Current Concepts Review

Fractures of the Radial Head and Neck

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➤ The majority of simple fractures of the radial head are stable, even when displaced 2 mm. Articular fragmentation and comminution can be seen in stable fracture patterns and are not absolute indications for operative treatment.

➤ Preservation and/or restoration of radiocapitellar contact is critical to coronal plane and longitudinal stability of the elbow and forearm.

➤ Partial and complete articular fractures of the radial head should be differentiated.

➤ Important fracture characteristics impacting treatment include fragment number, fragment size (percentage of articular disc), fragment comminution, fragment stability, displacement and corresponding block to motion, osteopenia, articular impaction, radiocapitellar malalignment, and radial neck and metaphyseal comminution and/or bone loss.

➤ Open reduction and internal fixation of displaced radial head fractures should only be attempted when anatomic reduction, restoration of articular congruity, and initiation of early motion can be achieved. If these goals are not obtainable, open reduction and internal fixation may lead to early fixation failure, nonunion, and loss of elbow and forearm motion and stability.

➤ Radial head replacement is preferred for displaced radial head fractures with more than three fragments, unstable partial articular fractures in which stable fixation cannot be achieved, and fractures occurring in association with complex elbow injury patterns if stable fixation cannot be ensured.

The role of the radial head in the functional anatomy and kinematics of the elbow and forearm continues to be defined. The importance of the radial head has stimulated a greater degree of interest in the fixation and reconstruction of traumatic injuries to the radial head and/or neck, whether simple (isolated) or complex (associated with concomitant osseous or soft-tissue injury). In this article, we will discuss the structural anatomy of the lateral side of the elbow, the role of the radial head in stability of the elbow, classifications of isolated fractures as well as fracture-dislocations, treatment algorithms, indications for internal fixation or arthroplasty, and best evidence regarding outcomes by fracture subtype.

Anatomy and Biomechanics

The articular surfaces of the radiocapitellar joint are congruent along their corresponding radii of curvature. The concave surface of the radial head articulates with the hemispherically shaped capitellum, and the radial head rim articulates with the lesser sigmoid notch. Articular cartilage covers the concave surface as well as an arc of approximately 280° around the rim[1]. Anatomic studies[2-5] have demonstrated that the radial head is not perfectly circular and is variably offset from the axis of the neck. van Riet and colleagues[2] found that the orientation of the long axis of the radial head is perpendicular to the lesser sigmoid notch of the ulna with the forearm in neutral rotation.

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

This anatomical relationship needs to be precisely restored during radial head fixation or replicated by prosthetic replacements to optimize outcomes.

The primary stabilizer to varus stress consists of the lateral collateral ligament complex. The lateral collateral ligament complex comprises the radial collateral ligament, the lateral ulnar collateral ligament, the anular ligament, and the accessory collateral ligament. The lateral ulnar collateral ligament origin at the isometric point of the lateral epicondyle as well as its insertion distal to the posterior attachment of the anular ligament on the crista supinatoris[6] provide both varus and posterolateral stability.

An intact radiocapitellar articulation is essential to both valgus and longitudinal stability of the elbow and forearm. Morrey et al.[7] demonstrated in a cadaveric model that the radial head is a key secondary stabilizer to valgus stress in the medial collateral ligament-deficient elbow; therefore, restoration of the radiocapitellar compartment is critical following trauma. Dushuttle et al.[8] found that capitellar excision creates coronal plane instability when the medial structures are disrupted.

Axial engagement of the radial head against the capitellum, in conjunction with the interosseous membrane, distal radioulnar joint ligaments, and triangular fibrocartilage complex, provides for load transfer from the wrist through the elbow as well as resistance to proximal migration of the radius[9-11]. Halls and Travill[12] showed that the radiocapitellar articulation bears almost 60% of the load at the elbow, with maximum force transmission through the proximal part of the radius occurring with the elbow in terminal extension and the forearm pronated. In a cadaveric model of concomitant comminuted radial head fracture and interosseous membrane disruption, Markolf et al.[13] demonstrated that restoration of anatomic radial length with use of an appropriately sized radial head prosthesis preserves distal ulnar load-sharing and prevents proximal migration of the radius.

