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ORIGINAL PAPER

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Non-union of the humeral shaft treated by internal fixation

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Abstract We reviewed 40 cases with non-union of the humeral shaft. There were 31 men and nine women patients with an average age of 38.5 (35–65) years. Thirty-four non-unions were of the atrophic type. Non-union was most often found at the transition of the middle third to the lower third of the humeral shaft. Six fractures were classified as open at the time of the initial injury. All patients were treated by open reduction and internal fixation with a dynamic compression plate (DCP). Cancellous bone graft was used in all atrophic non-unions. In one patient an additional fibular graft was used. The average follow-up was 13 (6–18) months. Final results were available for 34 patients. Thirty-one fractures (91%) healed in an average of 4.5 (3–9) months. Main complications were temporary radial nerve palsy in two patients and deep infection in one.

Résumé Nous avons examiné 40 cas de non – consolidation de la diaphyse humérale. Il y avait 31 hommes et neuf femmes avec un âge moyen de 38.5 années (35–65 années). Trente-quatre non – consolidations étaient du type atrophique. Le défaut de consolidation était le plus souvent à la jonction 1/3 moyen- 1/3 inférieur de la diaphyse humérale. Six fractures ont été classées comme ouvertes au temps de la blessure initiale. Tous les malades ont été traités par réduction ouverte et fixation interne avec une plaque à compression dynamique. Une greffe spongieuse a été utilisé dans tous les cas de non-consolidation atrophique. Chez un malades une greffe supplémentaire de péroné a été utilisée. La moyenne de suivi était 13 mois (6–18 mois). Les résultats définitifs étaient disponibles pour 34 malades. Trente-une fractures (91%) ont guéri dans une période moyenne de 4,5 mois (3–9 mois). Les principales complications étaient une paralysie temporaire du nerf radial pour deux malades et une infection profonde pour un patient.

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Introduction

Management of non-union of the humeral shaft is a difficult problem and several methods have been recommended in the literature. These include compression plating and bone grafting [1, 3, 4, 5, 6, 12, 13], intramedullary nailing [2], vascularised fibular grafting [7] and Ilizarov external fixator [9]. We are presenting our results of open reduction and internal fixation using a dynamic compression plate (DCP) with cancellous bone grafting in non-union of the humeral shaft.

Material and methods

This study included 40 cases of non-union of the humeral shaft fracture in 40 patients over a period of 4 years. There were 31 men and nine women patients with an average age of 38.5 years (35–65 years). Seventeen fractures were on the right side and 23 were on the left. Six fractures were open at the time of initial injury – four were Gustilo grade I, and one each were grade II and grade IIIA type. However, by the time these patients came for surgery, the wound in all of them had healed for at least 2 months. Two of these patients had persistent radial nerve palsy. Out of 40 patients, 34 were treated conservatively initially with a sling or a plaster slab, five by primary internal fixation (plate in three and unlocked nail in two) and one by an external fixator. Average time lapse after injury was 12.1 months.

All patients were operated under general anaesthesia. The non-union site was exposed through the anterolateral approach with identification of the radial nerve in fractures involving the upper two thirds of the humeral shaft. In the distal third, the triceps-splitting posterior approach was used. Fibrous tissue at the fracture site was excised, fracture ends were freshened and the medullary canal was opened on both sides. The fracture was fixed using either a narrow or broad compression plate engaging at least six and preferably eight cortices on either side of the fracture. In distal fractures (Fig. 1), if adequate distal fixation was not possible using a single plate, two small DCPs were used on each pillar. Cancellous bone graft from the iliac crest was packed around the fracture site in all atrophic non-unions. In hypertrophic non-unions local callus was used as bone graft. In one patient additional free fibular auto-

Fig. 1 **a** Atrophic non-union of a humeral shaft fracture in distal one third with severe angulation. **b** At 6 months after open reduction and internal fixation with cancellous bone grafting through posterior approach showing complete union

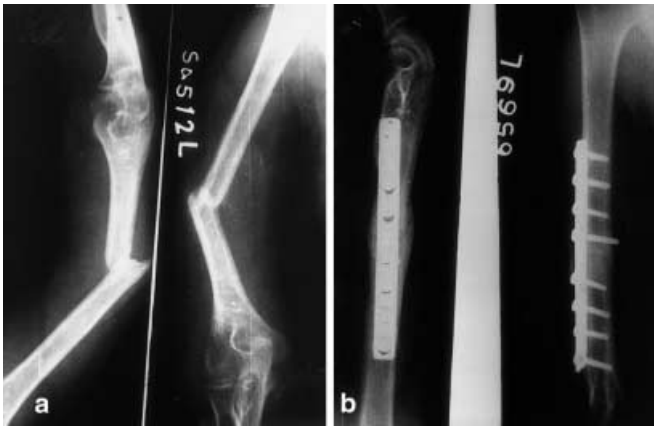

Fig. 2 **a** Atrophic non-union of a humeral shaft fracture. **b** At 6 months after open reduction and internal fixation with cancellous bone grafting showing complete union

graft was used to bridge the gap non-union following a gunshot injury.

