LOCKED NAILING OF HUMERAL SHAFT FRACTURES

EXPERIENCE IN EDINBURGH OVER A TWO-YEAR PERIOD

C. M. ROBINSON, K. M. BELL, C. M. COURT-BROWN, M. M. McQUEEN

From the Royal Infirmary of Edinburgh

We report the results of locked Seidel nailing for 30 fractures of the humerus. There were frequent technical difficulties at operation especially with the locking mechanisms. Protrusion of the nail above the greater tuberosity occurred in 12 cases, usually due to inadequate locking, and resulted in shoulder pain and poor function. Poor shoulder function was also seen in five patients with no nail protrusion, presumably because of local rotator cuff damage during insertion.

Our results suggest that considerable modifications are required to the nail, and possibly to its site of insertion, before its use can be advocated.

Fractures of the humeral shaft have traditionally been regarded as relatively benign, with a high percentage of primary healing with conservative methods, using either a U-shaped splint (Böhler 1966) or a functional brace (Sarmiento et al 1977; Zagorski et al 1988). These methods have been found to give better results than primary plate fixation in closed injuries (Pennsylvania Orthopaedic Society 1959; Stewart 1964).

Operative treatment has usually been reserved for the treatment of nonunion (Müller 1965), for polytrauma patients (Bell et al 1985; Van der Griend, Tomasin and Ward 1986) and for those with neurovascular complications (Holstein and Lewis 1963). The results in operated patients have been generally favourable, but there has been a tendency to use fracture union as the major determinant of outcome; few studies have examined function at the shoulder and elbow (Mast et al 1975).

Intramedullary nailing has theoretical advantages over other techniques of internal fixation and has been used to maintain the alignment and length of the humerus (Rush and Rush 1950; Küntscher 1967; Durbin, Gottesman and Saunders 1983; Hall and Pankovich 1987). Without static locking, however, fixation was often not sufficiently rigid and external splintage was needed until union occurred (Brumback et al 1986). The recent development of a locking nail for the humerus by Seidel (1989) has created renewed interest and excellent results have been reported in small numbers of patients (Habernek and Orthner 1991).

In view of our satisfaction with the results of closed intramedullary nailing of femoral and tibial fractures (Christie et al 1988; Court-Brown, Christie and McQueen 1990), it was decided to adopt the humeral nailing system. We report the results of our first two years' experience.

PATIENTS AND METHODS

Between March 1989 and April 1991 we treated 35 patients with the Seidel nail for humeral shaft fractures. Five were lost to follow-up, leaving nine men and 21 women with an average age of 59 years (20 to 84) for review. Of these, 23 were nailed within one week of their fracture and the other seven were initially treated conservatively for undisplaced fractures, but were nailed within six weeks of injury because of late displacement. Three groups of fracture were distinguished by cause: minor trauma, major trauma and pathological (Table I). The fracture was in the distal third of the humerus in one case, in the mid-shaft in 19, and in the proximal third in seven. There were three segmental fractures in the proximal and mid-shaft regions. All the operations were carried out by senior surgeons who were experienced in techniques of intramedullary fixation.

Technique of operation. Under general anaesthesia, the patient is placed supine on a 30° split table and the fracture reduced under image intensifier control. A short

C. M. Robinson, FRCS Ed, Registrar
K. M. Bell, FRCS Ed, Registrar
C. M. Court-Brown, MD, FRCS Ed(Orth), Consultant Orthopaedic Surgeon
M. M. McQueen, FRCS Ed(Orth), Senior Lecturer and Consultant Orthopaedic Surgeon
Orthopaedic Trauma Unit, Royal Infirmary of Edinburgh, 1 Lauriston Place, Edinburgh EH3 9YW, Scotland.

Correspondence should be sent to Mr C. M. Robinson at Princess Margaret Rose Orthopaedic Hospital, 41–43 Frogston Road West, Edinburgh EH10 7ED, Scotland.

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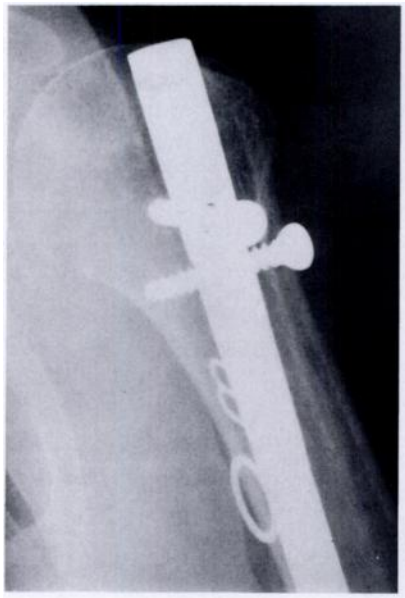