In the setting of elbow fracture-dislocation or longitudinal instability of the forearm, restoration of the proximal part of the radius through repair or reconstruction is essential to restore and maintain coronal plane (i.e., varus-valgus) stability, to decrease the stress imparted on the ulnar collateral ligament, and to prevent proximal migration of the radius. The need for careful clinical examination of the forearm axis and wrist must be emphasized. Even with a simple radial head fracture, magnetic resonance imaging of the forearm may demonstrate distal interosseous membrane injury, which may impact treatment and prognosis[14]. The role of repair or reconstruction of the interosseous membrane in the setting of longitudinal disruption of the forearm continues to be investigated[15,16].

Current Treatment-Based Classifications

Prior to definitive classification of the injury, radiographs should be assessed for associated lateral-column and periarticular osseous injuries[17], including fractures of the capitellum, trochlea, medial epicondyle, and coronoid[18-21]. The original classification system described by Mason[22] distinguished nondisplaced fractures (Type 1), displaced partial head fractures (Type 2), and displaced fractures involving the entire radial head (Type 3). Broberg and Morrey[23] attempted to quantify the extent of radial head involvement and included the presence of concomitant radial neck fracture. They suggested that a partial radial head fracture must be of sufficient size (30% of the articular surface) and displacement (2 mm) to be considered displaced (i.e., Mason Type-2 fracture). Johnston's modification[24] (Type 4) of the Mason classification system sought to include fractures of the radial head associated with elbow dislocation, with the recognition that proximal radial fractures may be associated with a variety of complex fracture-dislocation patterns about the elbow and forearm and may change the treatment and prognosis of a similar radial head fracture without dislocation. The AO classification system accounts for the spectrum of injuries at the proximal part of the radius (radial head and/or neck fractures), whether isolated (21-B injury pattern) or associated with complex elbow/forearm fracture-dislocations (21-C injury pattern)[25]. Proximal radial fractures associated with complex elbow/forearm injuries require careful characterization and preoperative planning.

The Hotchkiss[26] modification of the Mason classification system attempted to direct treatment. In this modified system, Type-1 fractures are defined as nondisplaced or minimally displaced fractures (displacement, <2 mm) or small marginal fractures that do not block motion and can be treated nonoperatively; Type-2 fractures are defined as displaced fractures (displacement, >2 mm) of the radial head or neck without comminution, and with or without mechanical block to motion, that are amenable to open reduction and internal fixation; and Type-3 fractures as displaced fractures that are not repairable and are either excised or replaced with a prosthesis.

Classification systems based on standard radiographic interpretations have demonstrated only modest interobserver reliability[27,28]. Sheps et al.[27], in a series of forty-three patients with radial head fractures, reported that the interobserver reliability of the Hotchkiss modification[26] of the Mason classification system was only moderate (kappa statistic, 0.585) and that the interobserver reliability of the AO classification system was fair (kappa statistic, 0.261). Interobserver reliability improved when Hotchkiss Type-2 and 3 fractures are consolidated into a single fracture class for observers (kappa statistic, 0.760) or when the final digit in the AO classification is not used (kappa statistic, 0.455). Doornberg et al.[28] reported that the Broberg and Morrey classification[23] of Mason Type-1 and 2 fractures demonstrated excellent intraobserver reliability (mean kappa, 0.85) but only moderate interobserver reliability (mean kappa, 0.45) when displacement was assessed in 119 isolated partial articular fractures of the radial head. Dillon et al.[29] found improved interobserver agreement when an external rotation oblique view was included.

Decision-Making Principles

A number of parameters must be taken into account when evaluating fractures about the radial head and neck to determine treatment. These include fracture stability, displacement, the magnitude of articular involvement, and the presence of associated complex injuries. These subtleties should be assessed

TABLE I Radial Head-Neck Fracture Characteristics Impacting Treatment

1. Partial articular versus complete articular
2. Fragment number
3. Fragment size (percentage of articular disc)
4. Fragment comminution
5. Fragment stability
6. Displacement and corresponding block to motion
7. Osteopenia
8. Articular impaction
9. Radiocapitellar malalignment
10. Radial neck and metaphyseal comminution and/or bone loss

together so that decisions are not rigidly based on classification schemes (Table I and Highlight Box).

