RETROGRADE LOCKED NAILING OF HUMERAL SHAFT FRACTURES

A REVIEW OF 39 PATIENTS

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We treated 39 patients with fractures of the humeral shaft by closed retrograde locked intramedullary nailing, using Russell-Taylor humeral nails. The mean healing time of all fractures was 13.7 weeks. After consolidation, shoulder function was excellent in 92.3% and elbow function excellent in 87.2%. Functional end-results were excellent in 84.6% of patients, moderate in 10.3% and bad in 5.1%.

One patient had a postoperative radial nerve palsy, which recovered within three months. There was additional comminution at the fracture site in three patients (7.7%) which did not affect healing, and slight nail migration in two older patients (5.1%). Two patients (5.1%) needed a second procedure because of disturbed fracture healing. One screw breakage was seen in a patient with delayed union.

Retrograde locked humeral nailing appears to be a better solution for the stabilisation of fractures of the humeral shaft than anterograde nailing or plate and screw fixation. We found the complication rate to be acceptable and shoulder and elbow function to recover rapidly in most cases.

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Until relatively recently, uncomplicated fractures of the humeral shaft were usually treated conservatively; careful management avoided complications and the end-results were satisfactory. The humeral shaft is totally covered with muscles and fracture fragments are well vascularised, while malunions with an angle of less than 20° are functionally and cosmetically well tolerated.

Conservative management varied between hanging casts, overhead-traction and functional casts (Böhler 1964; Kayser et al 1986). Bandi (1964) first defined clear indications for operative treatment, including open fracture, pseudarthrosis, transverse fracture, comminuted fractures with radial palsy and a distal fracture in an unacceptable position after conservative treatment. He advised anatomical reduction and stable internal fixation in accordance with AO principles. Plate and screw osteosynthesis seemed to be the most appropriate choice (Bandi 1964; Bell et al 1985; Foster et al 1985; Van der Griend, Tomasin and Ward 1986; Nast-Kolb, Knoefel and Schweiberer 1991).

We have used plate and screw fixation since 1978 when there were clear indications for operative treatment (Michiels, Broos and Gruewez 1986), but performed external fixation for open fractures with severe soft-tissue damage (Kamhijn, Michaelson and Waisbrod 1978). In 1989 we published the results of a retrospective study of 78 fractures, 71 treated with plate and screws and seven by an external fixator (Rommens et al 1989) and concluded that plate osteosynthesis had a number of advantages, but also important disadvantages. It allows anatomical reposition of most simple fractures with little risk of infection, mechanical problems or failure of healing. There is, however, danger to the radial nerve which has to be exposed. This requires meticulous dissection, especially for the dorsal approach, and in complex fractures or those in osteoporotic bone, fixation with a plate and screws may be difficult and suitable only for experienced surgeons.

Closed intramedullary nailing is widely accepted for the stabilisation of the femur and tibia and avoids most of the problems described above. We therefore decided to start using nailing for fractures of the humeral shaft by a retrograde method to avoid the problems of the anterograde method with the radial nerve and the rotator cuff (Robinson et al 1992; Ingman and Waters 1994).

PATIENTS AND METHODS

Our prospective study was from 1991 to 1993. All fresh fractures of the humeral shaft chosen for operative treatment, including isolated fractures and those in polytrauma patients, were nailed by one of five staff members. When there were no clear indications for operative treatment, patients were asked for informed consent for retrograde nailing. Open Gustilo type-III fractures and fractures in children and adolescents were excluded, as were patho-

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logical fractures, fractures primarily stabilised with other implants, proximal fractures within 2 cm of the surgical neck and distal fractures within 5 cm of the junction of the diaphysis and metaphysis on both anteroposterior and lateral radiographs.

All patients had closed retrograde nailing with a Russell-Taylor nail.

There were 20 men and 19 women with an average age of 43.8 years (15.5 to 97.3). Injuries were caused by traffic accidents (21), an accident at home (12), sport (3), an accident at work (2) and a fall (1) (Table I). Twenty-five fractures were in category A of the AO classification (Müller, Nazarian and Koch 1987), ten in category B and four in category C. Fourteen fractures were transverse, eight spiral and three oblique (Fig. 1). Details of the fractures are given in Tables II and III. Thirty-two had very little soft-tissue damage, three had severe but closed soft-tissue damage and four were open Gustilo type II. In 19 patients, the fracture of the humeral shaft was the only lesion and 20 patients were polytraumatised. Three patients (7.7%) had a radial nerve palsy preoperatively.

Thirteen patients were operated on the day of the accident, 12 on the following day, 11 after two days, two after four days and one at 31 days. Nineteen patients with a solitary fracture and no over-riding indication consented to operative stabilisation, 11 had operations because of polytrauma, four because of failed conservative treatment, three because of another fracture of the same arm, one because of soft-tissue damage and one for exploration of the radial nerve (Fig. 2).

