We describe a method of pinning extension supracondylar fractures of the humerus in children. Following closed reduction, a posterior intrafocal wire is inserted and a second lateral wire added when needed for rotational stability. Between May 2002 and November 2005 we performed this technique in 69 consecutive patients. A single posterior wire was used in 29 cases, and two wires in 40. The mean follow-up was two years (21 to 30 months). The results were assessed according to Flynn’s criteria. In the single-wire group there were 21 excellent, five good and one poor result. Two patients were lost to follow-up. In the two-wire group there were 32 excellent, two good and three poor results. Three were lost to follow-up. The poor results were due to a failure to achieve adequate reduction, fixation or both.

We conclude that the intact posterior periosteal hinge can be used successfully in the clinical situation, giving results that compare well with other techniques of pinning. The posterior route offers an attractive alternative method for fixation of supracondylar fractures of the humerus in children.

Gartland type II and III displaced extension-type supracondylar fractures are usually treated by closed reduction and percutaneous pinning.2-4 The method was first described by Swenson in 1948.5 Different configurations of placement of the Kirschner (K)-wires have been described using one medial and one or two lateral, or two or three lateral, placed parallel or divergent. Transarticular6,7 and intramedullary wires8 have also been utilised. Sawaizumi, Yakayama and Ito9 described a percutaneous leverage technique for reduction using a wire passed through the posterior cortex of the distal fragment supplemented by a lateral wire. Lee and Kim10 used a similar technique supplemented by two wires. We describe a technique of pinning, whereby a posterior intrafocal wire exerts leverage and stabilises the distal humeral fragment. It can be supplemented by a lateral wire for additional stability.

The aim of this study was to confirm the adequacy of the posterior periosteal hinge in maintaining the reduction of such fractures. The technique is based on an experimental supracondylar fracture model described by Abraham et al,11 who found that the periosteum fails in three stages. In minimally displaced fractures the anterior periosteum is intact but stretched and detached from the anterior surface of the humerus for a considerable distance. In the second stage, with more displacement, the detached periosteum is torn and displaced distally across the sharp edge of the proximal fragment. In the third stage (type III fractures), the periosteum is torn anteriorly but remains intact posteriorly and to some extent medially and laterally.

The triceps acts as a stabiliser of the distal fragment if the elbow is hyperflexed, as the lateral fibres become anterior to the long axis of the humerus. Two reports12,13 have demonstrated the critical amount of flexion to have stable reduction is 120° below which more than 80% of these fractures will displace. Swelling and vascular compromise limit flexion. In our technique, the posterior intrafocal wire uses the intact posterior periosteal hinge to lock the distal fragment instead of the triceps allowing the elbow to be extended without displacement of the fracture or risk of vascular compromise.

Patients and Methods
Between May 2002 and November 2005, intrafocal pinning was performed in 69 consecutive patients. Inclusion criteria for the study were extension-type supracondylar fractures of Gartland type II or III. Flexion injuries, comminuted fractures, and T- or Y-shaped
fractures were excluded. A single or an additional wire was used, depending on the intraoperative rotational stability.  

**Operative technique.** Under general anaesthesia and with image intensification, closed reduction is performed. It is important to achieve as good a reduction as possible. A posterior K-wire is then introduced. Its point of entry is the intersection of a line between the epicondyles and a vertical line at right-angles to this, dropped from the lateral border of the olecranon (Fig. 1). This ensures that the wire will lie in the middle of the shaft of the humerus.

The wire should be parallel to the axis of the forearm and in line with the axis of the humerus. It is introduced under fluoroscopic control into the roof of the olecranon fossa, through which the fracture line usually passes and into the fracture site. It is important to check the integrity of the posterior periosteal hinge, upon which the stability of the reduction depends. Leverage on the wire will challenge the posterior hinge and ensure it is intact (Fig. 2). This is confirmed if the distal fragment does not displace anteriorly or the fracture does not open posteriorly. The wire is then driven into the anterior cortex of the humerus. (Fig. 3)

The elbow is then extended to the limit allowed by the wire and the position is checked fluoroscopically. The reduction should be stable without coronal tilting. The shoulder is then gently rotated externally and internally (Fig. 4), and if there is any rotational instability a second lateral K-wire is passed across the fracture from distal lateral to medial proximal (Fig. 5). An above-elbow POP slab is applied for three or four weeks. The wires are removed in clinic after check radiographs have been taken.

