Comminuted fractures of the radial head and neck

IS FIXATION TO THE SHAFT NECESSARY?

M. Neumann, R. Nyffeler, M. Beck

From the Department of Orthopaedic Surgery, University of Bern, Inselspital, Bern, Switzerland

Mason type III fractures of the radial head are treated by open reduction and internal fixation, resection or prosthetic joint replacement. When internal fixation is performed, fixation of the radial head to the shaft is difficult and implant-related complications are common. Furthermore, problems of devascularisation of the radial head can result from fixation of the plate to the radial neck.

In a small retrospective study, the treatment of Mason type III fractures with fixation of the radial neck in 13 cases (group 2) was compared with 12 cases where no fixation was performed (group 1). The mean clinical and radiological follow-up was four years (1 to 9). The Broberg-Morrey index showed excellent results in both groups. Degenerative radiological changes were seen more frequently in group 2, and removal of the implant was necessary in seven of 13 cases.

Post-operative evaluation of these two different techniques revealed similar ranges of movement and functional scores. We propose that anatomical reconstruction of the radial head without metalwork fixation to the neck is preferable, and the outcome is the same as that achieved with the conventional technique. In addition degenerative changes of the elbow joint may develop less frequently, and implant removal is not necessary.

The radial head stabilises the radius during rotation of the forearm and is responsible for transmitting most of the axial load across the elbow joint. Loss of the radial head may lead to instability of the joint, with proximal migration of the radius.

Fractures of the radial head or neck are common and account for 17% to 19% of all elbow trauma, occurring as an isolated fracture or combined with other injuries of the elbow joint. The fractures are caused by axial compression of the extended and pronated forearm or by postero-lateral rotatory subluxation of the elbow, when marginal or radial fracture patterns occur. A fall backwards onto the supinated arm leads to compression or comminuted fractures of the radial head, and high-energy trauma may lead to a rupture of the interosseous membrane and of the capsule-ligamentous complex of the distal radioulnar joint, the so-called Essex-Lopresti lesion.

In 1954, Mason introduced a classification of radial head fractures that has been modified by Johnston. Mason type I are fissure fractures or marginal sector fractures without displacement. Mason type II are marginal fractures with displacement causing widening of the head and depression or tilting of the segment. Mason type III are comminuted fractures of the radial head. Fracture type IV was added later by Johnston and describes a fracture of the radial head combined with dislocation of the elbow. However, type IV fractures do not take into account the specific fracture pattern of the radial head, therefore it is more convenient to use the original Mason classification with a description of additional injuries. Additional injuries are found in up to 97% of cases and include fracture or rupture of the coronoid, the olecranon, the lateral and medial ligaments and the distal radioulnar joint. They are found in 50% of Mason type II and 75% of Mason type III fractures.

Treatment depends on the type of fracture. Type I fractures are usually treated conservatively. The treatment of type II fractures is a matter of some debate. In cases with moderately displaced two-part fractures, non-surgical treatment with early active movement has been reported to produce good results in 85% to 95% of patients. Open reduction and internal fixation or resection of the radial head is recommended in displaced fractures with two or three fracture fragments.

Type III fractures are generally treated by open reduction and internal fixation, resection, or...
occasionally prosthetic replacement, particularly in the presence of an Essex-Lopresti lesion. Resection of the radial head may be undertaken if the medial collateral ligament and the coronoid are intact, otherwise valgus instability may occur. Prosthetic replacement is necessary in the presence of a coronoid fracture combined with an unreconstructable radial head.

Post-operative complications after open surgery include displacement, synostosis, secondary loss of reduction, malunion and necrosis of the radial head. Additionally, poor forearm rotation, nonunion and radiocapitellar impingement due to the osteosynthesis plate have been reported.

Stabilisation of the radial head to the shaft can be difficult, and fixation may interfere with forearm rotation. Anatomical reconstruction of the radial head without stable fixation to the radial neck can be successful if the radial head rotates with the radial shaft. Supplementary screw or plate fixation of the radial neck fracture may not be required.

The aim of this retrospective study was to evaluate the outcome of Mason type III fractures treated by reconstruction of the radial head without fixation to the shaft, and to compare them with a group of patients where the conventional technique with fixation to the shaft was used. Our hypothesis was that the results of both techniques would be the same.

