intramedullary fibular graft and quadricortical plate fixation in atrophic non-union of the osteoporotic humerus

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Introduction

Fractures of the humerus account for approximately 5–8% of all fractures. Most humerus fractures heal uneventfully, but when non-union occurs, it is incapacitating for the patient, and challenging for the surgeon. Several surgical techniques have been used for treatment of non-union including compression plates, intramedullary nails and external fixators, with or without bone grafts.3–9,12 Atrophic non-union of the humerus presents a difficult reconstructive problem because of possible bone loss and osteopenia. Screw purchase in severe osteoporosis represents a surgical problem with risk of failure of fixation. Intramedullary fibula was used to increase the bone available for purchase of the screw thread.4,13 This study was done to report on the use of intramedullary fibular bone graft and plate fixation in diaphyseal atrophic non-union of the humerus with osteoporosis. This work has been approved by the ethical committee of our institution and all patients gave informed consent to the work.

Patients and methods

Between January 2000 and December 2005, 10 patients with diaphyseal non-union of the humerus were treated in our institution by intramedullary fibular autograft and plate fixation.

Inclusion criteria: Patients with atrophic diaphyseal non-unions of the humerus and osteoporotic bone were included. Osteoporosis was defined radiologically as marked thinning out of the cortical bone and widening of the medulla. Patients were selected when other lines of treatment had been failed or unsuitable to apply. Three out of 10 patients had had failed plate fixation, one of them had had three unsuccessful surgeries of plate fixation and revisions with cancellous bone graft. Seven patients presented after failed prolonged conservative treatment in plaster cast or functional brace. Patients with infected non-union were excluded.

Operative technique

1. Surgical exposure: The humerus was exposed through an anterolateral approach in eight patients, and through the posterior approach in two with exploration and neurolysis of the radial nerve out of the non-union site.
2. Excision of the pseudoarthrosis: The fibrous non-union and any dead bone was thoroughly excised.
3. Preparation of the medullary canal: The medullary canal was opened usually using a hand reamer of 7-mm diameter, followed gradually and cautiously by the larger reamers up to the size that could fit to the diameter of the medullary canal. The largest reamer size used was 12 mm. The aim was just to allow placement of
the fibular graft without excessive reaming of the medulla.

4. **Raising the fibular graft**: An autograft fibula was raised. The length of the graft was determined by the length of the plate to be used.

5. **Insertion of the fibular graft**: The fibular graft was fashioned to fit into the medullary canal. It was inserted first into the medullary canal of the longer bone segment and then moved into the shorter segment as the fracture was reduced. On two occasions half of a split fibula was used to fit a narrow canal.

6. **Plate fixation**: A narrow DCP was used with quadricortical screw fixation. Each screw hole was drilled and tapped through four cortices, two in the fractured bone and two in the intact fibula and 4.5 mm cortical screws were inserted. There was only tri-cortical screw fixation on the two occasions where half of a split fibula was used to fit a narrow canal.

7. **Autogenous bone grafts from the iliac crest** were placed around the fracture site in all the patients (Fig. 1).

**Post-operative management**

The arm was immobilized in a sling. Shoulder and elbow exercises were started 2 days post-operatively.

**Follow up**

After hospital discharge, patients were observed on a monthly basis till healing of the fracture. All patients were examined both clinical and radiological. Fracture union was considered radiographically if callus formation was seen in three of four cortices on anteroposterior and lateral views. Clinical union was considered when the fracture site was painless.

**Results**

**Patients’ data**

Age ranged between 55 and 70 years (average 64 years), with a male to female ratio of 2—8. Duration of non-union ranged between 6 and 36 months (average 16 months). Follow up period ranged from 24 to 64 weeks (average 40 weeks).

**Fracture union**

All fractures united without the need for other operative procedures (Fig. 2). Time to fracture healing ranged from 12 to 24 weeks (average 16 weeks).

