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Locked intramedullary nailing for difficult nonunions of the humeral diaphysis

Accepted: 30 April 2003 / Published online: 22 May 2003
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Abstract Antegrade intramedullary nailing and bone grafting was carried out for 27 patients with resistant atrophic nonunion of the humeral diaphysis. The initial fracture was open in 12 cases and closed in 15. There were ten proximal humeral fractures, 13 mid-shaft fractures and four distal humeral shaft fractures. Most had previous attempts at internal fixation with bone grafting. Fifteen cases united, but 12 remained ununited necessitating further surgical treatment. The failures were all in the more complex cases. Lack of rigidity and compression may be the problem.

Résumé Un enclouage centro médullaire antérograde avec greffe osseuse a été réalisé chez 27 malades avec une pseudarthrose atrophique de la diaphyse humérale. La fracture initiale était ouverte dans douze cas et fermée dans quinze. Il y avait 10 fractures proximales, 13 fractures médio-diaphysaires et 4 fractures distales. La plupart avaient eu des tentatives précédentes de fixation interne avec greffe osseuse. Quinze cas ont consolidé, mais douze ont nécessité un traitement chirurgical supplémentaire. Les échecs étaient toujours dans les cas les plus complexes. Le manque de rigidité et de compression est peut être le problème.

Introduction

Nonunion of the humerus is a frequent complication of fractures, whether operated on or not [4, 6, 7]. Intramedullary (IM) nails and plating have more or less similar results as the primary surgical treatment of fresh humeral fractures. However, use of the IM nail for treatment of nonunions of the humeral diaphysis still remains somewhat controversial [14, 18]. We present our experience

of 27 cases of difficult nonunions of the humerus over a 5-year period using one type of IM nail with an open technique combined with autogenous bone grafting.

Materials and methods

Between 1995 and 2000, we treated 27 cases of atrophic nonunion of the humerus. There were 18 men and nine women. Average age was 27 (range 15–56) years. The original injuries included 15 motor vehicle accidents, a fall in four, gunshot injury in six, one nonunion following open treatment of an aneurysmal bone cyst and one after osteotomy for varus deformity following a supracondylar fracture. There were 12 open and 15 closed fractures. Sepsis was the cause of nonunion in three open fractures, which were treated with debridement and hardware removal. At the time of presentation to us, they were free of infection both clinically and judged by laboratory results. All patients had their primary surgery in other centres. The number of previous operations ranged from zero to three. Duration of nonunion ranged from 6 months to 17 years and was evident both clinically and radiographically. All patients were treated with a reamed IM nail along with open autogenous bone grafting using one type of nail (Biomet Inc., Warsaw, IN, USA). Cultures and histological examination was performed on tissue taken from the nonunion site, which were negative for infection in all cases.

Operative technique

Patients were usually placed in the lateral decubitus position. The fracture site was exposed through a lateral approach for proximal and mid-shaft fracture or using the previous approach as necessary. In cases of distal third fracture (Fig. 1a and b), a posterior approach was used, but in some cases an osteotomy of the olecranon was also performed (Fig. 1c and d). In all cases, the radial nerve was found and protected. The fracture site was cleared of fibrous tissue, and a locked antegrade reamed IM nailing was then performed. All patients had autogenous bone graft from the iliac crest. Cement was occasionally used to augment fixation of the locking screws, especially distally (Fig. 2).

Results

All patients were followed for 1–6 years, with a mean of 4 years. Fifteen nonunions united in periods ranging from 3 to 6 months. Twelve patients had no signs of

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Fig. 1 **a, b** Preoperative radiographs of a 36-year-old man showing difficult nonunion of the distal third of the humerus. **c, d** Postoperative radiographs showing nail placement with the distal end of the nail cut off to provide distal interlocking

union at a minimum of 6 months of follow-up. Of these 12 cases of failed union, ten had had open fractures at the time of primary treatment. Three patients had already undergone three failed operations, five two failed operations, and four one failed operation. Six of these failed cases ultimately healed with the use of bone grafting and plating after removal of the nail, and two healed with the use of plating with the nail still in situ. Of the four with persistent nonunion, two had a fibrous union with minimal pain with the nail in place, and two had painful nonunion with nail in place but refused further surgery.

When first seen in the outpatient clinic, most of the patients had restriction of movements of the elbow and shoulder because of the injury and previous treatment. No significant improvement was noticed postoperatively, but no patient was worse. Mean preoperative shoulder abduction was 90° (range 40–180°). Mean postoperative abduction was 100° (range 60–180°). Mean preoperative flexion contracture of the ipsilateral elbow was 20° and was the same after surgery. Mean preoperative and postoperative flexion of the ipsilateral elbow was 100°.