Fig. 1a

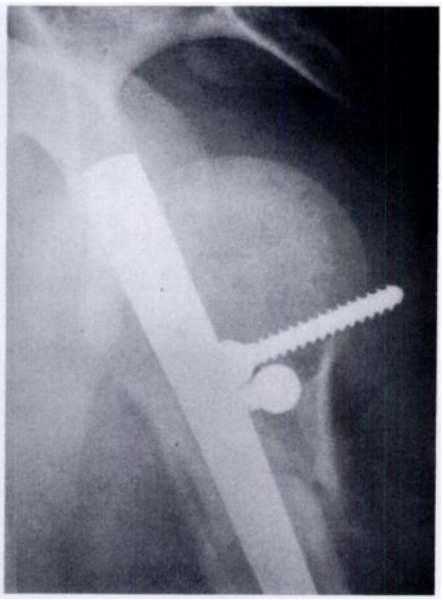

Fig. 1b

Figure 1a – Radiograph showing satisfactory proximal screw placement. Figure 1b – Two screws misplaced because of failure of the guide jig.

Table I. Three aetiological groups in 30 patients who had Seidel nailing for humeral shaft fractures

		Age in years	
Cause of fracture	**Number**	**Mean**	**Range**
Minor trauma	17	70	64 to 84
Major trauma (road-traffic accident or fall from a height)	10	39	20 to 56
Pathological	3	58	51 to 64
Total	30	59	20 to 84

Table II. Technical problems at operation in 30 cases of Seidel nailing

	Cases	
Problem	**Number**	***Per cent***
Initial failure to pass guide wire	3	*10*
Difficulty with proximal locking	8	*27*
Failed distal locking	9	*30*
Residual shortening	1	*3*
Residual angulation	4	*13*
Iatrogenic fracture	3	*10*

Fig. 2a

Fig. 2b

Figure 2a – Satisfactory expansion of the distal locking mechanism. Figure 2b – Failure of distal locking due to stripping of the screwdriver socket in the distal locking bolt.

deltoid-splitting approach is used to expose the greater tuberosity and a bone awl is passed through its apex to open the medullary canal. A guide wire is then passed across the fracture and the canal reamed to accept the Seidel nail. A special long screwdriver is introduced through the nail to unscrew the distal locking bolt, spreading the locking fins.

A guiding device mounted on the proximal end of the nail is used to insert proximal locking screws after drilling. The wound is closed in layers of rotator cuff, deltoid and skin.

After operation, patients began early active shoulder exercises under the supervision of a physiotherapist, and were reviewed and radiographed at regular intervals. Of the 30 patients 18 were reviewed at least six months after injury, and shoulder function was assessed by the Neer score (1970), modifying it to include the radiographic appearance of the united shaft fracture. Pain and range of movement at the elbow were also evaluated.

RESULTS

Technical difficulties. All operations were performed by experienced senior surgeons, but there were considerable technical difficulties during the nailings (Table II).

a) In three transverse mid-shaft fractures, the guide wire could not be passed across the fracture site, and open exposure was necessary.

b) There were difficulties with the proximal locking in eight cases: the guide device failed to locate accurately the locking holes in the nail. Osteoporotic bone often offered little resistance to drilling and it was difficult to be certain that screws had passed through the target holes. Operative radiography of this area proved difficult. In four of these eight cases proximal locking was not achieved: both screws missed their holes (Fig. 1), and in the other four one of the two screws was not correctly located.

c) The distal locking mechanism also gave problems (Fig. 2). All the nails were 9 mm in diameter and the shaft was usually over-reamed by 1 mm. The fins had therefore to expand by at least 1 mm to obtain a grip. We measured this distal expansion on postoperative films, allowing for radiographic magnification. The mean expansion was 1.35 mm, but in nine cases (30%) it was less than 1 mm. In these the distal mechanism had failed to operate properly due to stripping of the hexagonal socket for the long screwdriver in the distal locking bolt. In some osteoporotic patients there was minimal resistance to the opening of the distal fins, giving no distinct end-point and uncertainty whether adequate distal anchorage had been achieved.

d) Correction of shortening was possible in all but one case, but in four (13%) there was residual varus or valgus, or recurvatum angulation of 10° or more.

e) In three cases (10%) minimally displaced iatrogenic fractures occurred during nail insertion. One was in the proximal humerus at the site of cross-screw insertion, one was distal to the tip of the nail, and one was a longitudinal split along the length of the bone. All three united with conservative management with the nail left in situ.

Postoperative complications. There was proximal protrusion of the nail in 12 cases (40%) and this was attributable to four factors (Table III). In two cases the cross-screws, at first insertion, were passing across a proximal fracture, and the nail had to be withdrawn slightly to allow the screws to be placed above the fracture.

