radiographically, although adequate visualization to determine the correct height using this method may be difficult.

Radial head implants should be limited to the head and neck region. Long prostheses, which extend distal to the 15° angulation of the proximal part of the radius, are likely to create an angular offset from the native radial head on forearm rotation. Fracture of the radial head that extends into the neck can be difficult to manage. The surgeon must carefully inspect the neck of the radius to identify any nondisplaced fractures. Nondisplaced neck fractures should be prophylactically wired before insertion of the metallic prosthesis to prevent displacement when the prosthesis is inserted. Use of cement to fix the prosthesis is not necessary since the radial head prostheses serve as spacers.

Postoperative Care

Postoperative care is critically important for the patient with radial head fracture. Concerns regarding recurrent elbow instability must be balanced against the need for early motion, which minimizes long-term problems with elbow stiffness. Early ROM within a safe arc should be initiated, taking into account associated fractures and ligamentous injuries. An extension-splinting program is begun as soon as stability improves, and a splint is worn at night for 10 to 12 weeks. The patient with associated elbow fracture-dislocation is prescribed a 6-week course of indomethacin to minimize the risk of heterotopic bone formation.[26] Use of radiation is controversial. Stein et al[32] reported good results in 10 of 11 patients with elbow trauma who were treated with 700 cGy radiation within 72 hours of surgery.

Results

The current literature on complex radial head and neck fractures is sparse and provides limited guidance for choosing the optimal treatment method. Clinical results data on treating radial head fractures with ORIF, excision, or arthroplasty are conflicting, which creates more controversy.[5,7] The range of associated injuries to the elbow makes it difficult to isolate the effect of any particular treatment of the radial head fracture. Another dilemma is that medium- to long-term follow-up is necessary to fully appreciate the consequences of treatment decisions; however, techniques related to fixation, implants, and prostheses are evolving so rapidly that reports on previous techniques have been made obsolete.

Ikeda et al[33] compared the results of radial head excision to fixation in a series of 28 patients. At final follow-up, the patients who underwent radial head fixation had greater strength, function, and joint motion than did the group that underwent resection. However, the follow-up period in patients treated with fixation was 3 years, compared with 10 years in the resection group. Herbertsson and colleagues[1,34] reported on long-term (average, 18 years) results of radial head excision and showed favorable results in Mason type II and III fractures. However, compared with the noninjured elbows, the injured elbows had a higher percentage of arthritis (73% versus 7%).[1,34] In these patients, the timing of radial head excision was less important in predicting outcome.[1]

King et al[11] reported 100% excellent results after fixation of Mason type II fractures but only 33% excellent results for Mason type III injuries, suggesting that comminuted fractures should be managed with arthroplasty for better outcomes.

Ikeda et al[5] reported excellent results for Mason type III and IV fractures with fixation using precontoured low-profile implants. In this series of 10 patients, 90% good to excellent scores were achieved at 28 months after injury. Of note, 9 of 10 patients underwent hardware removal.[5]

In a recent study of 56 radial head fractures managed with internal fixation, Ring et al[12] recommended that fixation be reserved for fractures with three or fewer articular fragments. Thirteen of the 14 patients with Mason type III fractures with more than three articular fragments had an unsatisfactory result, compared with a satisfactory result in all 15 patients with Mason type II fractures. Of the 12 patients with a type III fracture in which the radial head was split into two or three simple fragments, none had early failure, 1 had nonunion, and all had an arc of forearm rotation ≥100°.[12]

Excellent results to date have been reported with metallic radial head implants. Bain et al[13] treated 16 patients with Mason type III injuries with a monoblock titanium prosthesis. The authors reported good to excellent results in 80% of patients at 2.8-year follow-up. They suggested that surgery not be delayed and indicated that early mobilization after surgery is important for satisfactory outcome.[13] Harrington et al[25] reported similar results with longer follow-up (average, 12 years) for radial head replacement in patients with grossly unstable elbow fracture-dislocations. Despite the current availability of and emphasis on the use of modular implants for radial head arthroplasty, no literature shows that results are better with modular or bipolar radial head implants compared with monoblock prostheses.

The problems of using a too-large or too-small prosthesis, including the dangers of overstuffing the joint, have been described in biomechanical studies.[29] However, no reports are available to confirm that these issues are clinically relevant. Another shortcoming in the literature on radial head fracture management is the absence of direct comparison between the results of ORIF versus arthroplasty. We found no reports in the English-language literature directly comparing the results of these two treatment modalities or reporting on the long-term effects on either the capitellum or the radius secondary to the radial head implant or spacer.

Summary

Radial head injuries range from minimally displaced to comminuted displaced fractures with elbow instability (Mason types I through IV). Appropriate management of radial head injury is important in restoring the normal mechanics and anatomy of the elbow joint. Associated bony and ligamentous injury must be addressed at the same time. With the availability of recent implants, including low-profile precontoured plates, ORIF is a viable option. We prefer this method when it can be technically easily accomplished. Radial head arthroplasty is needed for more complex injuries, and the surgeon should always have implants available in the operating room when managing these injuries. However, the preferential use of either ORIF or replacement continues to cause much debate and controversy. Results can be good to excellent with either of these treatment modalities, but outcomes depend on the fracture pattern and associated injuries. Unfortunately, the results of each technique have been reported separately or compared with resection, with relatively few long-term outcome data. The available literature, therefore, does not provide clear guidance as to the best treatment option for complex radial head injuries, especially those with associated elbow instability. Further studies with long-term follow-up are needed to determine the best form of treatment of these complex injuries.

References

Evidence-based Medicine: References of prospective, randomized level I and level II studies are cited (references 10, 18, and 33). The remaining references are level III / IV case-control or cohort studies of one technique. Expert opinion (level V) studies are also included (references 13, 19, 20, and 30).

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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