TRAUMA

Modification of the Resch procedure

A NEW TECHNIQUE AND ITS RESULTS IN MANAGING THREE- AND FOUR-PART PROXIMAL HUMERAL FRACTURES

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Controversy surrounds the management of displaced three- and four-part fractures of the proximal humerus. The percutaneous Resch technique of stabilisation involves minimal soft-tissue dissection and a reduced risk of stiffness and avascular necrosis. However, it requires a second operation to remove Kirschner wires and the humeral block. We describe a modification of this technique that dispenses with the need for this second operation and relies on a sequential pattern of screw placement. We report the outcome of 32 three-or four-part fractures of the proximal humerus treated in this way at a mean follow-up of 3.8 years (2 to 8). There were 14 men and 18 women with a mean age of 56 years (28 to 83). At final follow-up the mean Oxford shoulder scores were 38 (31 to 44) and 39 (31 to 42), and the mean Constant scores were 79 (65 to 92) and 72 (70 to 80) for three- and four-part fractures, respectively. We further analysed the results in patients aged <60 years with high-energy fractures and those aged ≥60 years with osteoporotic fractures. There were no cases of nonunion or avascular necrosis.

The results were good and comparable to those previously reported for the Resch technique and other means of fixation for proximal humeral fractures. We would recommend this modification of the technique for the treatment of displaced three-part and four-part fractures in patients both younger and older than 60 years of age.
contact between the humeral shaft and the head fragment were excluded.

**Surgical technique.** Previous tests were undertaken with Sawbones models of humeral fractures (Smith & Nephew, London, United Kingdom), in order to establish the optimum configuration and sequence of screw placement to achieve the best fixation (Fig. 1). This was assessed by the fracture gap, failure on loading, and the stability of the fragments on applying force across the fracture.

The patient is positioned in the beach chair position under general anaesthetic. Intravenous cefuroxime or augmentin is used, or teicoplanin for patients who are allergic to penicillin. A combination of percutaneous and mini-open lateral approaches is used. The position of the incision is identified fluoroscopically and is developed by blunt dissection, using an instrument such as a MacDonald’s dissector, which is passed into the fracture and used to elevate the humeral head. Particular attention is paid to the reduction of the medial calcar, between the head and the shaft. This can be difficult, especially with fractures with delayed presentation, and requires perseverance.

The greater tuberosity is repositioned under the reduced head using a hooked instrument to manoeuvre it into position. A 1.6 mm K-wire is introduced percutaneously and passed from the greater tuberosity into the medial calcar. This reduction and wire acts as a buttress to the reduced humeral head (Fig. 2).

A second K-wire is passed from the greater tuberosity into the head fragment (Fig. 3) and a third from the shaft into the head (Fig. 4). If the fracture is a four-part fracture involving the lesser tuberosity, the tuberosity is reduced after the head fragment is elevated and the greater tuberosity has been fixed to the medial calcar. A further K-wire is then passed in an anteroposterior direction to fix this fragment, which may require the fluoroscope to be repositioned. Further K-wires may be required to augment the fixation so that all fragments have some fixation. All the K-wires are replaced with cannulated screws using a 4.0 mm cannulated screw system (DePuy, Warsaw, Indiana) (Fig. 5).

Patients are initially immobilised in a Polysling (Molnlycke Healthcare, Dunstable, United Kingdom), and mobilisation begins three weeks post-operatively with pendular and active assisted exercises, followed by active exercises from six weeks post-operatively. Clinical and radiological evaluation was undertaken by the senior author (RP). Function was assessed using the Constant score, which has a maximum of 100 points, and the Oxford shoulder score, which has a score from 0 to 48 points, with a higher score representing better function. The vascularity of the humeral head and union of the fracture were assessed on anteroposterior and axial radiographs. Union required continuation of trabeculae across the site of the fracture, the presence of callus and resolution of the fracture gap.

**Results**

The mean follow up was 3.8 years (2 to 8), at which time the mean Constant score for the fractured shoulder of the whole cohort was 10 points (4 to 26) lower than that for the uninjured shoulder. The mean score was 77 (65 to 92) for the fractured shoulder and 87 (74 to 100) for the uninjured shoulder. The mean Oxford shoulder score was 38 (31 to 44).

<table>
<thead>
<tr>
<th>Table I. Demographics of the two groups</th>
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<tbody>
<tr>
<td>Age group</td>
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<td>------------</td>
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<tr>
<td>Patients (n)</td>
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<tr>
<td>Male:female</td>
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<tr>
<td>Fracture type (n, %)</td>
</tr>
<tr>
<td>3-part</td>
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<tr>
<td>4-part</td>
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**Fig. 1a** Sawbones model (a) and radiograph (b) of a three-part proximal humeral fracture.
Patients < 60 years old had a better Constant score with both three- and four-part fractures. However, those with four-part fractures had worse scores in comparison to the uninjured shoulder. There was no difference in the mean Oxford shoulder score between the two age groups regardless of whether the fracture was three or four parts (Table II).

All fractures were united at final follow up. There were no cases of avascular necrosis.

