Treatment of anterior fracture-dislocations of the proximal humerus by open reduction and internal fixation

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Over a seven-year period we treated a consecutive series of 58 patients, 20 men and 38 women with a mean age of 66 years (21 to 87) who had an acute complex anterior fracture-dislocation of the proximal humerus. Two patterns of injury are proposed for study based upon a prospective assessment of the pattern of soft-tissue and bony injury and the degree of devascularisation of the humeral head. In 23 patients, the head had retained capsular attachments and arterial back-bleeding (type-I injury), whereas in 35 patients the head was devoid of significant soft-tissue attachments with no active arterial bleeding (type-II injury).

Following treatment by open reduction and internal fixation, only two of 23 patients with type-I injuries developed radiological evidence of osteonecrosis of the humeral head, compared with four of seven patients with type-II injuries.

A policy of primary treatment by open reduction and internal fixation of type-I injuries is justified, whereas most elderly patients (aged 60 years or over) with type-II injuries are best treated by hemiarthroplasty. The best treatment for younger patients (aged under 60 years) who sustain type-II injuries is controversial and an individualised approach to their management is advocated.

In complex anterior fracture-dislocations of the proximal humerus, a Neer three- or four-part fracture is combined with disruption in the anteroinferior soft-tissue envelope. Because of the comparative rarity of this injury pattern, a detailed review of its anatomy and prognosis has not previously been undertaken.

Owing to the devascularisation of the humeral head as a result of the disruption of its capsular attachments, there is a high risk of osteonecrosis or nonunion following this injury. Arthroplasty therefore, has been the most widely advocated primary treatment, although the functional outcome may be sub-optimal. Complications of this procedure, such as stem loosening, instability and infection may compromise in the longer term, an initially satisfactory outcome.

In comparison to arthroplasty, successful open reduction and internal fixation offers the prospect of an improved functional outcome and the possibility that the development of osteonecrosis may be incomplete or relatively asymptomatic and complete revascularisation of the humeral head may occur through creeping substitution. However, the results of secondary arthroplasty following failure of a primary head-conserving procedure, may be less satisfactory than a primary arthroplasty.

In light of this information, we felt that a more detailed appraisal of the complex three-dimensional soft-tissue and bony anatomy of these injuries may improve our understanding of the potential viability of the humeral head and may serve as a guide for treatment. Our study had two aims; to evaluate the pathological anatomy of the soft-tissue and bony injury in a consecutive, unselected series of patients with anterior fracture-dislocation and to assess whether the anatomical configuration of the injury was predictive of the development of osteonecrosis and nonunion, in patients who underwent open reduction and internal fixation.

Patients and Methods

We chose to study patients with acute complex anterior fracture-dislocation of the proximal humerus, but not the more common two-part fracture-dislocations of the greater tuberosity or injuries in which the humeral head was subluxed. Over a seven-year period, a total of 76 patients fitted these criteria. We excluded seven patients who had a chronic fracture-dislocation, three who were treated non-operatively due to medical contra-indications to surgery and four who died within the first two years post-injury. In addition, four patients were lost.
Open reduction and internal fixation (ORIF) was carried out for all type-I injuries. Owing to our concerns regarding the long-term risks of the use of primary hemiarthroplasty, we also performed ORIF for patients under 60 years of age with type-II injuries. Patients aged 60 years or over with type-II injuries were treated by cemented hemiarthroplasty.

In patients undergoing ORIF, we attempted to reduce and stabilise the humeral head anatomically after its relocation. The metaphyseal defect, created behind the anatomical neck following reduction, was filled with either carbonated apatite bone cement (Norian SRS, Synthes Ltd., Welwyn Garden City, United Kingdom), for defects less than 20 ml, or morsellised femoral head allograft, for defects larger than 20 ml. The tuberosities were reduced anatomically and were secured to each other using osteosseous sutures. Following this, the reduction was stabilised, using a small fragment clover leaf plate.

Outcome assessment. All information was documented and analysed using SPSS (SPSS Inc., Chicago, Illinois) software. All patients underwent routine clinical and radiological follow-up evaluation by a blinded observer (anteroposterior and modified axial views) at 1, 6, 12 and 24 weeks and at one and two years post-injury. Our hypothesis was that type-I fractures treated by ORIF would be at a reduced risk of developing osteonecrosis or nonunion, when compared with type-II injuries. Our primary outcome measure was the development of radiologically-apparent osteonecrosis or nonunion of the fracture, within the first two years, in patients who underwent ORIF. We assessed the presence of osteonecrosis from post-operative radiographs.

Risk factors for osteonecrosis or nonunion, including the patient’s age, gender, medical co-morbidities, alcohol intake, smoking, mechanism of injury, time to surgery, extent of the metaphyseal void, use of Norian or allograft, fracture configuration and fracture displacement were considered in a logistic regression analysis, to determine those factors which were independently predictive of these complications.

