Current concepts in the management of radial head fractures

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Abstract
Fracture of the radial head is a common injury. Over the last decades, the radial head is increasingly recognized as an important stabilizer of the elbow. In order to maintain stability of the injured elbow, goals of treatment of radial head fractures have become more and more towards restoring function and stability of the elbow. As treatment strategies have changed over the years, with an increasing amount of literature on this subject, the purpose of this article was to provide an overview of current concepts of the management of radial head fractures.

Key words: Elbow; Fracture; Management; Radial head; Trauma

INTRODUCTION
Fractures of the radial head are the most common fractures in the elbow[1]. Although it has been 80 years since one of the first reports on radial head fractures...
was published in the New England Journal of Medicine; the radial head is still a topic for debate in the orthopedic and trauma literature[2]. Over the last decades, the radial head is increasingly recognized as an important stabilizer of the elbow[3,4]. In order to maintain stability of the injured elbow, the main goal in the treatment of radial head fractures is to restore the anatomy of the radial head and surrounding tissues. The purpose of this article was to discuss current aspects in the etiology and management of radial head fractures in adults.

**EPIDEMIOLOGY**

Fractures of the radial head are common, with an estimated incidence of 2.5 to 2.8 per 10000 inhabitants per year. They account for approximately one-third of all elbow fractures. The mean age of patients that sustain a radial head fracture varies between 44 to 47.9 years[5-7]. Male-female ratios vary between 1:1, 2:3 and 3:2[1,6,8,9]. Female patients are significantly older compared to male patients (37-41 years vs 48-54 years)[6,7]. The peak incidence in men is between the age of 30 and 40 years and in women it is between 50 and 60 years[6]. Once the age rises above 50 years, the number of female patients with a radial head fracture is significantly larger than the number of male patients[6]. This typical distribution can be explained by a correlation with the presence of osteoporosis in female patients above the age of 50 years and higher energy trauma in young males[10].

**BIOMECHANICS**

The radial head is an important secondary stabilizer in valgus and external rotation. The issue of the individual contributions of the radial head and soft-tissue stabilizers of the elbow is very complex. Several biomechanical studies have been conducted to quantify elbow stability for simulated fractures, radial head excision, and radial head replacement, with and without the integrity of the collateral ligaments[2,11].

Radial head excision alters the kinematics and varus-valgus laxity of the elbow with intact ligaments and that stability is improved after radial head arthroplasty[11-13]. Also an increase in external rotation of the ulna with respect to the humerus during passive motion with the forearm in supination was observed after radial head excision when both ligaments were intact[12].

A significant decrease in elbow stability was noted if the radial head was excised in elbows with an associated disruption of the lateral collateral ligament (LCL). Elbow laxity was improved following radial head arthroplasty; however, these elbows were still unstable relative to those with intact ligaments[12]. These findings suggest that repair of the disrupted LCL complex is essential in order to restore elbow stability following open reduction and internal fixation (ORIF) of the radial head or radial head arthroplasty.

Pomianowski et al[14] reported that laxity was increased after radial head excision in elbows with disruption of the medial collateral ligament (MCL). Radial head arthroplasty restores valgus stability in elbows with disruption of the MCL to a state similar to that seen in elbows with a native radial head[14,15]. Other studies observed an improved but not normal stability after radial head arthroplasty with MCL insufficiency[12,16]. However, the amount of instability was very small, possibly because of the stabilizing effect of the biceps and brachialis.

**ASSOCIATED INJURIES**

When treating patients with a fracture of the radial head, special attention has to be given to the detection and treatment of associated injuries of the injured extremity. van Riet et al[7] found an incidence of associated injuries in 39% in a retrospective evaluation of 333 patients with a radial head fracture. Loss of cortical contact and comminution of the radial head fracture are strongly related to a high incidence of associated injuries[7,21]. Associated injuries as ligamentous injuries, or bone bruise of the capitellum can be found using magnetic resonance imaging (MRI) in 76% to 96% of the patients with a radial head fracture[26,27]. In 9 of 14 patients with a Mason type I radial head fracture Hausmann et al[28] found partial lesions of the interosseous membrane (IOM) with MRI. Seven of these patients reported pain...
in the region on the distal IOM[28]. On the other hand, McGinley et al[29] only found incomplete or complete tears of the IOM in 5 patients with a Mason type II or III radial head fracture, the IOM was intact in all 13 patients with a Mason type I fracture[29]. Overall, the clinical relevance of associated injuries found with MRI is likely to be limited[30].

