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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

Core tip: The radial head is one of the most debated subjects 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.

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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[3,11].

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.

CLASSIFICATION

Mason[1] observed, back in 1954, the fracture patterns of the radial head in 100 patients and divided them in three groups. Mason Type Ⅰ fractures (73%) of the radial head involved fractures without displacement, type Ⅱ fractures (19%) were marginal sector fractures with displacement, and type Ⅲ fractures (8%) were comminuted[17]. In 1962, Johnston[18] added fractures of the radial head that were associated with a dislocation of the elbow, as a type Ⅳ to the system. Subsequently, Broberg and Morrey[19] and Hotchkiss[20] further quantified the amount of dislocation for type Ⅱ fractures. More recently, Rineer *et al*[21] suggested that the stability of the fracture can be determined based on the detail whether there was cortical contact between the fragments, or not. The various classifications are summarized in Table 1 and Figure 1. The interobserver agreement for diagnosing a 2 mm gap (κ = 0.55) or cortical contact (κ = 0.43) on standard radiographs was moderate[22]. Two- or three-dimensional computed tomography (CT) scans improved sensitivity for diagnosis in another study, though the interobserver agreement was still only moderate for most fracture characteristics[23]. Potential benefit of CT reconstructions is to determine the location of the fracture in the radial head (most commonly anterolateral quadrant with the forearm in neutral position), which may be associated with change on associated injuries and elbow instability[24,25].

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 injures 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

Table 1 Classification and description of radial head fractures

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

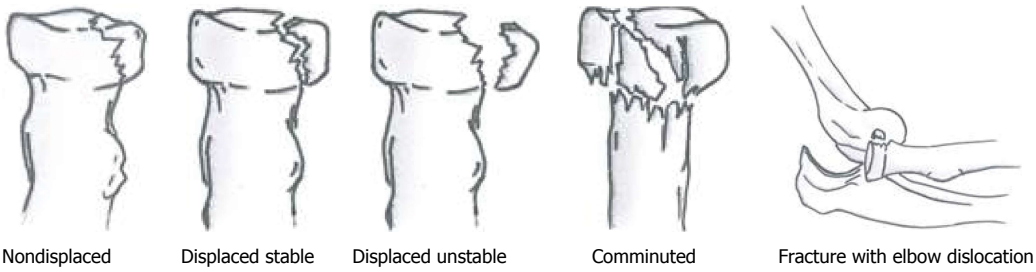

Figure 1 Different types of radial head fractures and possible associated injuries.

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[30]. 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[33].

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].

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[41]. Aspiration of the intra-articular haematoma leads to a decrease in intra-articular pressure and pain[42]. 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[43]. 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[44]. In several series, patients with the shortest period of immobilization had the best patient-reported outcome measure scores (PROMs) at follow-up[44,45]. Shulman *et al*[46] 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[47-52]. Later, enthusiasm grew with reports of good results on surgical treatment of these Mason type Ⅱ fractures[49-51,53]. On the other hand, articles on the conservative treatment of Mason type Ⅱ fractures also report favorable outcomes[54,55]. Lindenhovius *et al*[56] 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*[54] 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*[57], in which nonoperative management was compared to ORIF. They found no clinically significant difference in PROMs, ROM and strength between the groups[57]. However, more complications [failure of hardware and heterotopic ossifications (HO)] were seen following ORIF, and younger patients scored worse on PROMs. Helling *et al*[58] 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*[59] 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[59]. 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[60].

MANAGEMENT OF COMMINUTED FRACTURES

Although Mason[1] 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[61]. 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[62]. Subsequently, management by ORIF became more popular. Good results were reported after ORIF for stable radial head fractures[51]. However, Ring *et al*[63] 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[63]. 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*[64] 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*[65], 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 prosthesis 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- to mid-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

Table 2 Summery of treatment options for different types of radial head fractures

Mason type	Indication	Treatment options[1]
I	All	Conservative with early motion
II	Stable	Conservative with early motion or ORIF
	Unstable	Conservative with early motion or ORIF
	Block with rotation	ORIF
III	2-3 simple fragments	ORIF
	> 3 unstable fragments	Arthroplasty
IV	See above	See above

[1]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.

considered an established and routine procedure. It is currently unknown whether one fixation technique has superior outcomes over the others. The same question accounts for material and design of the implants. Future research should therefore compare the various types of RHP and obtain long-term results of the implants.

MANAGEMENT OF ASSOCIATED INJURIES

The treatment of complex elbow trauma is based on 2 principles[35]. 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[35].

CONCLUSION

The radial head is 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.

In all cases of surgically treated radial head fractures it is of utmost importance to adequately assess and treat associated injuries of the coronoid, olecranon and ligaments.

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