The patients were followed up at four weeks, 12 weeks, six months, one year, 18 months and two years. At each review the carrying angle and range of movement were recorded using a goniometer. The mean follow-up was for two years (21 to 30 months). The outcome was assessed according to the criteria of Flynn, Matthews and Benoit,14 Webb and Sherman15 and Boyd and Aronson16 (Table I).

**Results**

A total of 29 patients were treated with a single posterior wire and 40 with two wires.

In the single-wire group there were 12 girls and 17 boys with a mean age of 5.25 years (1.2 to 10). Two patients were lost to follow-up; 13 fractures were type II and 16 type III. The left side was affected in 21 patients and the right side in eight. One patient had a pre-operative anterior interosseous nerve injury which recovered by 12 weeks and one had ipsilateral fractures of the distal radius and ulna. One patient lost the last 10° of extension and two had proximal migration of the posterior wire through the anterior cortex of the humerus. The wire was removed under local anaesthetic after three weeks. In one patient the wire
backed out. The outcome was excellent in 21 patients, good in five and poor in one (96.3% excellent or good).

In the two-wire group there were 18 girls and 22 boys, with a mean age of 5.7 years (2.1 to 12.10). Three patients were lost to follow-up. A total of 37 patients completed a minimum of two years’ follow-up; six fractures were type II and 34 type III. The right side was involved in 17 cases and the left in 23. Seven patients had a pre-operative anterior interosseous nerve palsy and two a radial nerve palsy. All recovered at eight to 12 weeks. Two patients had a pin track infection which healed within a week of wire removal. Two patients had proximal migration of the wires, which were removed under local anaesthetic. One patient had exploration of the brachial artery for spasm. One patient had a Gustillo grade I open fracture, one had an ipsilateral fracture of the lower radial epiphysis, and one had fractures of the distal radius and ulna. The fractures were pinned simultaneously. The outcome was excellent in

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**Table 1.** Flynn’s cosmetic and functional factors and the outcome as described by Webb and Sherman\(^\text{15}\) and Boyd and Aronson\(^\text{16}\)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Cosmetic factor carrying angle loss (°)</th>
<th>Functional factor movement loss (°)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>0 to 5</td>
<td>0 to 5</td>
<td>The lower of the two ratings and an elbow with a varus deformity is automatically graded as poor</td>
</tr>
<tr>
<td>Good</td>
<td>6 to 10</td>
<td>6 to 10</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>11 to 15</td>
<td>11 to 15</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>&gt; 15</td>
<td>&gt; 15</td>
<td></td>
</tr>
</tbody>
</table>

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In the two-wire group there were 18 girls and 22 boys, with a mean age of 5.7 years (2.1 to 12.10). Three patients were lost to follow-up. A total of 37 patients completed a minimum of two years’ follow-up; six fractures were type II and 34 type III. The right side was involved in 17 cases and the left in 23. Seven patients had a pre-operative anterior interosseous nerve palsy and two a radial nerve palsy. All recovered at eight to 12 weeks. Two patients had a pin track infection which healed within a week of wire removal. Two patients had proximal migration of the wires, which were removed under local anaesthetic. One patient had exploration of the brachial artery for spasm. One patient had a Gustillo grade I open fracture, one had an ipsilateral fracture of the lower radial epiphysis, and one had fractures of the distal radius and ulna. The fractures were pinned simultaneously. The outcome was excellent in
32 patients, good in two and poor in three (91.9% excellent or good).

On review of the poor results, there was one in the single-wire group (type II) and three in the two-wire group (one type II, two type III). In these patients the initial displacement was posteromedial in three and posterior in one. All had almost transverse fracture lines, and one had medial comminution (Fig. 6). In three fractures the reduction was poor, and in two there was an error of technique. In none was there loss of reduction during healing.