For fractures of the radial head, fracture instability and displacement are not synonymous. The majority of isolated fractures involving only a part of the radial head are inherently stable even when displaced ≥2 mm[30]. Currently, fracture fragment displacement of ≥2 mm[31] is often used as a criterion for consideration of operative treatment. However, this amount of displacement can be seen in association with a stable fracture[28] and preserved elbow and forearm motion. Furthermore, when forearm motion is maintained, long-term follow-up studies have demonstrated successful outcomes in association with nonoperative treatment[32,33]. Stability of a displaced and/or impacted fragment may be preserved by the periosteal attachments. Fracture stability, the preservation of forearm rotation, radiocapitellar alignment, and associated injuries are evaluated when operative intervention is being contemplated and should be considered in addition to the magnitude of displacement. Fragmentation or comminution of the articular surface also may be seen even in association with stable, minimally displaced fractures. Malalignment of the radiocapitellar articulation on radiographs should heighten suspicion for associated soft-tissue and/or osseous injury.

In contrast to the above injuries, gross displacement of fracture fragments indicates instability and disruption of soft-tissue attachments. These unstable and widely displaced fractures of the radial head are more often associated with fracture-dislocation patterns about the elbow and forearm. In a series of 121 modified Mason Type-2 radial head fractures, Rineer et al.[34] showed that complete loss of cortical contact between a single fracture fragment and the rest of the proximal part of the radius is an important predictor of the presence of a complex elbow injury. In addition, fracture instability has often been defined intraoperatively by the presence of mobile fragments separated from the intact radius[35,36]. Preoperative computed tomography (CT) may be used to better define the magnitude of articular involvement and the anatomic zone of articular injury but is not routinely performed unless there is an associated complex periarticular injury involving the distal part of the humerus or the proximal part of the ulna[37,38].

Current Treatment Guidelines of Select Fractures

Stable, Nondisplaced Fractures and Isolated, Stable Partial Articular Fractures

There is consensus that nondisplaced and stable, minimally displaced partial articular fractures of the radial head should be treated nonoperatively[39,40].

The simple and moderately displaced partial radial head fracture (displacement, 2 to 5 mm) is an uncommon fracture pattern[28]. As noted by Athwal and King[41] in a recent review of these rare injuries, the best available evidence is limited to retrospective case series and relatively small cohort studies with differences in fracture classification; treatment techniques and approaches; methods of clinical, functional, and radiographic evaluation; and durations of follow-up. As the series discussed below are limited to Level-III and IV data[42], grade B/C recommendations exist for both nonoperative and operative treatment of these fracture types. Randomized, prospective, and/or case-control cohorts are needed to elucidate the optimum treatment of partial articular fractures of the radial head.

Long-term clinical outcome studies[32,33] have supported nonoperative treatment and early active motion of two-part fractures of the radial head associated with 2 to 5 mm of displacement when there is no block to elbow or forearm motion and the elbow is stable. A hematoma aspiration and lidocaine injection can be helpful if a mechanical block is suspected. Akesson et al.[32], in a retrospective cohort series of forty-nine patients with two-part partial articular fractures of the radial head that were displaced 2 to 5 mm and that comprised >30% of the articular surface (Mason Type-2a fractures according to the Broberg-Morrey modification of the Mason classification system) that were treated with early mobilization, reported that forty patients (82%) had no subjective complaints after a mean duration of follow-up of nineteen years and that there were only minimum clinical differences between injured and uninjured elbows in terms of ulnohumeral and pronation-supination arcs of motion. Six patients underwent radial head excision (after less than six months) because of an unsatisfactory outcome. Although posttraumatic arthrosis was more prevalent in the injured elbows, its presence did not correlate with pain or motion. In a larger retrospective series of 100 patients with Mason Type-2 and 3 fractures, Herbertsson et al.[33] reported a good outcome in eighty-four (84%) of 100 patients after nineteen years of follow-up. However, that study remains limited in that the outcomes at this long-term follow-up interval were not specifically stratified by treatment rendered. As a result, differences in outcomes between the treatment subgroups (nonoperative treatment [n = 78], acute radial head excision [n = 19], acute open reduction and internal fixation [n = 2], and medial collateral ligament repair [n = 1]) is not known. These data, in conjunction with historical series[43-47] demonstrating satisfactory results in the majority of patients with isolated displaced partial articular fractures following nonoperative management, suggest that these fractures were stable, albeit displaced. Lindenhovius et al.[48] reported good-to-excellent results following open reduction and internal fixation of isolated, stable, displaced, partial articular fractures in thirteen (81%) of sixteen patients at a mean of twenty-two years postoperatively. However, clinical and functional outcomes were not superior to those obtained following nonoperative treatment of these injuries in previous series. The magnitude of displacement and articular surface involvement that is acceptable and reliably portends an acceptable clinical and functional outcome is not known. However, at increasing magnitudes of displacement, complex patterns and associated injuries are more common and should be strongly suspected.