Patients and Methods
Local ethics approval was obtained. We searched our medical database for patients with radial head fractures treated in our clinic from 1998 to 2006. We classified them according to Mason and van Riet and Morrey, which includes associated lesions of the elbow joint. We also used the modification introduced by Ikeda et al., in which type A is a simple fracture of the entire radial neck with the head completely displaced from the shaft and type B is an articular fracture involving the entire head, consisting of more than two large fragments which are completely displaced from the shaft. Type C fractures are tilted, with an impacted articular segment and some articular fragments displaced from the shaft (Fig. 1).

Traditionally, treatment has involved anatomical reconstruction of the radial head, followed by fixation of the reconstructed radial head to the radial neck/shaft. In 2001 an alternative concept was introduced where following reconstruction of the radial head and repair of soft-tissue, the rotational stability of the neck fracture was assessed by forearm pronation and supination. If the radial neck rotated as one with the shaft of the radius, fixation to the shaft was considered unnecessary. Patients managed in this way constituted group 1 (Figs 2 to 4). If the radial head did not rotate synchronously with the shaft, the head was fixed to the radial neck using a low-profile AO mini-plate (Synthes, Oberdorf, Switzerland), and these were the group 2 patients.

In total, we found 78 patients with 80 fractures (two bilateral) of the radial head, of whom 14 with Mason type I, 16 with Mason type II and 11 with polytrauma were excluded from the study. Resection of the radial head was necessary in five cases, with prosthetic replacement in three patients. In all, five patients were lost to follow-up. This left 24 patients with 25 Mason type III fractures for the study. The mean follow-up was four years (1 to 9). There were 20 males and four females, whose mean age at operation was 42 years (14 to 78). Group 1 had a mean age of 48 years (14 to 67), and group 2 had a mean age of 32 years (19 to 74). Group 1 included nine male and two female patients. Group 2 included ten male and two female patients. In addition one man sustained bilateral fractures; one was treated in group 1, the other in group 2. In 12 elbows fixation to the radial shaft was not considered necessary (group 1), and in the remaining 13 elbows the reconstructed radial head was fixed to the shaft (group 2).

Post-operative care was the same for both groups. For six weeks the elbow was protected in a removable splint. Assisted mobilisation exercises with free range of pronation and supination were started on the first post-operative day. However, flexion and extension were restricted to approximately 10° less than full movement.

All patients were seen at six weeks, three and six months, as well as one year after surgery, and then every year on an individual basis by the treating surgeon. Those patients whose last examination was more than one year ago at the time of this study were contacted and returned for updated clinical and radiological examination. The clinical evaluation by two authors (MN, RN) included evaluation of stability, and measurement of range of flexion and extension of the elbow and pronation and supination of the forearm using a goniometer.

Anteroposterior (AP) and lateral radiographs of the elbow were taken and degenerative changes in the elbow joint were classified as described by Broberg and Morrey by the same two authors (MN, RN).

Function of the elbow was measured using the functional rating index introduced by Broberg and Morrey. A maximum of 40 points is given for range of movement and 20 points for strength. Stability has a maximum of five
points and absence of pain has a maximum of 35, making a maximum total of 100 points.

For statistical comparison of the two groups the unpaired $t$-test was used, and statistical significance was set at a p-value of $< 0.05$.

**Results**

The mean follow-up was 7.8 years (4 to 114 months) for group 1 and 3.5 years (3 to 105 months) for group 2. The distribution of severity of the fractures was almost equivalent between the two groups, but group 2 had more associated injuries, especially fractures of the coronoid and olecranon. Three medial collateral ligament injuries were present in group 2. Only one distal radioulnar joint lesion was found and this occurred in group 1 (Table I).

Post-operative range of movement showed comparable results for both groups (Table II), although group 1 achieved slightly better movement. The mean loss of extension in group 2 was increased but none of the differences were statistically significant and none were clinically relevant.

The mean functional outcome was excellent in both groups: 95.4 points in group 2 and 97.5 points in group 1.
No patient suffered from pain at the latest follow-up. Neither the overall difference in movement (p = 0.9331) between the two groups nor the functional outcome (p = 0.716) reached statistical significance.

At the latest follow-up degenerative changes were seen more frequently in group 2, in which two patients had narrowing of the joint space, compared with none in group 1. Subchondral cysts were observed in one patient from group 2. This difference was not statistically significant (Fisher’s exact test, p = 0.14). In group 2 two cases of non-union of the radial neck occurred after one and 1.5 years respectively, compared with one case after two years in group 1. These were successfully treated with osteosynthesis. Heterotopic ossification was not seen in either group.
There were no post-operative infections or neurological deficits. Implant removal was necessary in seven patients from group 2 because of limitation of extension and supination caused by the plate after a mean of nine months (4 to 15), and in one case in group 1 after ten months (too long screws).