Discussion
In contrast to the pin leverage technique described by Lee and Kim, we do not use a mini posterior incision, special pins, or remove the posterior pin after reduction. Our method gives results comparable to those of other techniques (Table II) and has several advantages. The posterior route is easy, safe, and away from the important structures around the elbow. It avoids the medial route and possible injury to the ulnar nerve. The posterior wire allows three-point fixation. It locks the distal fragment, converting the fracture to a type I injury. It is a quick procedure with less radiation exposure. If a single wire is used the mean time for radiation exposure is 10.11 seconds. The posterior wire allows extension of the elbow while screening, thereby permitting easy visualisation of the lower end of the humerus to judge the coronal alignment. When two wires are used, they produce fixation in two planes, sagittal and coronal, compared to other techniques which depend on fixation in one plane. The method would allow vascular exploration, as it spares the skin on the medial side and the block to extension would prevent stretching of the vascular repair.

We found that by locking the distal fragment and converting it to a Gartland type I injury, the reduction is stable if the posterior periosteal hinge is intact. Technical errors were the most common cause of poor results; medial comminution contributed, but obliquity of the fracture line did not. Thus attention to the technique of insertion of the wires is essential for a satisfactory outcome.

Apart from one syndromic patient in the single-wire group, the posterior wire did not prevent a full range of extension being obtained in both groups. The presence of a posterior wire in the triceps did not induce heterotopic ossification. Ponce et al. in a review of complications in 104 patients treated by percutaneous pinning, reported three cases with proximal migration necessitating removal and four cases of pin track infection. In our series, two patients in the double-wire group had a superficial infection.

In conclusion, we have confirmed the experimental work of Abraham et al in the clinical situation and have achieved results that compare well with other pinning techniques. The posterior route is an attractive alternative method for fixation of supracondylar fractures of the humerus in children.
Table II. Clinical results compared with those of other series in the literature

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Authors</th>
<th>Number of cases</th>
<th>Cosmetic</th>
<th>Functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral pinning</td>
<td>Boyd and Aronson[16]</td>
<td>71</td>
<td>68 3</td>
<td>0 0 60 7 3 1 -</td>
</tr>
<tr>
<td></td>
<td>Mazda et al[10]</td>
<td>82</td>
<td>76 3</td>
<td>0 3 77 5 0 0 -</td>
</tr>
<tr>
<td></td>
<td>Foead et al[23]</td>
<td>27</td>
<td>22 2</td>
<td>1 2 16 6 1 4 -</td>
</tr>
<tr>
<td></td>
<td>Remarks: Functional for extension loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossed wires</td>
<td>Foead et al[20]</td>
<td>28</td>
<td>21 4</td>
<td>2 1 14 7 3 4 -</td>
</tr>
<tr>
<td></td>
<td>Flynn et al[4]</td>
<td>52</td>
<td>42 7</td>
<td>2 1 - - - - -</td>
</tr>
<tr>
<td></td>
<td>Meheserie and Meehan[11]</td>
<td>33</td>
<td>23 7</td>
<td>1 2 - - - - -</td>
</tr>
<tr>
<td></td>
<td>Remarks: Cosmetic and functional outcome for total cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two lateral and one medial wires</td>
<td>Shim and Lee[22]</td>
<td>63</td>
<td>47 15</td>
<td>0 1 58 5 0 0 -</td>
</tr>
<tr>
<td></td>
<td>Remarks: Cosmetic and functional outcome for total cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrafocal posterior pinning</td>
<td>Fahmy et al†</td>
<td>27</td>
<td>21 5</td>
<td>0 1 - - - - -</td>
</tr>
<tr>
<td>Posterior &amp; lateral pinning</td>
<td>Fahmy et al†</td>
<td>37</td>
<td>32 2</td>
<td>0 3 - - - - -</td>
</tr>
</tbody>
</table>

* this series
† Ex, excellent; G, good; F, fair; P, poor

Supplementary material
Tables showing Flynn’s criteria are available with the electronic version of this article on our website at www jbjs org uk

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