Unstable Partial Articular Fractures

Unstable partial articular fractures of the radial head are defined by gross displacement, periosteal disruption, metaphyseal bone loss, radiocapitellar articular incongruency, malalignment and impaction, block to elbow and forearm motion, and the presence of associated elbow or forearm fracture-dislocation patterns[38]. Involvement of the anterolateral quadrant of the radial head articular surface is often seen following posterolateral subluxation or dislocation. This is the nonarticular portion of the radial head, and the lack of subchondral bone may make it more prone to fracture and comminution and less able to provide support for fixation[34]. Open reduction and internal fixation along with soft-tissue repair is indicated to restore stability of the elbow when primary ligamentous stabilizers have been disrupted.

Operative Exposure

When operative fixation of an isolated radial head and neck fracture is required, a lateral surgical approach is generally utilized for exposure. A lateral skin incision at the elbow is centered over the lateral epicondyle and extends from the anterior aspect of the lateral column of the distal part of the humerus along the midaxial line of the radial head and proximal part of the radius. Several deep muscular intervals may be exploited, including the Kocher interval[49] between the anconeus and extensor carpi ulnaris muscles or the Kaplan interval[50] between the extensor carpi radialis longus and extensor digitorum communis. Alternatively, the extensor digitorum communis may be split as described by Hotchkiss[26]. The exposure can often proceed through the traumatic defect in the lateral structures. An arthrotomy is performed anterior to the lateral ulnar collateral ligament to prevent creating posterolateral rotational instability. Bain et al.[51] advocated a lateral "Z" step-cut ligament-sparing capsulotomy anterior to the lateral ulnar collateral ligament at the level of the anular ligament to avoid overtensioning if one elects capsular repair during closure. Distal exposure of the proximal radial shaft requires elevation of the extensor-supinator complex and protection of the posterior interosseous nerve. Tornetta et al.[52] found that in only one (2%) of fifty arms did the posterior interosseous nerve lie directly on the radius and that the average distance (and standard deviation) from the radial head to the origin of the posterior interosseous nerve was 1.2 ± 1.9 mm, with the takeoff being proximal to the radial head in thirty-one cases. In a cadaveric study, Schimizzi et al.[53] found that the mean distance between the posterior interosseous nerve and the radiocapitellar joint in neutral, supination, and pronation was 44.5, 40.8, and 48.2 mm, respectively. On the basis of these data, the posterior interosseous nerve may be safer during exposure with forearm pronation. An extensile lateral column exposure may be needed to reduce and fix a concomitant coronal shear capitellar-trochlear fracture[19-22].

When a posterior and/or medial exposure is anticipated, a midline extensile posterior skin incision with elevation of full-thickness skin flaps may be used. In the setting of a "terrible triad injury" (posterolateral elbow fracture-dislocation with associated radial head and coronoid fractures)[26], resection of the associated comminuted radial head fracture may yield access to the coronoid fracture from the lateral side without an additional medial exposure in select cases. Alternatively, a medially based exposure (i.e., flexor-pronator split or elevation) may be used for open reduction and internal fixation of larger or anteromedial facet coronoid fractures.

