



Open reduction and internal fixation of humeral non-unions : Radiological and functional results

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This study aimed at assessing the effectiveness of open reduction and plate fixation combined with autogenous bone grafting in the treatment of non-united fractures of the humeral shaft.

Forty six patients (27 men, 19 women ; mean age, 35.6 years ; range, 23-53 years) were operated on for non-union of a diaphyseal fracture of the humerus. Sixteen patients had surgical treatments and 30 patients had non-surgical treatments prior to operation. They were operated on average 7.8 months (6-17) following their initial treatment. None of the nonunions were infected. Radial nerve deficit was present in no patient. Treatment included open reduction and plate fixation combined with autogenous bone grafting. The mean follow-up period was 26 months (range : 13-41). No patient was lost to follow-up.

The operative time averaged 91 minutes (range : 68-123). Union was achieved in all patients in a mean of 6.1 months (range : 5-13). There were nine postoperative complications (superficial infection in 5 and radial nerve palsy in 4). The infections resolved after local treatment. The radial nerve palsies recovered spontaneously. On clinical evaluation, shoulder range of motion was excellent in 41 patients (89.1%), and moderate in five patients (10.9%). Elbow range of motion was excellent in 30 patients (65.2%), moderate in 14 patients (30.4%) and poor in 2 patients (4.4%). Functional results were excellent in 24 patients (52.2%), good in 14 patients (30.4%), fair in 6 patients and poor in 2 patients (04.4%).

In this study, plate fixation combined with autogenous bone grafting appeared as a safe and effective option in non-infected non-union of the humeral shaft.

Keywords : non-union ; pseudarthrosis ; humerus ; plate fixation ; autogenous bone grafting.

INTRODUCTION

Although many humeral shaft fractures heal uneventfully, non-union is not rare (2,16,17). The occurrence rate of humeral non-union as a complication of both non-operative and operative treatment has been reported to be as high as 13% (5,17).

Absence of bony union 4 to 8 months following primary treatment is accepted as non-union (2,5,14). Pain and loss of function with difficulties in activities of daily living are common problems in humeral non-union.

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Non-union of the humerus should be treated operatively. Various methods have been recommended, including intramedullary nailing, cortical bone grafting, external fixation and a variety of plate techniques (2,6,8,10,16).

Although plate fixation remains one of the most efficient techniques, poor bone quality or a deficient plating technique may lead to failure to heal the non-union (2,16).

The aim of this study is to assess the results of open reduction and plate fixation combined with autogenous bone grafting in the treatment of humeral non-union.

PATIENTS AND METHODS

Patients

We reviewed the patients who had undergone plate fixation for non-union of the humeral shaft between 2006 and 2009. Fractures which did not heal in 6 months following initial treatment were considered as non-unions. The diagnosis of non-union was made by clinical examination and on plain radiographs in all patients.

A total of 46 patients were treated by plate fixation and autogenous bone grafting for non-union of a humeral shaft fracture. There were 27 male and 19 female patients. Their mean age was 35.6 years (range : 23-53 years). The right arm was involved in 26 cases, the left arm in 20. The mechanism of injury included motor vehicle accidents (25 patients), occupational accidents (13 patients), and falls (8 patients). According to the situation of the initial fractures, there were 10 proximal-third fractures, 21 middle-third fractures, and 15 distal-third fractures.

Sixteen patients had surgical treatments and 30 patients had non-surgical treatments prior to operation (Fig. 1 & 2). Twenty five patients had hypertrophic and 21 patients had atrophic or oligotrophic non-unions. Patients were operated on average 7.8 months (range : 6-17) following their initial treatment. There was no infected non-union. No patient had a radial nerve deficit.

Operative technique

General anaesthesia was used in all patients. The arm was placed on a side table. A tourniquet was not used. Previous incisions were used in patients with previous surgeries and anterolateral incisions in others. The radial



Fig. 1. — A 43-year-old male sustained a closed displaced humerus fracture in a traffic accident, which was treated non-operatively. a. Anteroposterior and lateral radiographs of the arm showing non-union of the humerus nine months after the injury ; b. Fracture union achieved 7 months after open reduction and plate fixation with autogenous bone grafting.

nerve was explored and the non-union was thoroughly débrided.

Fixation was performed with dynamic compression plates and an additional interfragmentary screw when



Fig. 2. — A 36-year-old male sustained a closed diaphyseal humeral fracture in a road traffic accident, which was treated operatively. a. Anteroposterior radiograph of the arm showing the non-united fracture three months after the index surgical treatment; b. Union achieved 10 months after open reduction and plate fixation with autogenous bone grafting.

possible. Grafting with autogenous bone was performed in all patients. Cancellous grafts were procured from the iliac crest in 31 patients, and from a hypertrophic callus in the other 15.

Postoperatively, the patients wore a splint and a sling for three weeks. They were encouraged to perform

range-of-motion exercises of the shoulder and elbow while avoiding torque or resisted activities until healing occurred.

Evaluation

The mean follow-up period was 26 months (range : 13-41). At latest follow-up, range of motion in shoulder and elbow were assessed according to Rommens *et al* (13) and functional results were assessed according to Stewart and Hundley (18) (Tables I & II). Absence of bony union at 3 months following the operation was considered delayed union.

RESULTS

The operative time averaged 91 minutes (range : 68-123). No patient was lost to follow up.

Union was achieved in all patients, in a mean of 6.1 months (range : 5-13) (Fig. 1 & 2). There were eight delayed unions (17.4%), all of which went on to union between 3 and 6 months following surgery.