In one of the four cases with angulation after nailing, late movement at the fracture site caused proximal protrusion.

Migration due to inadequate proximal or distal locking (Fig. 3) was seen in five cases, usually secondary to the technical difficulties mentioned above. There was migration of the nail despite apparently adequate locking in four osteoporotic patients; this was presumed to be due to loosening or cutting-out (Fig. 4). In cases with protrusion, the nail was removed as soon as there was evidence of radiographic union.

Two patients had bacteriologically proven infections, controlled with the nail in situ. One of these, however, required exchange nailing later for delayed union.

The mean time to union was 18 weeks (8 to 96) but seven patients required treatment for delayed union (Table III). Five of them had exchange nailing with over-reaming. This failed in three, two of whom then had open dynamic compression plating with bone grafting. Two patients had primary plating and grafting for nonunion. Three of the seven patients have persisting nonunion.

The cap washer, a device designed to stabilise the humeral head to the proximal end of the nail, was used in three patients with Neer group-III injuries. Four other proximal fractures were managed by locking screws. In these seven patients there was failure of fixation in three, requiring re-operation using either plating or a Rush pin and tension band wire. One patient developed a radial nerve palsy after nailing, but this recovered over three months.

In our 30 patients 21 secondary operations were needed, including eight implant removals after union. One or more operative or postoperative complications have occurred in 26 patients (87%).

Functional results. Functional assessment was carried out on 18 patients at a mean follow-up of 11 months (6 to 20). All had clinical and radiographic evidence of union.

Neer scores for shoulder function in the three fracture groups are shown in Table IV. Thirteen patients had moderate to severe shoulder pain, and the mean ranges of movement were: flexion 98°, extension 15°, abduction 86°, external rotation 10°, and internal rotation 30°. The numbers were too small to show any differences between the aetiological groups. Eight of the 13 patients

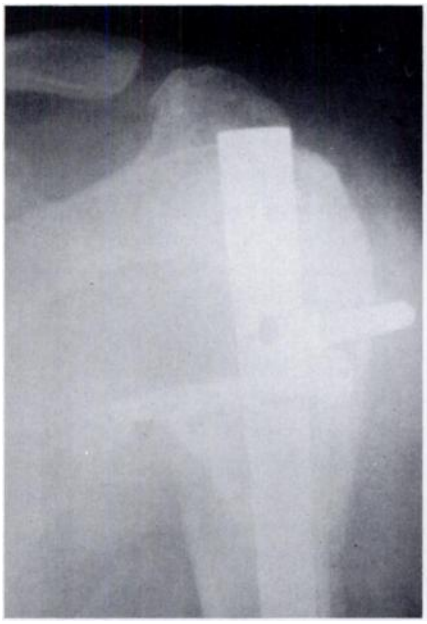

Fig. 3a

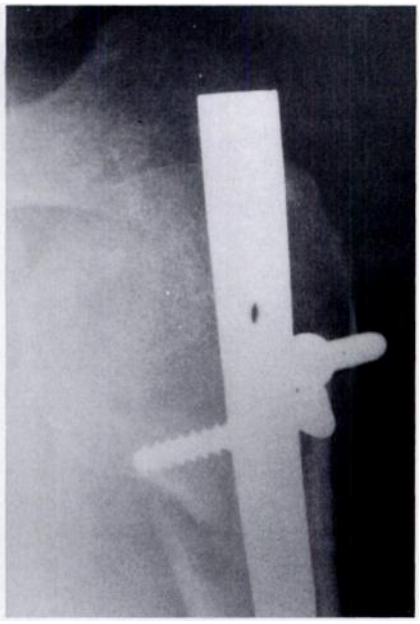

Fig. 3b

Proximal migration after inadequate locking in a 27-year-old patient with a proximal fracture. Figure 3a – Soon after nailing showing inaccurate screw placement. Figure 3b – After three weeks there is nail protrusion above the greater tuberosity.

Table III. Postoperative complications in 30 patients after Seidel nailing of the humerus

Complication	Cases	
	Number	*Per cent*
Proximal protrusion of nail	12	*40*
Intentional	2	*7*
Angulation after nailing	1	*3*
Inadequate locking	5	*17*
Migration	4	*13*
Infection	2	*7*
Delayed or nonunion requiring operation	7	*23*
Exchange nailing	5	*17*
Plating and bone grafting	2	*7*
Failure of fixation	3	*10*
Radial nerve palsy	1	*3*

Table IV. Shoulder function by Neer score in 18 patients after Seidel nailing

	Minor trauma (n = 9)	Major trauma (n = 8)	Pathological (n = 1)
Excellent (> 89)	1	1	0
Satisfactory (80 to 89)	2	1	0
Unsatisfactory (70 to 79)	2	3	1
Poor (< 70)	4	3	0