Complications

One patient sustained an iatrogenic fracture of the humerus during reaming. The nail bypassed his fracture and both the old nonunion and the fresh fracture went on to heal. Two patients had transient radial nerve palsy and one an ulnar nerve palsy, all of which recovered fully. One patient had an iatrogenic radial nerve section, which occurred when isolating the radial nerve from the callus at the fracture site. After immediate repair, the nerve function recovered completely. Two patients had wound breakdown, which eventually healed. There were no postoperative infections or recurrences of infection. All patients received antibiotic prophylaxis for 48 h. Implant problems were seen in two patients, but with complete union. One patient had a proximal screw back out which was removed, the other patient's implant had to be removed after healing because of shoulder pain due to impingement of the proximal end of the nail.

Discussion

The use of surgical intervention for certain humeral fractures is well established, though indications may vary from surgeon to surgeon. For multiple trauma or pathological fractures, stabilization provides pain relief and easier rehabilitation. The results have been more or less similar for plating and intramedullary nailing for fresh fractures [2, 11]. Retrograde nailing has resulted in less

Fig. 2 **a** Preoperative radiographs of a 50-year-old woman after two previous platings and bone grafts; loose plate “sequestered” adjacent to the bone. **b, c** Postoperative radiographs with distal fixation augmented with cement 3 years following surgery. No sign of union

complications with the rotator cuff and is suitable for distal and middle-third humeral fractures [19]. The use of a plate requires more soft tissue dissection and carries potential risk for radial nerve damage [1, 19].

The nonunion rate after primary intramedullary nailing has been reported as high as 29% [3, 8]. Higher rates of nonunion are reported for high-velocity open fractures with extensive soft-tissue injury. In cases of nonunion, there is often osteopenia, which may compromise good screw fixation, especially in cases of distal humerus fractures [9]. Surprisingly, we have found the IM humeral nail the most useful in nonunions of the distal metaphysis [15].

Various methods have been used in the treatment of nonunion of humeral shaft fractures. The use of external fixators such as the Ilizarov frame has been successful. This device is useful for open fractures or infected cases and particularly versatile in handling complex angular deformities. Patel et al. [16] described 16 nonunion of humeral diaphysis. All but one united with improvement of pain and function. In their series, the nail was left in place and fracture was compressed over it. Compression seems useful for success whether a plate or an external fixator is used. Compression is lacking in an intramedullary nail device.

Other methods, like vascularized fibular graft, have been used with success, but this procedure is complex [12]. More recently, Hornicek et al. [9] reported results with the use of onlay bone plate allograft augmentation along with a compression plate. Union rate was 100%. Again, compression was used in this series along with bone graft, both of which addressed the problem of osteopenia.

Plating with or without compression has been the established treatment to which all others must be compared. Healey [7] reported excellent results in humeral nonunion in 26 patients. Of the 26 nonunions, the 24 (92%) treated with bone graft and rigid internal fixation healed in an average of 5.6 months. In their series, there were 19 atrophic nonunions. They recommended bone grafting with plating for nonunions of the humerus. Ring et al. [17] treated 15 patients with atrophic non-union with cancellous graft and a bridging plate and obtained union in all but one patient.

One problem remaining with plating and bone grafting is extensive dissection and possible injury to the radial nerve, which is often stuck in the scar tissue. Rommens [19] reported a 12.8% incidence of radial nerve palsy, and complete functional recovery occurred in only 60% of patients.

The intramedullary nail was used by McKee [14] in ten patients with humeral nonunion. Only four humeri united. Robinson [18] reported two unions out of five. Failure may have been due to the absence of axial loading [10]. Similarly, Flinkkila [5] reported union in only six of 13 patients who had humeral nonunion treated with exchange nailing. Better results with open bone grafting and nailing were reported by Lin et al. [13]. In their series, there were 28 nonunions and 13 delayed unions. All but two did not unite.

In our series, we had 12 failures after intramedullary nailing and open bone grafting out of 27 cases. This was only a 56% success rate. Our failure rate correlated directly with severity of the injury, whether the fracture was open or not and the number of previous operations. All of these patients had one or more previous surgical intervention (Fig. 2a). Ten of these 12 failures had open fractures at the time of initial presentation; three of these had documented infection. The previous surgery for these 12 cases included seven intramedullary nails, three external fixators and two platings.

The type of implant used also had some effect on healing. Patients who had a previous intramedullary nail seemed more prone to develop a resistant nonunion as compared with those who had plating. Nonunions after previous use of an intramedullary nail were surprisingly difficult to treat as compared to previous plating. This may be because of poor endosteal circulation secondary to repeated reaming or injury of previous surgeries, or osteopenia either primary or secondary to immobilization.

Our experience leads us to suggest that nonunions after complex open fractures of humeral diaphysis that have been primarily treated with an IM nail should be treated with plating and autogenous grafting. Intramedullary nailing to stabilize the nonunion does not provide adequate compression compared to plating.

We improved no range of movement in the elbow or the shoulder. Due to the nature of the injury and previous surgery, most patients had restriction of movement in the elbow and shoulder. All patients, however, regained the preoperative range of motion.

The treatment of nonunion of the humerus with an IM humeral nail plus autogenous bone grafting had a high rate of failure in our series (44%), which correlates with the complexity of the previous injury. Also, IM nail lacks rigidity and the ability to apply compression. Nonunions from previous IM nailing are particularly prone to failure.

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