**Complications**

Post-operative stress supracondylar fracture of the humerus occurred once. It was treated by internal fixation of the fracture with achievement of union after 12 weeks. There

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**Figure 1** Quadrucortical fixation. Each screw hole was drilled and tapped through four cortices, two in the fractured bone and two in the intact intramedullary fibula and 4.5 mm cortical screws were inserted. Autogenous iliac cancellous bone graft was placed around the fracture site in all the patients. The intramedullary fibula may act as an intramedullary strut, adding to the stability of the fracture.

**Figure 2** Follow up X-ray 12 weeks post-operatively showing progression of fracture union.
was no reported major problem regarding the fibular or iliac autograft donor sites.

Discussion

A variety of operative techniques has been used for treatment of non-union including compression plates, intramedullary nails and external fixators, with or without bone grafts.1,9,10 The geometry of the humerus, particularly at its proximal and distal ends, limits the choice of implant. The insertion of the deltoid limits proximal plating, and the olecranon fossa limits distal plating. Frequently, the radial nerve may be encased in scar, making it more at risk for iatrogenic injury. Exposure of the fracture is needed to excise the non-union site, explore and protect the radial nerve, correct angular or rotational deformity, remove a failed implant, or to apply a bone graft. For these reasons plate fixation is often used for fixation in non-union of the humerus. The limitation of plate fixation in non-union with osteoporosis is screw purchase in the bone. This depends on the quality of the bone.1,9,10 The quality of the bone is compromised by advanced age or postmenopausal status and by disuse during previous treatment lines of the fracture.

Methylmethacrylate bone cement has been used to augment screw fixation but it may have harmful effects on the blood supply of the bone and on healing of the fracture, especially if it extrudes from the holes of the plate into the fracture site.2,11 It has an exothermic reaction, the heat from which may kill adjacent cells and inhibit the biologic aspects of healing. Finally, the cement represents an intraosseous foreign body that may become problematic if additional surgery is needed or if there is a deep infection.6 Several other techniques have been suggested for improving internal fixation of osteoporotic bone including application of a strut of cortical bone (usually allogenic), exchange of loose 4.5-mm cortical screws with 6.5-mm cancellous screws, and application of a supplementary intramedullary plate to substitute for a deficient or osteoporotic opposite cortex. Although these techniques are useful, each has specific drawbacks that limit their application.

The use of locking compression plates may improve fixation in osteoporotic bone. The locking head screws are fixed to the plate and each screw behaves like a fixed blade. There is only one report6 on the successful use of locking compression plates in 24 patients with osteopenic delayed unions or non-unions of the shaft of the humerus with biological augmentation by bone graft or demineralised bone in all patients. One concern in the use of these plates is direct pullout of the locked bolts because of their shallow threads.6 Intramedullary fibula was used to increase the bone available for purchase of the screw thread.4,13 The intramedullary fibula provides cortical bone of good quality to enhance screw purchase. Biomechanical tests have shown the efficacy of using an intramedullary bone graft to improve screw fixation.13

Advantages and disadvantages of intramedullary fibular graft

The fibula does not only improve screw purchase by providing good cortical bone, but also it may add fixation and stability to the fracture site by acting as an intramedullary strut (Fig. 1). It may also improve the biological factors as a bone graft.

A possible disadvantage of this technique is the disruption of both the periosteal and the endosteal blood supply. This is already compromised at the site of non-union and it is usual to ream the medullary canal in non-unions regardless of the method of fixation applied.13 There was no need to ream the medullary canal in our study as it was already wide but we opened it only enough to allow insertion of the fibular graft.

Another possible disadvantage is raising an autograft with donor site morbidity.

Conclusion

This study reports on the use of an intramedullary fibular autograft to enhance plate fixation by quadricortical or tricortical screw purchase in atrophic osteoporotic diaphyseal non-unions of the humerus. This technique is useful when other fixation methods have been failed or expected to fail.

References