Results

Type-I injuries (viable humeral head with retained capsular attachments). In this sub-group of 23 patients, consisting of 14 men and nine women (mean age 59 years; 21 to 81), the fracture of the anatomical neck extended from the area of an osteochondral fracture of the posterior humeral head (Hill-Sachs lesion), which was locked onto the anterior

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Table I. Analysis of mechanism of injury by age and gender in patients with anterior fracture-dislocations

<table>
<thead>
<tr>
<th>Mechanism of injury</th>
<th>Number type-I fracture-dislocations</th>
<th>Number type-II fracture-dislocations</th>
<th>Mean age in yrs (range)</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple fall</td>
<td>11</td>
<td>26</td>
<td>74 (60 to 87)</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Falls from height</td>
<td>2</td>
<td>8</td>
<td>57 (48 to 77)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Road traffic accident</td>
<td>6</td>
<td>1</td>
<td>50 (26 to 73)</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Seizure</td>
<td>4</td>
<td>0</td>
<td>42 (21 to 66)</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Total population</td>
<td>23</td>
<td>35</td>
<td>66 (21 to 87)</td>
<td>20</td>
<td>38</td>
</tr>
</tbody>
</table>
glenoid rim (Figs 1 and 2). The Hill-Sachs lesion had to be disengaged from the rim of the glenoid before reduction of the head into the glenoid could be achieved. The antero-inferior capsulolabral complex injury comprised either a soft-tissue Bankart lesion (20 cases) or a bony Bankart lesion (avulsion of the antero-inferior bony glenoid rim, three cases).

In three patients, the head fragment was initially undisplaced. However, each of these patients had undergone attempted closed manipulation in the Emergency Depart-
ment, which resulted in separation of the head fragment from the humeral shaft, without its relocation. In the other 20 patients, the head was shown to be displaced from the shaft on initial radiographs.

Of the 23 patients, 21 had Neer three-part greater tuberosity fractures. Of these, 11 had an intact lesser tuberosity, while ten had a fractured lesser tuberosity, which was minimally-displaced because of retained periosteal sleeve...
attachments to the humeral head. There was also one four-part fracture and one two-part fracture, in which the greater tuberosity was fractured but undisplaced and the lesser tuberosity was intact. In 18 patients, the humeral head had retained an extra-articular postero-medial cortical bone spike, whereas in the other five patients the fragment was attached to the shaft.

**Type-II injuries (non-viable humeral head, devoid of significant capsular attachments).** The 35 patients in this subgroup consisting of six men and 29 women (mean age 74 years; 48 to 87) were significantly older (Mann-Whitney U test; p = 0.007), more likely to be female (Fisher exact test; p = 0.001) and more likely to be injured in simple falls (Fisher exact test; p = 0.039) than patients with type-I injuries. Open reduction and internal fixation was performed in seven of these patients, who were under 60 years of age, whilst the remaining 28 patients, who were aged 60 years or over, were treated with a cemented hemiarthroplasty.

The humeral head was not engaged on the anterior glenoid rim and there was no osteochondral fracture of the posterior humeral head (Figs 3 and 4). The head was dislocated through a tear in the anteroinferior capsule, in the region of the axillary pouch. This was relocated by delivering it back through the gap in the capsule. The glenoid labrum and anteroinferior bony glenoid rim were intact in all but two cases, where there was partial inferior soft-tissue labral detachment.

In 31 patients the anatomical neck was initially impacted and compressed onto the proximal humerus in an impacted-valgus fracture configuration. On initial radiographs it was often difficult to distinguish this type of injury from a two-part greater tuberosity fracture dislocation. In eight of these patients, secondary displacement of the humeral head from the shaft had been caused by closed manipulation in the Emergency Department. A further four patients who had not undergone closed manipulation, showed complete separation of the humeral head from the shaft on initial radiographs.

The tuberosities were separated from each other, as well as from the humeral head (Neer four-part fracture) in 17 patients, whereas in 18 cases they were attached to each other, forming a composite tuberosity shield fragment (Neer three-part fracture). Splitting of the humeral head articular surface was present in 25 cases, leaving joint surface fragments attached either to one, or both, tuberosities.

**Outcome following reconstruction.** Of the 23 patients with type-I injuries who underwent ORIF, two developed radiological evidence of osteonecrosis by two years post-injury. Both patients were treated non-operatively because they were asymptomatic, with 30% and 40% humeral head involvement and minimal collapse. These two patients have now completed a five year follow-up with no evidence of further clinical or radiological deterioration.

Of the seven type-II injuries that underwent ORIF, four developed radiologically-apparent osteonecrosis by two years post-injury. Two patients were initially asymptomatic, with 25% and 50% involvement of the humeral head and no collapse. One of these patients had deteriorated by the three-year follow-up and was treated by hemiarthroplasty, whereas the other showed no further clinical or radiological deterioration at four years post-injury. The other two had symptomatic humeral head collapse within two years and were treated using an arthroplasty.

Logistic regression analysis of the 30 patients who underwent ORIF reconstruction (23 type-I injuries and 7 type-II injuries), showed that of all the factors considered, only the sub-classification into type-I and type-II injuries was significantly predictive of the later development of osteonecrosis (p = 0.016; relative risk for type-II injuries = 5.3; 95% confidence interval = 1.6 to 17.7).