Operative technique. The patient is positioned prone with the upper arm on a radiolucent side-table and the lower arm hanging down. The triceps muscle is divided longitudinally in its distal part, just above the olecranon fossa; the capsule of the elbow is not opened. The distal humeral metaphysis is exposed and an oblique canal is made in the centre of the triangle to obtain a straight access to the distal medulla. This is done very carefully to avoid a fissure or fracture of

![Fig. 1a](image1.png)![Fig. 1b](image2.png)

An oblique fracture of the left humerus in a 62-year-old woman with a large medullary canal (a). Retrograde nailing with a 9 mm nail produced union after 16 weeks (b). There was perfect function of both shoulder and elbow.

**Table I.** Cause of humeral shaft fractures in 39 patients treated by retrograde nailing

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic accident</td>
<td>21</td>
</tr>
<tr>
<td>Motor-car driver</td>
<td>14</td>
</tr>
<tr>
<td>Motor-cycle driver</td>
<td>3</td>
</tr>
<tr>
<td>Cyclist</td>
<td>2</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2</td>
</tr>
<tr>
<td>Accident at home</td>
<td>12</td>
</tr>
<tr>
<td>Sport</td>
<td>3</td>
</tr>
<tr>
<td>Accident at work</td>
<td>2</td>
</tr>
<tr>
<td>Fall</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table II.** AO classification of 39 humeral shaft fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>8</td>
</tr>
<tr>
<td>A2</td>
<td>3</td>
</tr>
<tr>
<td>A3</td>
<td>14</td>
</tr>
<tr>
<td>B1</td>
<td>4</td>
</tr>
<tr>
<td>B2</td>
<td>6</td>
</tr>
<tr>
<td>C1</td>
<td>2</td>
</tr>
<tr>
<td>C2</td>
<td>2</td>
</tr>
</tbody>
</table>
A comminuted spiral fracture with primary radial nerve palsy in a 63-year-old man (a). The radial nerve was explored and a humeral nail inserted through the same approach (b). A radiograph at four months shows early union (c).

Radiographs of a spiral fracture of the right humerus in a 27-year-old woman (a), treated by retrograde locked nailing (b). There was an excellent functional result at one year (c).

The smallest diameter of humeral nail (7 mm) is chosen for most patients, a larger one being used only in those with osteoporosis and a broad medullary canal. The 7 mm humeral nails are solid and are inserted without a guide wire, but this is used for 8 or 9 mm nails. After insertion, the nail is locked with two self-tapping screws, the proximal one from lateral to medial and the distal from posterior to anterior (Fig. 3).
After operation, a sling is used in adduction, and one week after fixation active and active-assisted mobilisation of the shoulder and elbow is started. Active rotation of the upper arm against resistance is discouraged until callus is visible on radiographs.

Assessment. We recorded peroperative and postoperative problems, healing time, and secondary operations. Shoulder or elbow function was graded as excellent when there was less than 10\(^\circ\) loss of range in any direction, moderate when there was loss of between 10\(^\circ\) and 30\(^\circ\) and as poor with loss of range of more than 30\(^\circ\). The total functional outcome at the time of review took both joints into account.

RESULTS

The average hospital stay was 13 days and the mean healing time of all fractures was 13.7 weeks. Patients with isolated lesions were in hospital for a mean of 10.6 days (3 to 18).

At review, shoulder function was excellent in 36 patients (92.3\%), moderate in two (5.1\%) and poor in one (2.6\%). Elbow function was excellent in 34 patients (87.2\%), moderate in two (5.1\%) and poor in three (7.7\%) (Table IV). The only case of poor function of both shoulder and elbow was in a polytrauma patient with severe cerebral injuries who developed massive periarticular ossification around many joints. The second patient with poor elbow function due to a 70\(^\circ\) extension deficit, had a ‘teardrop’ ossification in the olecranon fossa (Fig. 4). Removal of the implant and the ossification gave nearly normal elbow function. The third patient had an extension deficit of 40\(^\circ\), having been referred to us in a hanging cast one month after her injury.

The total functional outcome was excellent in 33 patients (84.6\%), moderate in four (10.3\%) and poor in two (5.1\%). Preoperative radial nerve damage recovered fully in two patients and incompletely in one.

Complications. Postoperatively, there was iatrogenic radial nerve palsy in one patient (2.6\%), which fully recovered within three months. There were no infectious, vascular or other neurological problems. Three patients (7.7\%) suffered additional comminution at the fracture site (Fig. 5). There was slight nail migration with no adverse consequences in two older patients (5.1\%).

Two patients (5.1\%) needed a second operation for delayed healing. In one with a closed segmental fracture, the proximal transverse fracture failed to heal. After six months, the nail was removed and the proximal fracture was plated and autografted with good results. The second patient with a type-II open spiral fracture required change to a thicker retrograde nail and autografting at one year, also with good results. The same patient also had the only screw breakage of the series (1.3\%).