Articular Surface Reconstruction

The goals of open reduction and internal fixation include stable articular surface fixation and restoration of articular congruencies and the radial head-neck relationship to facilitate early active motion. Small (1.5 to 2.4-mm) cannulated headless compression screws or screws countersunk beneath the articular surface are often used for unstable fractures[36,48,54-57]. When there is comminution of the articular surface, screws may be inserted in neutral mode (i.e., without lag technique) to avoid narrowing the articular disc. Bioabsorbable implants[58] or terminally threaded wires may be helpful for securing very small fragments. Occasionally, widely displaced articular fragments devoid of soft-tissue attachments are assembled to each other on the back table and then are secured to the remaining head and/or neck. The overall stability of the construct will depend on associated injuries as well.

Various low-profile periarticular plates are available for the treatment of unstable extra-articular radial neck fractures or combined radial head-neck fractures. These implants are applied within the "safe zone,"[59,60] defined as the posterolateral quadrant of the radial head that is nonarticular with the lesser sigmoid notch of the ulna and is located laterally between the radial styloid and the Lister tubercle with the forearm in neutral rotation[61]. When there is a concomitant fracture of the radial head and neck, reconstruction of the articular disc with use of buried implants may be performed first and then plate fixation may be used to secure the head to the neck. Alternatively, these fractures may be treated with a single low-profile plate-screw construct.

Impacted or deformed[62] articular fragments require elevation to restore the head-neck and radiocapitellar relationships. The articular surface is then fixed to the proximal part of the shaft with a plate-screw construct (Figs. 1-A through 2-B). Even with fixed-angle constructs, there is benefit to addressing the metaphyseal void (created at the time of articular elevation) with use of local autograft (olecranon or lateral epicondyle), allograft, or bone-graft substitute.

For extra-articular but displaced simple transverse fractures of the radial neck, antegrade, crossed, countersunk screws may be used. In a fresh-frozen cadaveric biomechanical model of isolated radial neck fractures, Capo et al.[63] demonstrated that a 2.4-mm T-plate in conjunction with an antegrade interfragmentary screw placed from a nonarticular portion of the head into the shaft provided the highest rigidity in both bending and torsion. The addition of a lag screw (antegrade or retrograde)

Fig. 1-A

Fig. 1-B

Figs. 1-A and 1-B Preoperative anteroposterior (**Fig. 1-A**) and lateral (**Fig. 1-B**) radiographs demonstrating a displaced radial head and neck fracture.

across the neck fracture always increased the torsional and bending stiffness of the construct. In contrast, locking buttress pins or locking screws did not increase torsional or bending rigidity. In cases of radial neck impaction, comminution, or metaphyseal bone loss, fixed-angle implants (i.e., a minicondylar blade-plate or locking plate) remain advantageous.

Outcomes of Operative Treatment

Several retrospective studies[36,38,54,57] have demonstrated good to excellent results following open reduction and internal fixation of partial articular fractures of the radial head. Khalfayan et al.[54] retrospectively compared outcome differences at a mean of 1.5 years of follow-up in a study of Mason Type-2 fractures that were treated nonoperatively (n = 16) or with open reduction and internal fixation (n = 10). Clinical outcomes were significantly better in the open reduction and internal fixation group (with a 90% rate of good to excellent results) in comparison with the nonoperative treatment group (with a 44% rate of good to excellent results) ($p < 0.01$). At a mean of eighteen months of follow-up, radiographs demonstrated a higher prevalence of articular depression, displacement, and arthrosis in elbows that had been treated nonoperatively. Pearce and Gallannaugh[55] reported good to excellent results in all nineteen patients following open reduction and internal fixation of isolated, displaced partial articular fractures. However, it is difficult to discern from these series if the fractures represented stable or unstable partial articular radial head fractures or a combination of these injuries. Ring et al.[38] retrospectively reported on