There were four complications, all in patients with four-part fractures. One patient < 60 years old required arthroscopic capsular release for limitation of movement. In those ≥ 60 years: in one a single screw had breached the articular surface and required removal under local anaesthetic at eight weeks; in two there was some loss of reduction, with backing-out of the a single screw, but neither required further surgery.

**Discussion**

The worst functional results occur with four-part fractures and in the elderly. Surgery that preserves the humeral head has a good functional outcome, but requires good alignment to prevent non- or malunion, which is necessary to restore movement.

Although open reduction allows visualisation of reduction and simplifies the use of locking plates, there are a number of disadvantages. First, there is the risk of damage to the blood supply of the humeral head. The risk of avascular necrosis following open reduction is twice that
following closed reduction. Secondly, the soft-tissue dissection can lead to increased post-operative stiffness. Thirdly, the bulk of any plate might necessitate its subsequent removal.

Closed or minimal open reduction with percutaneous fixation as described by Resch et al has the advantage of preserving the periosteal bridges and soft-tissue attachments, which reduces the risk of devascularising the humeral head. They found a rate of avascular necrosis of 0% in three-part fractures and 11% in four-part fractures. Other authors have reported a rate of avascular necrosis of 0% to 7.8% using this technique. A further

**Table II. The differences in the mean Constant score and Oxford shoulder score**

<table>
<thead>
<tr>
<th>Fractures (n)</th>
<th>Whole cohort</th>
<th>Age &lt; 60 years</th>
<th>Age ≥ 60 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21</td>
<td>3-part</td>
<td>4-part</td>
</tr>
<tr>
<td>Fractured shoulder</td>
<td>79 (6.96; 65 to 92)</td>
<td>83 (6.26; 74 to 92)</td>
<td>75 (5.52; 65 to 84)</td>
</tr>
<tr>
<td>Uninjured shoulder</td>
<td>86 (6.12; 74 to 100)</td>
<td>92 (3.58; 86 to 100)</td>
<td>84 (5.06; 74 to 90)</td>
</tr>
<tr>
<td>Mean (SD) Oxford</td>
<td>38 (3.40; 31 to 44)</td>
<td>39 (3.30; 38 to 44)</td>
<td>37 (3.85; 31 to 44)</td>
</tr>
</tbody>
</table>

*Fig. 4a*  
Sawbones model (a) and radiograph (b) showing placement of the third Kirschner wire from the humeral shaft to the humeral head.

*Fig. 4b*  

*Fig. 5a*  
Radiographs showing a) showing the replacement of Kirschner-wires with cannulated screws and b) the result at two years post-operatively.

*Fig. 5b*
advantage includes minimal soft-tissue damage and therefore less scarring, which might account for good mean Constant scores, ranging from 78 to 85 for three-part and 67 to 82 for four-part fractures.\textsuperscript{13,15,16} The original Resch technique had the disadvantage of requiring a second operation to remove wires and the humeral block.

Our modification eliminates the need for a second operation, but retains the advantages of preservation of the blood supply, a low rate of avascular necrosis, minimal soft-tissue dissection and good functional scores. The technique relies on following a set pattern of screw placement that initially establishes a strong platform upon which the humeral head is supported. Subsequently the greater tuberosity can be reduced and fixed both to the medial calcar and the head. Finally the head is secured to the humeral shaft. As this technique ensures that all the fragments have some fixation, mobilisation can begin at three weeks, with this delay having no apparent detrimental effect on the outcome.

In this study there was displacement in two patients aged $\geq$ 60 years with four-part fractures. The functional outcome was less good for four-part than for three-part fractures, which is consistent with previous studies.\textsuperscript{15-17} Our results are, however, better than those reported for hemiarthroplasty performed for four-part fractures.\textsuperscript{10,12}

Some authors have reported that the outcome of non-operative management for valgus impacted fractures is as good as that after operative management.\textsuperscript{8,22} However, Jakob et al\textsuperscript{7} recommended open reduction and fixation of valgus impacted fractures as they considered non-operative treatment could lead to osteoarthritis due to malposition of the head fragment, impingement due to malposition of the tuberosity and stiffness due to altered biomechanics. In a series of 125 patients with a displaced three-part fracture treated non-operatively and reviewed at one year, Court-Brown et al\textsuperscript{23} reported a mean Constant score of 65.6, and patients $< 60$ years of age had a mean score of 62. We found that, for three-part fractures including non-valgus impaction types, the mean Constant score at a mean of 3.8 years was 83 in those aged $< 60$ years and 75 in those aged $\geq 60$ years.

There are limitations to this study including the small number of patients involved and that the senior author undertook the functional and radiological assessments, introducing the risk of bias. However, the Oxford shoulder score was completed by the patients and correlates well with the Constant score.\textsuperscript{9} Part of the success of this technique lies in recognising its limitations. We did not use it for fractures when there was no contact between the shaft and head fragment, which would already have a high risk of avascular necrosis and it may be difficult to use in the absence of a medial calcar, or if the fracture is very comminuted. Thus, another limitation of this study was the strict exclusion criteria.

This method gave good results in patients aged $< 60$ years with high-energy fractures and those $\geq 60$ years with osteoporotic fractures, but those $< 60$ years of age did slightly better and experienced fewer metalwork problems than the group aged $\geq 60$ years. The best results were in displaced three-part fractures.

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