DISCUSSION

Most surgeons believe that intramedullary nailing is the best internal fixation for femoral and tibial shaft fractures, but there is no agreement about the ideal procedure for fractures of the humeral shaft. Plate osteosynthesis requires extensive dissection with the risk of radial nerve damage (Rommens et al 1989); this has been reported in 3\% to 29\% of cases in a prospective study in 12 German hospitals (Nast-Kolb et al 1991). Patient tolerance of external fixa-

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**Table III.** Localisation of 39 humeral shaft fractures treated by retrograde nailing

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal third</td>
<td>1</td>
</tr>
<tr>
<td>Transition proximal to middle third</td>
<td>6</td>
</tr>
<tr>
<td>Middle third</td>
<td>21</td>
</tr>
<tr>
<td>Transition middle to distal third</td>
<td>9</td>
</tr>
<tr>
<td>Distal third</td>
<td>2</td>
</tr>
</tbody>
</table>

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**Table IV.** Shoulder and elbow function after union of 39 humeral shaft fractures treated by retrograde nailing, by number and percentage

<table>
<thead>
<tr>
<th></th>
<th>Shoulder</th>
<th>Elbow</th>
<th>Total outcome at review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>36 92.3</td>
<td>34 87.2</td>
<td>33 84.6</td>
</tr>
<tr>
<td>Moderate</td>
<td>2 5.1</td>
<td>2 5.1</td>
<td>4 10.3</td>
</tr>
<tr>
<td>Poor</td>
<td>1 2.6</td>
<td>3 7.7</td>
<td>2 5.1</td>
</tr>
</tbody>
</table>
tion is low; the pins perforate muscle bellies and pin-track infections are often seen (Kamhin et al 1978). Ender nails, Rush pins and Küntscher nails (Mackay 1984; Brumback et al 1986; Hall and Pankovich 1987; Rush 1987) tend to displace and obstruct shoulder or elbow movement while their rotational stability is low. Hackethal nailing was once popular (Hackethal 1961; Heimel and Okumusoglu 1979; Kocher and Ledermann 1980), but gives insufficient stability and the implants may migrate (Hennig, Link and Wolfel 1988).

The Seidel nail was specifically designed for humeral fractures (Seidel 1989; Eberle et al 1992), but is too big for many medullary canals: reaming is always necessary. The insertion may be difficult and cause fractures (Ruf and Pauly 1993). It can only be used by an anterograde technique (Seidel 1989; Riemer et al 1991) which risks damage to the rotator cuff. Other problems are protrusion, lack of rotational stability and loosening of the distal fixation with risk of pseudarthrosis (Robinson et al 1992).

The Russell-Taylor humeral nail is smaller in diameter (7 to 9 mm) and is slightly curved both proximally and distally, while two locking screws give rotational stability. It can be inserted by either an anterograde or a retrograde approach which is totally extra-articular. The technique is similar to that of Hackethal nailing, but the Russell-Taylor nail is not elastic and insertion has to be carried out more carefully. It is important that the opening to the medullary canal is placed exactly in the centre of the triangle of the dorsal surface of the distal metaphysis, and is slightly higher than the level chosen by Ingman and Waters (1994) to avoid mechanical hindrance to the elbow. The opening has to be very oblique to allow hand reamers to be inserted without major resistance. We caused additional comminution during nailing in three patients because the opening was made less oblique than it should have been. Reaming should be limited to the absolute minimum, just enough to allow the isthmus of the humeral canal to be passed without difficulty. The tip of the nail should not be more proximal than the surgical neck, so that the locking screw can be inserted without danger to the axillary nerve or the articular cartilage. After nail insertion, the distal wound must be thoroughly cleaned to avoid periarticular callus formation.

Our series of 39 carefully studied patients provided very positive experience. The nail insertion requires great care, but we found the whole procedure less demanding than a plate and screw osteosynthesis. Healing was usually uneventful and there were adequate reasons for delay in both our cases which required reoperation and grafting.

The functional results were also very satisfactory: limited elbow function was related to the procedure in only one patient with teardrop ossification. In the other two patients with limited elbow function, one had severe cerebral trauma and in the other there was a delay of one month with the elbow immobilised at 90° flexion.
The retrograde technique allowed a reduced incidence of postoperative radial nerve palsy. Shoulder function recovered very rapidly, elbow function rather slower because of the dissection of the triceps tendon and muscle.

We conclude that retrograde humeral nailing is better than anterograde nailing or plate and screw osteosynthesis for patients with indications for the operative treatment of fractures of the humeral shaft. Retrograde nailing is an attractive option in polytrauma for isolated fractures which would be difficult to treat conservatively and for patients who require a rapid functional recovery.

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