Fig. 1-C

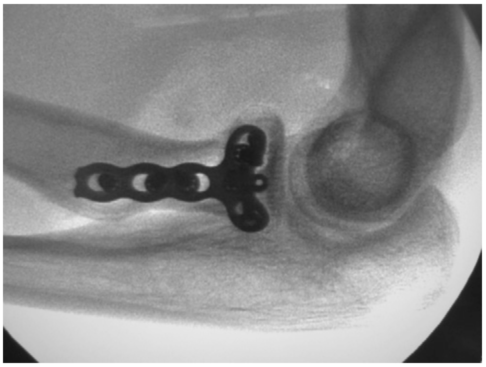

Fig. 1-D

Figs. 1-C and 1-D Postoperative fluoroscopic images following fixation. Note that the orientation of the long axis of the radial head is perpendicular to the lesser sigmoid notch of the ulna with forearm in neutral.

Fig. 2-A

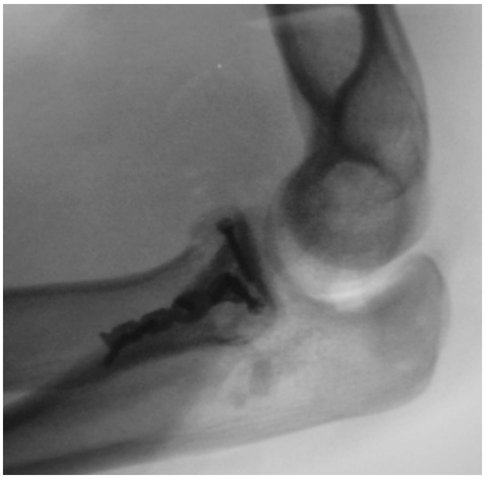

Fig. 2-B

Postoperative anteroposterior (**Fig. 2-A**) and lateral (**Fig. 2-B**) radiographs of the elbow, demonstrating fixation with a combination of buried screws and minicondylar blade-plate fixation.

thirty patients following open reduction and internal fixation of displaced partial articular fractures. Fifteen fractures were comminuted, and fifteen consisted of a single fragment. Four (27%) of the fifteen patients with comminution of the partial articular fragment had an unsatisfactory outcome, and all four of these cases were associated with a fracture-dislocation of the elbow or forearm. In contrast, all fifteen patients who had a displaced, noncomminuted single-fragment fracture achieved a satisfactory outcome.

When a partial articular fracture of the radial head creates a mechanical block to motion but is not amenable to open reduction and internal fixation, fragment excision may be performed. If fragment excision is contemplated, it must be confirmed that the fragment or fragments are not essential to elbow or forearm stability. If stability is in question, radial head replacement is performed. The effect of radial head fracture size on elbow kinematics and stability has been demonstrated[64]. Excision of radial head fragments totaling >25% of the surface area of the articular disc should be avoided.

Patients should be counseled that radial head excision, prosthetic replacement, and intra-articular osteotomy remain options if symptomatic malunion or nonunion of a partial articular fracture develops.

Complete Articular Fractures (Mason Type 3)

In the case of a young patient with a complete multifragmentary articular injury, priority is given to open reduction and internal fixation to salvage the native radial head if stable fixation can be achieved. This allows for restoration of the lateral column and early motion. In the case of a highly comminuted fracture in which stable fixation cannot be achieved, prosthetic replacement is preferred (Figs. 3-A through 3-D). Ring et al.[38] suggested that open reduction and internal fixation is best reserved for minimally comminuted fractures with three or fewer articular fragments. Attempted fixation when there are more than three fragments at the site of an unstable displaced fracture risks failure of fixation, fragment nonunion and/or osteonecrosis[38,65], and unpredictable ulnohumeral and forearm motion[36,38]. The risks of open reduction and internal fixation failure should be balanced against the long-term effects of radial head arthroplasty. For unstable and complex complete articular fractures, radial head arthroplasty may offer more predictable results[51,65-72] while restoring radial length, radiocapitellar contact, and elbow kinematics[67]. To elucidate the optimum treatment of the displaced, unstable radial head fracture—that is, open reduction and internal fixation or arthroplasty—prospective, randomized, controlled studies are needed. This is a difficult task given the incidence of these injuries combined with the reality that many unstable, displaced fractures may not be amenable to stable open reduction and internal fixation once intraoperative exposure and assessment has been performed.