**Discussion**

Three- and four-part anterior fracture dislocations are regarded to be the most severe forms of proximal humeral fracture, because of the devascularisation of the humeral head, which is caused by displacement from the glenoid, therefore increasing the risk of nonunion and osteonecrosis. The rarity of these injuries means that few surgeons gain sufficient experience in managing them to be confident in their assessment and treatment. However, as a result of sub-specialisation in our Shoulder Unit, we were able to treat a consecutive, unselected series of such injuries in order to produce for the first time, a detailed appraisal of their pathological anatomy.

We found that type-I injuries occurred in a younger population (aged under 60 years) of predominantly male patients, who commonly sustained their injury during a high-energy incident. In these individuals, the humeral head retained capsular attachments through either an intact periosteal sleeve around the lesser tuberosity, or a retained extra-capsular posteromedial bone spike, attached to the head. The pattern of injury described here is similar to that seen in patients sustaining a first-time isolated anterior dislocation of the glenohumeral joint. Common to both is either a soft-tissue, or bony Bankart lesion and an acute osteochondral fracture of the posterior humeral head (Hill-Sachs lesion), caused by its impact on the anterior glenoid rim. The fracture of the dislocated humeral head was propagating through the Hill-Sachs lesion and in all cases, the lesion was locked onto the anterior glenoid rim. We hypothesise that in these injuries the fracture occurs after the humeral head has been dislocated.

Type-II injuries occurred in an older (aged 60 years or over), predominantly female population who sustained their injuries in low-energy trauma. Radiologically, these injuries resembled impacted-valgus compression fractures. The humeral head was not engaged on the glenoid and the configuration of the compression ‘impacted-valgus type’ fracture suggests that the dislocation occurred after the fracture of the humeral head.

The uncomplicated impacted-valgus fracture has a good prognosis in terms of both healing and the risk of
osteonecrosis because the anteroinferior capsular ‘hinge’ remains intact, therefore providing a blood supply to the fractured humeral head. However, in the type-II patients in this series, the anteroinferior capsular attachments were presumably torn during the dislocation and the humeral head was completely denuded of soft-tissue attachments.

In both type-I and type-II injuries, undisplaced fractures of the anatomical neck were difficult to detect on routine radiographs and displacement was commonly caused by attempted closed manipulation. Therefore, computerised tomography should be obtained routinely, where an undisplaced fracture of the anatomical neck is suspected from initial radiographs. We concur with other authors that the practice of closed manipulation of these types of injuries should be avoided, except for patients who are medically unfit for surgical intervention.

The most widely recommended primary treatment for these injuries is hemiarthroplasty. However, while this removes the risk of nonunion and osteonecrosis, it does carry its own significant risk of early complications, including tuberosity nonunion and malunion, infection, dislocation and longer term complications such as loosening, infection and peri-prosthetic fracture. Although Neer reported satisfactory outcomes following arthroplasty for acute three- and four-part fractures, recent studies suggest that the functional results are often sub-optimal.

Our concerns regarding the prognosis of functional outcome following hemiarthroplasty, led us to develop a protocol for performing ORIF for all type-I injuries and for younger patients (aged under 60 years) with type-II injuries. We feel that the evidence from this study justifies the protocol for type-I injuries, as the prevalence of osteonecrosis following ORIF was lower than previously reported.

These type-I patients often sustain their injuries in early middle age and are most at risk of developing the longer-term complications of a hemiarthroplasty. It is our clinical impression that hemiarthroplasty should remain the treatment of choice for older patients (aged 60 years and over) with type-II injuries because of their lower functional demands and life-expectancy and their higher risk of requiring secondary arthroplasty, following a failed primary ORIF procedure.

The most appropriate treatment for type-II injuries in younger patients (aged under 60 years) is more contentious. Despite the relatively benign, undisplaced appearance of many type-II injuries on plain radiographs, the humeral head is often deprived of a significant blood supply because of extensive capsular injury. However, three of the seven type-II patients in our study treated by ORIF had a recovery free from complication and a further patient has not required additional surgery despite developing radio-logically apparent partial humeral head osteonecrosis. In these cases, we assume that although there was injury to the main nutrient arteries, the head retained its integrity, either through revascularisation or creeping substitution.

The successful preservation of the humeral head in these patients may result in a more durable outcome than would otherwise have been achieved by prosthetic replacement, although long-term follow-up will be required to confirm this. It is unclear whether the requirement for a secondary arthroplasty in the remaining three younger patients with type-II injuries compromised the functional result they might have obtained if they had been treated by a primary hemiarthroplasty. The classification into type-I and type-II was made by a single surgeon and no assessment of observer error was made.

Currently, we feel that an individual approach to the treatment of younger patients with type-II injuries is appropriate. This should include consideration of the patient’s physiological status, their opinions and expectations, and the surgeon’s level of expertise in the use of either hemiarthroplasty or ORIF. The issue of whether successful ORIF produces an improved functional outcome when compared with a primary hemiarthroplasty, remains unresolved.

Taking into account the rarity of this injury, a large multi-centre, randomised controlled trial, with long-term follow-up, would be required to fully resolve this issue.

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