**Ligamentous injuries**
Using MRI in 61% to 80% of the patients with a radial head fracture ligamentous injuries are seen; although these findings were not always clinically relevant[29]. Persistent symptoms after LCL injuries were seen in 11% of the patients with a radial head fracture, and in 1.5% of the patients with a MCL lesion. Lesions of both the MCL and LCL are found in 6%[7]. Ligamentous injuries of the elbow occur as the radial head fractures with the elbow in flexion and pronation with the hand fixed on the ground. As a result of the forced supination of the forearm the LCL ruptures when the body rotates internally on the elbow under axial compression. A posterolateral dislocation with or without rupture of the MCL can occur if rotational and axial forces continue. Also as a result of a valgus moment the MCL can rupture[31,32].

**Elbow dislocation and coronoid process fractures**
Posterolateral dislocation of the elbow accompanies 3% to 14% of radial head fractures and can occur after a fall on the (nearly) extended arm[6,7]. In the trauma mechanism as mentioned above, the coronoid process is forced under the trochlea of the humerus and can cause a shear fracture. The combination of an elbow dislocation, radial head fracture and coronoid fracture is called "the terrible triad of the elbow”. Severe elbow instability and many post-traumatic complications are associated with this terrible triad[30].

**Ulnar fractures**
Ulnar fractures occur in 1.2% to 12% of the patients with a radial head fracture[6,7]. This includes the Monteggia lesion, which is a radial head dislocation in combination with a fracture of the distal one third of the ulna[34]. The trauma mechanism is a fall on the outstretched arm with the forearm in hyperpronation. A dislocation of the fractured radial head can also occur in complex proximal ulna fractures[35].

**Capitellar injuries**
(Osteo)chondral lesions of the capitellum occur as the radial head is forced on the capitellum under the axial loading. In MRI studies injury to the capitellum is seen in 39% to 96% of the patients[26,27]. Capitellar fractures occur in 2%[7].

**Other associated injuries**
A rare associated injury of radial head fractures is a rupture of the IOM between radius and ulna and rupture of the triangular fibrocartilage complex. It is also known as an acute longitudinal radioulnar dissociation or Essex-Lopresti injury[36]. Neurovascular injuries can also occur. Neurologic injuries occur in 20% of elbow dislocations of which the ulnar and median nerve are most commonly affected[37]. Severe anterior displacement of the radial head can cause injury to the radial nerve. Posterior interosseous nerve injury has also been reported[38,39]. Brachial artery injury accompanies 0.3% to 1.7% of elbow dislocations[40].

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**Table 1 Classification and description of radial head fractures**

| Type | Mason | Johnston | Hotchkiss | Broberg and Morrey | Rineer |
|------|-------|----------|-----------|-------------------|--------|
| I    | Without displacement | Without displacement | < 2 mm dislocation | < 2 mm dislocation | Cortical contact between fragments |
| II   | With displacement | With displacement | > 2 mm dislocation | > 2-3 mm dislocation and involves > 30% of radial head | No cortical contact between fragments |
| III  | Comminuted | Comminuted | Fracture associated with dislocation of the elbow | Comminuted | Fracture associated with dislocation of the elbow |
| IV   | - | - | - | - | - |

**Figure 1 Different types of radial head fractures and possible associated injuries.**
MANAGEMENT OF NONDISPLACED FRACTURES

In general, the treatment of Mason type I fractures is conservative with a pressure bandage and sling for support, and active mobilization as early as possible. Aspiration of the intra-articular haematoma leads to a decrease in intra-articular pressure and pain. Though there is no significant difference in pain between groups of patients in which the haematoma was aspirated compared to patients in whom aspiration was combined with bupivacaine injection in the elbow joint. The natural course of Mason type I fractures is in general benign, however, in some studies persistent complaints have been reported in 20% of cases. In several series, patients with the shortest period of immobilization had the best patient-reported outcome measure scores (PROMs) at follow-up. Shulman et al. recently evaluated the follow-up of patients with a Mason type I fracture, and concluded that "orthopaedic surgeons are likely over treating patients with Mason-Johnson Type I radial head fractures by recommending frequent radiographic follow-up without modifying treatment, leading to unnecessary patient visits, radiation exposure, and increased costs". 

MANAGEMENT OF STABLE PARTIAL ARTICULAR DISPLACED FRACTURES

There is currently no consensus on the treatment of patients with isolated, displaced, stable, partial articular fractures of the radial head. Surgical repair of radial head fractures became popular after the introduction of new techniques and implants for the fixation of small articular fracture fragments. Later, enthusiasm grew with reports of good results on surgical treatment of these Mason type II fractures. On the other hand, articles on the conservative treatment of Mason type II fractures also report favorable outcomes. Lindenhovius et al. reported on the long-term outcome of ORIF for stable displaced partial articular fractures of the radial head with an average 22 years follow-up. Although the results were good, complications were seen in 44% of patients. Furthermore, they compared their results with the 19 years follow-up of the same type of fractures that were treated conservatively by Akesson et al. and concluded that ORIF is not superior in the long-term. These results are in accordance to a recent retrospective comparative study by Yoon et al., in which nonoperative management was compared to ORIF. They found no clinically significant difference in PROMs, ROM and strength between the groups. However, more complications (failure of hardware and heterotopic ossifications (HO)) were seen following ORIF, and younger patients scored worse on PROMs. Helling et al. found no significant difference in outcome between ORIF with metal screws vs biodegradable polylactide pins for the treatment of displaced radial head fractures. Kaas et al. performed a systematic review on the treatment of Mason type II fractures and concluded that, based on 9 included retrospective series, there was insufficient evidence to determine which treatment is superior. Currently, the inclusion of patients for a multicenter randomized controlled trial is initiated to define whether stable partial articular displaced fractures of the radial head are best treated by ORIF or nonoperative management.