Radial Head Arthroplasty

Radial head prosthetic replacement aims to help stabilize an elbow with traumatic instability[66] when stable fixation of a multifragmentary articular fracture of the radial head is not possible[36,38]. The indications for the use of a metallic radial head prosthesis include an acute comminuted fracture of the radial head (with or without neck involvement) involving >30% of the articular surface of the radial head for which satisfactory reduction and stable internal fixation cannot be achieved. A low threshold for radial head replacement in the setting of associated complex elbow and forearm fracture-dislocation patterns such as terrible triad injuries, longitudinal instability of the forearm, and Monteggia and transolecranon fracture-dislocations is recommended[36,38,66]. Various prosthetic head and

Fig. 3-A

Fig. 3-B

Figs. 3-A and 3-B Preoperative anteroposterior (**Fig. 3-A**) and lateral (**Fig. 3-B**) radiographs demonstrating an unstable, complete articular fracture of the radial head with loss of cortical contact as a component of a ''terrible triad'' injury. The fracture was not amenable to stable fixation.

stem implant designs are available and aim to replicate native radial head size, height, and head-neck offset to restore radiocapitellar and proximal radioulnar joint in vivo kinematics.

Radial Head Excision

Acute radial head excision is rarely indicated given the coincidence of unstable, displaced partial articular (Mason Type-2) and complete articular (Mason Type-3) fractures of the radial head and neck associated with complex periarticular fracture-dislocations about the elbow and forearm[18,62]. Open reduction and internal fixation yields results superior to radial head excision for the treatment of unstable Mason Type-2, 3, and 4 fractures associated with complex elbow fracture-dislocations[73,74]. When excision is contemplated for the treatment of an isolated, irreparable radial head fracture with no radiographic evidence of instability on radiographs[75], intraoperative assessment for ligament injury, particularly of the ulnar collateral ligament and interosseous membrane, is required[26,75]. The prevalence, severity, and clinical sequelae of proximal migration of the radius after the excision of isolated fractures of the radial head remain controversial[75-77]. While biomechanical alterations at the ulnotrochlear articulation are seen following resection[72,78], Antuña et al.[79] reported no correlation between satisfactory functional outcomes and the degree of arthrosis at the time of long-term follow-up after acute radial head resection in young patients with isolated fractures without associated instability.

Radial Head and Neck Fractures Associated with Complex Elbow and Forearm Injuries

Unstable, displaced Mason Type-2 and 3 fractures of the radial head and neck are often a component of complex fracture-

Fig. 3-C

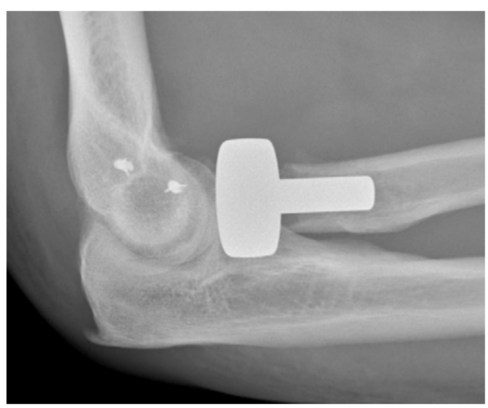

Fig. 3-D

Figs. 3-C and 3-D Postoperative radiographs made after radial head replacement and suture anchor repair of the avulsed lateral collateral ligament complex.

dislocation patterns about the elbow and forearm[62]. These patterns include the spectrum of posterolateral rotatory instability injuries (displaced partial or complete articular fractures of the radial head in conjunction with rupture of the lateral collateral ligament and terrible triad injuries), valgus injuries of the elbow (tensile failure and disruption of the ulnar collateral ligament complex followed by lateral column fracture), posterior transolecranon fracture-dislocations and posterior Monteggia[80] variants (Bado[81] Type-2 injuries), and longitudinal instability of the forearm (Essex-Lopresti[82] lesions). Although series have been of a retrospective nature, it has been consistently demonstrated that restoration of stable radiocapitellar contact and the lateral column buttress is essential to optimize outcomes following these complex elbow and forearm injuries[66,83-89]. In these injuries, prosthetic replacement of the radial head is preferred over suboptimal fixation because the radial head and neck will bear increased axial, coronal, and sagittal plane forces because of the associated soft-tissue disruptions. Suboptimum fixation may result in early or late failure. In addition, greater disability and inferior clinical outcomes have been reported in patients who receive delayed treatment of radial head fractures associated with complex fracture-dislocation patterns[90].