Discussion
Reconstruction of the radial head and correct alignment on the neck are both essential for normal rotation of the proximal radio-ulnar joint.\textsuperscript{8,23,24} Preservation of the radial head via open reduction and internal fixation is currently the recommended method of treatment to restore alignment and stability of the elbow, where feasible.\textsuperscript{7,11,14,19,23} The use of modern modular metallic radial head prostheses is not entirely satisfactory, as studies show reduced range of movement and strength.\textsuperscript{26-28}

When internal fixation of Mason type III fractures of the radial head is performed, fixation of the radial head to the shaft can be difficult and implant-related complications are common.\textsuperscript{7,14}

Furthermore, devascularisation of the radial head can result from fixation of the plate to the radial neck. In order to avoid these problems, Smith et al.\textsuperscript{25} recommended a low-profile fixation with screws running obliquely from the radial head to the shaft. However, it would be even more advantageous if fixation of the radial neck fracture could be omitted, provided that the anatomically reconstructed radial head healed to the radial shaft.

In this retrospective study the technique of reconstruction of the radial head in isolation (group 1) was compared with reconstruction of the radial head and additional plate fixation of the reconstructed radial head to the neck (group 2). We were able to show that fixation of the reconstructed radial head to the radial neck was not always necessary, and that the outcome in such cases could not be clinically distinguished from those that were fixed.

A theoretical concern was a possible higher prevalence of nonunion in group 1. However, only one nonunion was observed in this group, compared with two in group 2. The key is to decide whether the neck fracture needs fixation, and this depends on whether or not the head and neck rotate together at operation. Factors that influence rotatory stability are an intact periosteal sleeve across the fracture, ragged fracture lines that facilitate interlocking of the fracture fragments and stable soft-tissue repair.

The two different techniques revealed no statistical difference in clinical outcome and function, possibly because of the small numbers in each group. Interestingly, degenerative changes were more often observed in group 2, where two elbows developed narrowing of the joint space and one showed the appearance of subchondral cysts. Neither was observed in group 1. There are two possible explanations for this. First, although the severity of the fracture pattern of the radial head was equal in both groups, there were more associated lesions in group 2, suggesting that these elbows were subjected to more severe trauma, which may have caused more severe cartilage damage and subsequent joint degeneration. Secondly, it is possible that the mobility across the fracture in group 1 allowed self-centring of the radial head with anatomical healing, whereas rigid, imperfect anatomical fixation of the radial head could lead to incongruence of the radio-humeral and/or radio-ulnar joint, with consequent degenerative changes.

Functional outcome and subjective satisfaction in this retrospective study were comparable with those in other studies of open reduction and internal fixation.\textsuperscript{9,11,12,29} Our results are comparable with a study in which the radial neck fracture was stabilised with oblique screws from the radial head into the radial neck.\textsuperscript{23} The avoidance of supplementary plating means that soft-tissue dissection along the radial neck is not required, with less disturbance of the vascular supply to the radial head, although neither study is actually able to demonstrate this theoretical benefit. Additionally, if a plate is not used in an already constrained space where it might interfere with rotation of the forearm, the need for subsequent removal does not arise.

There are several limitations to this study. It was a small retrospective, non-randomised study comparing two different techniques. Treatment was guided by intra-operative assessment of the rotatory stability of the radial neck fracture, which may have led to a selection bias where the more severe fractures were allocated to group 2. However, during the study period a rigid protocol did not exist, and it was the preference of some surgeons always to use a plate when treating these fractures. It is therefore likely that some fractures in group 2 could have been treated without fixation of the radial neck. Furthermore, although the severity of the fractures in both groups was comparable, there were more associated lesions in group 2. This could explain the reduced incidence of later degenerative changes in group 1.

Our study shows that fixation of the reconstructed radial head to the radial shaft is not always necessary, and that the outcome is at least equivalent to that of conventional techniques with internal fixation to the shaft, with the advantage that there is no need for removal of hardware. Overall, the technique with an anatomically reconstructed radial head as a biological spacer offers promising results in the treatment of Mason type III fractures. However, prospective randomised trials evaluating different techniques of fixation are still necessary to determine the optimal treatment of these fractures.

Listen live
Listen to the abstract of this article at www.jbjs.org.uk/interactive/audio

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References