

Infected non-union of the Humerus after Failure of Surgical Treatment: Management using the Orthofix External Fixator

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Abstract

Introduction: The failure of a humeral fracture to unite after surgical treatment may be due to many factors. When there are additional complications of infection, treatment by conventional methods of internal fixation becomes very difficult. **Materials and Methods:** We treated 8 infected non-union of diaphyseal fracture of the humerus by the Orthofix external fixator. All had previous surgical treatment. Non-union followed plating in 6 cases and in 2 cases after the external fixator. All patients had pain, at least one sinus discharging pus and severe functional impairment of the affected arm. There were 6 men and 2 women with a mean age 40.6 years. **Results:** Bone union was achieved in all cases. The mean time to union was 4.5 months (range, 2 to 8). Patients expressed high levels of satisfaction with the outcome, despite relatively modest improvement in pain and function, mainly because of long standing infection and intractable non-union. There were no major pin tract problems requiring the removal of the Schanz screws. Radial nerve palsy developed in 1 patient who recovered spontaneously. No patient required an additional bone grafting procedure. **Conclusion:** The use of the Orthofix external fixator without bone grafting was successful in the treatment of infected non-union of the humeral shaft. It shortened the duration of hospitalisation and immobilisation with moderate functional recovery.

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Introduction

The incidence of non-union after operative treatment of humeral shaft fractures has been reported to range between 2.5% and 13%.¹⁻⁴ While a number of methods of managing atrophic ununited fractures with bone defects have been suggested, each has its drawbacks. Grafts of cortical bone revascularise slowly and incompletely. There is a substantial risk of infection, delayed union and non-union, and fractures through the graft are common.⁵⁻¹⁰

Vascularised bone grafting requires surgical expertise and equipment is not readily available in every hospital. The technique is demanding for time and resources, and vascular thrombosis may compromise the result.¹¹⁻¹⁵

Bone transport, using distraction histogenesis in the treatment of complex post-traumatic problems, has a certain appeal, but enthusiasm for the Ilizarov technique has been tempered by its complexity and technical difficulty, the commitment of time and resources required for a good

result and the potential for numerous complications.^{16,17}

Rosen⁴ has defined a delay of 3 to 4 months in bony healing as a delayed union and a delay of 6 to 8 months as a non-union. Failure of bone union following a distal humerus fracture is painful and disabling. Patients are unable to use the limb for loaded activities and often have intractable pain. A distal humerus non-union can persist for years despite appropriate medical and surgical care.^{18,19}

The presence of infection with a distal humeral non-union increases the treatment challenge and is associated with lower rates of successful bone union, limited fixation options and worse functional outcomes.^{20,21}

We have used the Orthofix external fixator to stimulate union by stabilisation and compression after radical excision of the infected bone. We report the results of the treatment of 8 consecutive patients with non-union of the humeral shaft that were managed at our hospital using the Orthofix external fixator.

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Materials and Methods

Eight consecutive patients with infected humeral shaft non-union were treated at our University Hospital (Table 1). The 8 patients consisted of 6 men and 2 women, with a mean age of 40.6 years (range, 23 to 60). The non-union was in the middle third in 3, and in the distal third of the humerus in 5 cases. The patients had undergone an average of 1.7 previous surgical procedures (range, 1 to 4) (Table 1). These injuries had resulted from a traffic accident in 6 patients and from a fall in 2 patients. The initial treatment was operative in all the cases. The initial fracture was open in 2 cases and closed in 6 cases. The 6 closed fractures were infected after plate fixation (Figs. 1a and 1b). The mean period between the initial treatment and the application of the Orthofix external fixator was 14.2 months (range, 3 to 36). The infective organisms were Methicillin-resistant *Staphylococcus aureus* (MRSA) in 1 patient, *Pseudomonas aeruginosa* in 1 and *Staphylococcus aureus* in 4. In 2 cases, no organisms could be detected (Table 1).

The surgery was a one-stage procedure that involved exploration of the radial nerve, removal of previously inserted implant, obtaining deep cultures, a thorough debridement and sequestrectomy of the non-union site to expose fresh bleeding bone ends, application of the Orthofix external fixator and bone shortening of an average 2.0 cm via the Orthofix fixator with immediate bone-to-bone contact at the non-union site (Figs. 2a and 2b). Surgical exposure in all cases was performed through the prior incision. Following debridement, none of the resulting segmental defects were larger than 3.0 cm, and shortening was acceptable in all cases. The Orthofix external fixator was fixed to the humeral diaphysis using 5 mm diameter 3 half pins proximally and 3 half pins distally in all cases except in case 3 where only 2 pins were applied as the distal segment was too short to insert 3 pins above the olecranon fossa. Postoperatively, all patients were administered 6 weeks of appropriate