Postoperative Care

When rigid fixation is achieved or prosthetic replacement is performed, a long arm posterior plaster splint or bulky compressive dressing is worn until the first office visit between seven and ten days postoperatively. Active and active-assisted range of motion of the elbow and forearm is then initiated on the basis of the stability of fixation and assessment of the radiographs. In the presence of concomitant ligamentous or functionally equivalent osseous injuries, a ligament-specific protocol may be instituted with mobilization in pronation (lateral-sided injury)[91] or supination (medial-sided injury)[92]. Shoulder abduction and varus stress on the elbow is avoided when lateral-sided injury is present. Strengthening exercises are initiated when there is clinical and radiographic evidence of fracture union. Delayed or protected mobilization with a hinged elbow brace may be necessary when there is concern about elbow stability following complex fracture-dislocations. A hinged brace with gradual reduction of the extension block helps to maintain radial head congruity against the capitellum and to protect soft-tissue repairs. Extension splinting may be used to address flexion contracture. Static progressive splinting can be effective for regaining ulnohumeral motion[20,93], although flexion contracture release may be needed.

Overview

Fractures of the radial head and neck continue to represent technical challenges to the upper extremity surgeon. A better appreciation of the spectrum of injuries that may be seen at the proximal part of the radius, whether in isolation or in conjunction with associated complex elbow and forearm injury patterns, continues to emerge. Headless or variable-pitch compression screws buried in a subarticular fashion allow for stable fixation of the articular disc in select cases of partial head fractures. Complete articular fractures and combined radial head-neck fractures may be addressed with a low-profile periarticular implant that allows for a single fixation construct in cases of neck or shaft extension. Fixed-angle low-profile periarticular implants help to address technical challenges created by metaphyseal comminution and bone loss in the radial neck, radial head-neck impaction, and osteopenia. Evolution in radial head prosthetic designs to better match the dynamic in vivo relationships in the radiocapitellar and proximal radioulnar joints may improve outcomes following radial head arthroplasty.

Displacement, fragment stability, the magnitude of articular comminution of fracture fragments, and associated complex injuries are essential components to consider in the decision-making process. The concept of fracture fragment stability is often undefined in current studies of elbow fractures. Recognition of fragment instability may help to elucidate the optimum treatment of Type-2 fractures and may prove to be an important determinant of outcomes following radial head fractures[35].

Current evidence supports the treatment of isolated, minimally displaced or stable Mason Type-2 partial articular fractures without associated block to motion with early, progressive active range of motion. Displaced, partial articular fractures creating mechanical impediment to motion are treated with open reduction and internal fixation. Isolated, unstable and multifragmentary fractures of the radial head and those associated with complex elbow fracture-dislocation and ligamentous injuries are usually treated with radial head arthroplasty. Open reduction and internal fixation is performed when a stable fixation construct that allows for radiocapitellar contact and early motion is obtainable. Fixation failure, nonunion, osteonecrosis, recurrent instability, and poor functional outcomes are seen following open reduction and internal fixation of these complex fractures if fixation is tenuous. Severe articular fragmentation, displacement with loss of cortical contact, metaphyseal bone loss, and the size and quality of the fracture fragments make open reduction and internal fixation technically challenging. The optimum fracture for open reduction and internal fixation will have three or fewer articular fragments without impaction or deformity, each of sufficient size and bone quality to accept screw fixation, and little or no metaphyseal bone loss. The exposure that is selected will be determined on the basis of the constellation of osseous, ligamentous, and soft-tissue injuries. ■

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