There were nine postoperative complications (19.6%) : superficial infection in 5 patients and radial nerve palsy in 4 patients. The infections resolved after local treatment. The radial nerve palsies recovered spontaneously. Other complications such as compartment syndrome, deep infection, nonunion, malunion, implant failure or permanent nerve damage were not noted.

On clinical evaluation at final follow-up, 30 patients (65.2%) reported that they had no pain, 10 (21.8%) reported occasional pain, 4 (8.6%) reported pain after efforts, and 2 (4.4%) reported continuous pain. Shoulder range of motion was excellent in 41 patients (89.1%), and fair in five patients (10.9%). Elbow range of motion was excellent in 30 patients (65.2%), fair in 14 patients (30.4%) and poor in 2 patients (4.4%).

Functional results were excellent in 24 patients (52.2%), good in 14 patients (30.4%), fair in 6 patients and poor in 2 (04.4%) patients.

DISCUSSION

Although majority of humeral shaft fractures heal uneventfully, nonunion is not uncommon (16, 17). The rate of non-union is reported to be 2 to 10%

Table I. — Assessment of range of motion in shoulder and elbow joint according to Rommens *et al* (13)

	Excellent	Fair	Poor
Restriction in shoulder motion	< 10°	10° - 30°	>30°
Restriction in elbow motion	<10°	10° - 30°	> 30°

Table II. — Functional assessment according to Stewart and Hundley (18)

Results	Criteria
Excellent	<ul style="list-style-type: none"> – No pain – Full range of motion – Proper alignment
Good	<ul style="list-style-type: none"> – Occasional pain – Less than 20° restriction in any adjacent joint motion – Angulation less than 10°
Fair	<ul style="list-style-type: none"> – Pain following effort – 20-40° restriction in any adjacent joint motion – Angulation more than 10°
Poor	<ul style="list-style-type: none"> – Continuous pain – More than 40° restriction in any adjacent joint motion – Nonunion or iatrogenic nerve damage

in non surgically treated, and 10 to 15% in surgically treated humeral shaft fractures (2,5,12,17).

A number of factors have been reported to encourage non-union of humeral shaft fractures, such as the severity of initial injury, a transverse fracture pattern, distraction of the fracture, soft tissue interposition, inadequate immobilization, obesity, and inadequate treatment (5).

Various treatment methods have been recommended, including intramedullary nailing, cortical bone grafting, external fixation and a variety of plating techniques (2,6,8,10,16).

Union is usually not achieved with Seidel nails and there is a need for secondary surgical interventions in 34 to 58% of cases (1,19). Despite successful results with antegrade nailing, this type of treatment may affect function in the shoulder joint (3). Martinez *et al* (10) treated 21 patients with retrograde unreamed nails and cancellous autograft in order to avoid the risk of loss of function in the shoulder joint. They achieved union in all cases but observed over 10° loss in shoulder and elbow motion in 33% of their cases. They also observed varus and valgus malunions with 5° angulation in two patients.

External fixation techniques may provide some advantages in the treatment of humeral shaft non-union (7); Among these advantages, are absence of a need for bone grafting and the possibility to treat infected non-unions. Besides, the technique allows for immediate postoperative motion. On the other hand, the patients may experience discomfort caused by the frame, and treatment may have some severe complications. Lammens *et al* (8) achieved union in 28 of 30 patients treated with Ilizarov external fixation. Pin tract infections which required oral antibiotic treatment occurred in all patients.

Healy *et al* (6) reported plate fixation to be the most successful treatment method in humeral non-unions. Stable plating achieved by fixation of 6 cortices on both fragments was reported by the authors to be the most important factor for a successful result. On the other hand, obtaining a bone bed with a good blood supply and grafting the non-union site can only be achieved following adequate debridement of bone and soft tissues (14,15). Achieving a perfect cortical contact between fragments also influences healing in both acute fractures and non-unions (9).

Rubel *et al* (16) achieved union in 34 (92%) of 37 patients with humeral shaft non-union who were treated by open reduction and internal fixation.

Although several authors have recommended plate fixation to treat humerus shaft non-union, a deficient plating technique is one of the main reasons why fractures may fail to heal (4,14,17). Murray *et al* (11) pioneered the use of double-plate constructs for non-unions in 1964. Using an antero-lateral approach, they placed one plate on the lateral side of the humerus and a second plate on the posterior aspect. They suggested that this provides a more stable construct than achieved with a single plate because of the biplanar control provided by the two plates at right angles to each other. Foster *et al* (4) reported a 96% rate of union in their study of fixation of both fractures and non-unions. They used both single and dual-plate constructs with or without lag screws. They recommended the use of the dual plate-technique for long-standing non-unions. A concern regarding the use of two plates instead of one is the amount of soft-tissue dissection and devascularization needed to place a second plate at 90° angle to the first plate.

We achieved union in all patients using a one plate construct combined with autogenous grafting. Successful results in our series may be attributed to the fact that none of the non-unions was infected, and also to the fact that all patients were relatively young, with good quality of bone, without osteoporosis. We did not observe any complications such as a persisting radial nerve injury and deep infection, which are the major potential disadvantages of plate fixation (9,15).

As a conclusion we advocate open reduction and plate fixation combined with autogenous grafting in humeral shaft non-union without infection. A two-plate construct may sometimes be helpful if bone quality is poor or the stability achieved by the first plate is not clinically sufficient.

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