intravenous antibiotics (Table 1). The Orthofix external fixator was used to apply monofocal compression at an initial rate of 0.25 mm per day for 1 to 2 weeks. Patients and their families were instructed in pin care, cleaning and hygiene. Each pin site was cleaned once or twice daily with normal saline solution. The pin sites were covered with sterile dressings, which were changed after pin cleaning or showering. The pin sites were inspected at each hospital visit, and patients were instructed to call immediately if swelling, erythema, purulent discharge, or severe pain were noted at any pin site. Postoperative rehabilitation included active and active-assisted range of motion beginning on the first postoperative morning. Passive range-of-motion exercises and joint mobilisation of the elbow were incorporated into the rehabilitation programme as tolerated, usually within the first 2 weeks following surgery. Physical therapy modalities were used to manage symptoms. Gradual strengthening exercises for the hand, wrist, elbow and shoulder were added during the outpatient rehabilitation and during the compression and consolidation phases of treatment. All patients attended regular therapy sessions, usually 2 to 3 times a week, and were instructed to perform a home exercise programme twice a day. Patients returned to the clinic every 1 to 2 weeks for monitoring of compression rate and bone healing in the first postoperative month and then every 2 to 4 weeks until bone union was achieved. The Orthofix external fixator was removed when there was evidence of bony union seen on 3 of 4 cortices, as described by Heckman and colleagues.²² Two patients (case 2 and case 5) had delayed radiological signs of union for more than 6 months. We applied 'callus massage'¹⁶ at the sites of the fracture, alternating short periods of progressive distraction with periods of compression (0.5 mm of distraction a day for 7 days, followed by 1 mm of compression a day for 7 days, over a 4-week period). The result was net compression with slight shortening. Our primary objective was bone union accepting the resultant shortening.²³

Table 1. Patient Characteristics at Presentation and the Type of Infecting Organism

Case	Age (y)	Gender	Time of non-union	Aetiology	Previous treatment	Type of fracture	Localisation	Type of organism
1	23	M	7	RTA	1	Open	Middle 1/3	<i>S. aureus</i>
2	60	M	3	Fall	1	Closed	Distal 1/3	No growth
3	36	M	12	RTA	2	Closed	Distal 1/3	<i>S. aureus</i>
4	43	M	36	RTA	4	Open	Distal 1/3	<i>S. aureus</i>
5	55	F	18	Fall	2	Closed	Distal 1/3	MRSA
6	28	M	5	RTA	1	Closed	Middle 1/3	<i>S. aureus</i>
7	33	F	24	RTA	2	Closed	Middle 1/3	No growth
8	47	M	9	RTA	1	Closed	Distal 1/3	<i>Pseudomonas</i>

MRSA: Methicillin-resistant *Staphylococcus aureus*; RTA: road traffic accident; *S. aureus*: *Staphylococcus aureus*

Table 2. The Modality of Treatment, Time of Union, Time in the Fixator, Follow-Up Period, Complications, Range of Elbow Motion, the Outcome Regarding Union and the Bone Gap after Debridement

Case	Treatment mode	Time of union (mo)	Time in fixator (mo)	Time of follow-up (mo)	Complications	Outcome	Elbow motion (°)	Bone gap (cm)
1	Compression	3	5	40	None	Union	Full	1
2	Compression distraction	7	9	24	Pin-site infection Transient nerve injury	Union	Full	3
3	Compression	2	4	40	None	Union	0-90	2
4	Compression	3	5	18	Pin-site infection Transient nerve injury	Union	0-60	3
5	Compression distraction	8	10	12	Pin-site infection	Union	0-90	2
6	Compression	4	6	28	Radial transient nerve injury	Union	Full	1
7	Compression	4	6	36	None	Union	0-90	2.5
8	Compression	5	7	32	Pin-site infection	Union	Full	1.5

Results

Union was achieved in all 8 patients (Figs. 3a and b) and infection was arrested in all patients. All wounds healed primarily. The mean time to union was 4.5 months (range, 2 to 8) after application of the frame and the mean time to removal of the frame was 6.5 months (range, 4 to 10) (Table 2).

Cure of disease was defined as no recurrence of infection or sinus discharge at the latest follow-up ranging from 12 to 40 months. The ultimate range of elbow motion was full in 4 cases and 0 to 90 degrees in 3 cases. Another patient (case 4) with limited elbow motion 0 to 60 degrees had an open type III-B fracture that had been treated initially by Hoffman external fixator. The stiffness was attributable to repeated surgery and severe tissue scarring.