Post-operatively, patients were allowed only pendulum exercises and passive mobilisation of the shoulder and gentle mobilisation of the elbow for the first 6 weeks. All patients were followed clinically and radiologically at 6 weeks, 3 months and quarterly thereafter. After check radiographs at the first visit more intensive active physiotherapy for both shoulder and elbow was allowed. A fracture was declared united if the patient was clinically asymptomatic and radiologically there was evidence of bridging of three cortices. The average follow-up time was 13 (6–18) months.

Results

Atrophic non-union (Figs. 1 and 2) was seen in 34 patients and hypertrophic in six. The most common site of non-union was at the transition of the middle third to the lower third of the humeral shaft (15 patients), followed closely by the middle third in 13 patients. Soft tissue interposition between the fracture fragments was the leading cause of non-union in 20 patients. Other causes of non-union were improper reduction in 12 patients, failure of primary surgery in five and bone gap in one. Some patients had more than one cause while, in nine cases, no cause could be identified.

Out of 34 fractures 31 united in an average period of 4.5 (3–9) months. Three fractures failed to unite. One was due to deep infection in a patient who sustained a grade II open fracture at the time of initial injury. The second patient suffered an additional undisplaced intercondylar fracture with slight angulation and bent plate at the operated site following a fall. The third patient had severe osteoporosis, which resulted in loss of fixation within 2 weeks after the operation. All three patients needed further procedures to achieve union.

Average range of movement of the elbow was 10°–120° and the average shoulder abduction was 140°. Complications included deep infection in one patient, as described above; superficial infection in three, which responded to oral antibiotic treatment; and post-operative radial nerve palsy in two, which completely recovered in 3 months.

Discussion

Fracture of the humeral shaft is often treated by closed methods with a good success rate. However, non-union is a recognised problem, which can result after both conservative and operative management. Aseptic non-union of the humeral shaft is commonly treated either by compression plating or intramedullary nailing. A high success rate has been reported after using a compression plate [1, 3, 5, 6, 12]. In our series, a union rate of 91% compares with the findings of Healy et al. [5] who reported union in 92% of cases, and Barquet et al. [1] who reported a union rate of 96% with the use of a compression plate and cancellous bone grafting.

The main concern after plating has been poor screw purchase, particularly in osteoporotic fractures. Various methods, including the use of bone cement [13], cortical allograft [6], intramedullary fibular graft [14] and internal fixation with locked intramedullary nailing [2] have been suggested to overcome this problem. The presence of bone cement may have deleterious effects on bone blood supply and on healing if it extrudes into the fracture site. Bone cement also makes any further surgery more difficult. The use of an intramedullary free fibular graft has been recommended, especially when previous fixation methods have failed, when bone is osteopenic and in patients who have significant bone loss [6, 14]. In this study free fibula was used in one patient only, with successful results. One of the three failures in this study was due to early loosening of the implants in a very osteopenic bone. Use of the fibular autograft at the time of the first operation might have prevented this complication. Clinical and biomechanical investigations have shown that it improves the fixation of screws by quadricortical fixation [14].

Though good results have been reported after using cortical allograft with compression plating [6], it carries an inherent risk of disease transmission and is not widely available in developing countries. A vascularised fibular graft also has been recommended for humeral shaft non-union, but routine use of this technique is limited by availability of facilities and expertise. Therefore, this technique should be reserved only for very complex cases [7].

Use of a locked intramedullary nailing system in the humerus is associated with some serious problems. These include shoulder dysfunction [10], migration of nail despite adequate locking in osteoporotic patients [10], radial nerve palsy [10, 11], ossification in the olecranon fossa causing elbow dysfunction [11], creation of additional comminution at the fracture site [2, 10, 11] and a fracture below the locking humeral nail [8]. Moreover, there are very few studies on the use of locked intramedullary nailing in humeral shaft non-union. Crolla et al. [2] recommended primary bone grafting in all atrophic non-unions after three of their nine cases failed to unite and required second operation for bone grafting with the use of locked intramedullary nailing. Since a high incidence of atrophic non-union (70–90%) has been noted in our series and other studies [1, 3, 5, 12], a high proportion of patients undergoing "closed" nailing will need exposure of the fracture site for bone grafting. Moreover, in the humeral non-unions after intramedullary nailing, an exchange nailing is not as successful as in the tibia and the femur. Robinson et al. [10] reported failure in three out of five non-unions after exchange nailing, leading Emmerson and Sher [4] to propose treatment by compression plating and bone grafting over the nail.

Based on our results we recommend open reduction and internal fixation with a compression plate and the use of cancellous bone graft in all atrophic non-unions of the humeral shaft.

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