MANAGEMENT OF COMMINUTED FRACTURES

Although Mason originally advised to perform a resection of the comminuted fractured radial head, numerous other surgical techniques have been described last decades. In cases of isolated comminuted radial head fractures, without associated instability of the elbow, resection of the radial head may lead to satisfactory results. Replacement of the radial head by silicone implants was performed with the idea to restore elbow stability, but resulted in several implant-related problems and complications. Subsequently, management by ORIF became more popular. Good results were reported after ORIF for stable radial head fractures. However, Ring et al. established that ORIF for Mason type III fractures with more than three articular fragments was more likely to result in unsatisfactory outcomes compared to fractures with only 2 or 3 simple fragments. These severely comminuted unstable fractures of the radial head are difficult to restore and are prone to result into hardware failure or nonunion. Moro et al. therefore advised to use metallic radial head prosthesis (RHP) if a stable internal fixation of the comminuted radial head cannot be achieved. A literature search revealed only one randomized study by Chen et al., which compared ORIF vs arthroplasty for comminuted unstable radial head fractures. After two years of follow-up patients in the replacement group had significantly better PROMs. Furthermore, more complications (limitation in motion, nonunion, malunion, HO, infection) were seen following ORIF (11/23) compared to arthroplasty (3/22). The authors concluded that replacement is more effective than ORIF in clinical practice. However, they justly noted that prostheses have problems with ageing, loosening and wear, which are not seen in the short-term follow-up of that study. The main problem with of current RHP designs is that only short-term results are known. RHP may be classified according to the different materials used: (silicone, polyethylene, pyrocarbon, metal), into differences in modularity (monoblock vs modular), polarity (uni- or monopolar vs bipolar) or fixation method (cemented vs uncemented press fit vs intentional loose fit). Despite the growing amount of data, evolving surgical technique and improving implant design and rationale; prosthetic radial head replacement is far from what should be
Some observations on fractures of the head of the radial head were made by Mason ML in 1954. He noted that elbow function should be maintained by restoring the ulnohumeral joint. Fractures of coronoid, olecranon, or distal humerus should therefore be treated by osteosynthesis. The second principle is that elbow stability should be reestablished. As described above, the radial head is an important secondary stabilizer of the elbow, and radial head fractures are commonly concomitant to ligamentous injuries. Lesions of the LCL and MCL should therefore be repaired in most cases.

### MANAGEMENT OF ASSOCIATED INJURIES

The treatment of complex elbow trauma is based on 2 principles. The first principle is that elbow function should be maintained by restoring the ulnohumeral joint. Fractures of coronoid, olecranon, or distal humerus should therefore be treated by osteosynthesis. The second principle is that elbow stability should be reestablished. As described above, the radial head is an important secondary stabilizer of the elbow, and radial head fractures are commonly concomitant to ligamentous injuries. Lesions of the LCL and MCL should therefore be repaired in most cases.

**CONCLUSION**

The radial head is an important secondary stabilizer of the elbow, and fractures of the radial head (and its associated injuries) can result in pain, posttraumatic osteoarthritis and impaired elbow function. Management of radial head fractures should therefore be directed to achieve a stable and functional elbow joint (Table 2). Nondisplaced fractures should be treated by early active motion. The best treatment of stable partial articular fractures is currently unclear, and can be either conservatively by early motion, or ORIF and early motion. Comminuted unstable fractures that consist of 2 or 3 simple fragments can be treated by ORIF. However, if stable internal fixation is not obtained, or the fracture consists of more than 3 fragments, radial head arthroplasty results in better outcomes in the short-term. Long-term results of RHP are still unknown.

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**Table 2 Summary of treatment options for different types of radial head fractures**

| Mason type | Indication | Treatment options |
|------------|------------|-------------------|
| I          | All        | Conservative with early motion |
| II         | Stable     | Conservative with early motion or ORIF |
|            | Block with rotation | ORIF |
| III        | 2-3 simple fragments | ORIF |
| IV         | > 3 unstable fragments | Arthroplasty |
|            | See above  | See above |

*The treatment options for the radial head are listed here. It is essential to recognize associated injuries that may require surgical treatment such as lateral collateral ligament ruptures and impaction damage of the capitellum. ORIF: Open reduction and internal fixation.
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