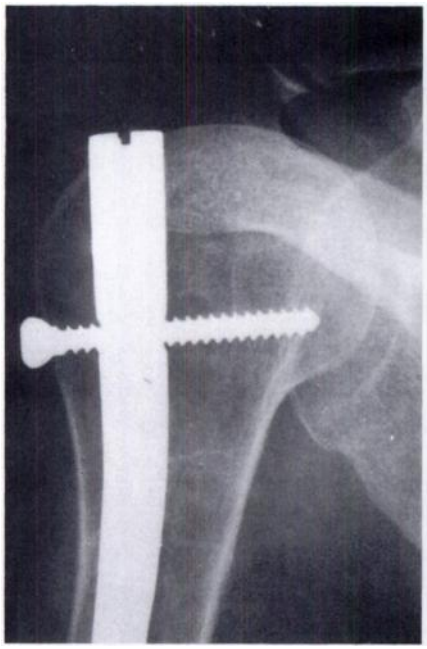

Fig. 4a

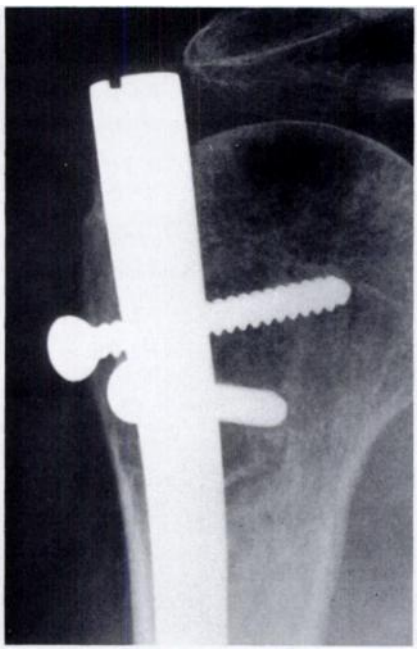

Fig. 4b

Proximal migration in a 74-year-old patient with a transverse mid-shaft fracture despite apparently adequate locking. Figure 4a – Postoperatively, the screws are in the correct position. Figure 4b – Radiograph at one month shows proximal migration of the nail.

with poor or unsatisfactory shoulder scores had nail protrusion which necessitated implant removal at union, but the other five had no radiological evidence of nail protrusion.

Two patients had elbow pain with 20° loss of extension. One of these had a distal fracture and, during nailing, sustained a longitudinal split which reached the elbow.

DISCUSSION

In contrast to previous reports of Seidel nailing (Seidel 1989; Habernek and Orthner 1991), our results show that there are considerable problems at present in the use of the humeral locking nail. We had major difficulties with both proximal and distal locking and, partly due to this, there was a high incidence of migration and subacromial impingement. The modifications to proximal locking suggested by Habernek and Orthner (1991), would help to improve the accuracy of placement of proximal cross-screws, but we feel that a major modification or re-design of the distal system is also required. Nail protrusion was also seen after technically adequate locking; this raises doubts about the efficacy of locking in osteoporotic patients with poor bone stock.

The incidences of delayed and nonunion in our series are comparable to those reported for conservative management (Mast et al 1975) or internal fixation (Stewart 1964; Stern et al 1984), but our treatment of established nonunion has been less successful. Over-reaming and exchange nailing is a useful technique for femoral and tibial nonunion after nailing, but failed in three of our five cases. The provision of nails of larger size than the standard 9 mm would allow more reaming, providing a greater stimulus to callus formation.

Our functional results show the importance of the assessment of joint function after shaft fractures. One of the major theoretical advantages of locked nailing is that it should permit early active movement. Habernek and Orthner (1991) reported no impairment of shoulder function at six weeks, but this has not been our experience, and although in a proportion of cases shoulder pain and reduced range of movement were caused by subacromial impingement due to nail protrusion, in five patients poor shoulder function and signs of impingement were present without evidence of this. This finding is a cause for concern since the most likely reason for symptoms in these patients was rotator cuff injury at the time of nail insertion. Using other nails, Van der Griend et al (1986) also found that proximal insertion caused impairment of shoulder function, and Brumback et al (1986) obtained better results by using a distal insertion, proximal to the olecranon fossa. We found that the potential benefits of closed nailing were largely negated by poor shoulder function. Theoretically, locked medullary nailing of humeral shaft fractures is an attractive technique, especially for the rapid, closed stabilisation of polytrauma patients and for pathological fractures. In practice, the current Seidel system was found to be insufficiently 'user-friendly', with many disadvantages. We cannot advocate its use unless there are major modifications to the nail itself, and possibly to its portal of insertion.

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