None of the patients complained of persistent pain or instability at the site of non-union. A good range of forward elevation and external rotation of the shoulder within 10° of the opposite side was achieved in 6 of the 8 patients (Fig. 3b). Two patients had restricted shoulder movement with forward elevation of 70° and 110°, and external rotation 30° and 40°, respectively. Seven of 8 patients reported that they were satisfied with the outcome of the revision non-union surgery. One patient was dissatisfied. His initial humerus fracture resulted from a polytrauma motor vehicle accident in which he sustained a closed head injury and multiple other long bone injuries (case 4).

Complications

The application of the Orthofix external fixator resulted in nerve injuries in 3 patients. The median and the lateral antebrachial cutaneous nerve were involved in 2 cases (case 2 and 4) but there was full recovery within a week of operation. The third (case 6) suffered an intraoperative palsy

of the radial nerve. During the operation, the surgeon noticed twitching in the extensors of the wrist during retraction of the nerve. The patient had a wrist drop immediately after the operation, but regained MRC grade-5 strength in the extensors 3 months later. Pin-track infection occurred in 4 patients. With local skin care and treatment with oral antibiotics, this resolved in all except 1 patient whose pin tracks required incision and drainage. No patient developed chronic deep infection. Puckering of the skin around the pins caused discomfort in 2 patients. It was relieved by incising the skin around the site of the pin under local anaesthesia.

Discussion

The purpose of our study was specifically to assess the effectiveness of using the Orthofix external fixator in treating infected non-union since such cases are notoriously difficult to treat.²⁴⁻²⁶ Further surgery can put vital structures such as the radial nerve at risk. Internal fixation in the presence of infection would be contraindicated and can be difficult because of osteopenia and bone defects. Satisfactory results with the Ilizarov method of treating non-union of fractures of the humerus had been previously reported.²⁷⁻³⁰ However, the Ilizarov technique has been tempered by its complexity and technical difficulty, the commitment of time and resources required for a good result and the potential for numerous complications.^{16,17}

The hallmark of infected non-union consists of non-viable tissue, sequestrum and sinus discharge. Local ischaemia renders non-union more vulnerable to superimposed infection and resistant to systemic antibiotics. We designed one-stage treatment protocol to terminate the vicious cycle. First we eliminated the infection, followed by osseous reconstruction. Infected non-union in the humerus compromises upper limb function. The ultimate goal of

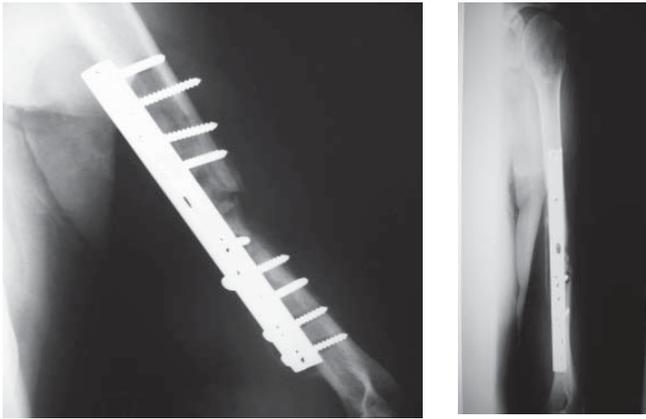


Fig. 1a.

Fig. 1b.

Fig. 1. Preoperative X-ray in case 1 showing infection and bone lysis after internal fixation, (a) anteroposterior view and (b) lateral view.

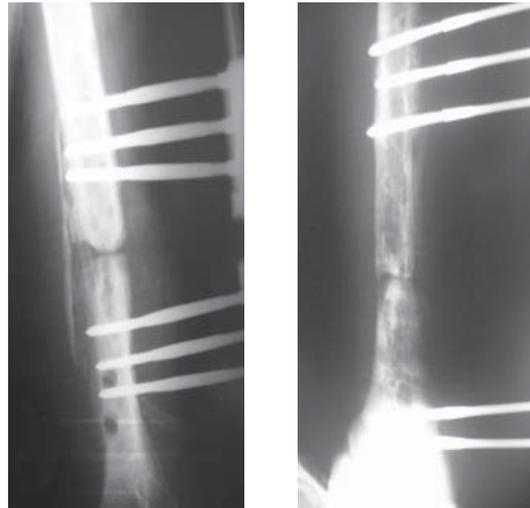


Fig. 2a.

Fig. 2b.

Fig. 2. Postoperative X-rays after debridement and application of the fixator, (a) case 1 and (b) case 3.

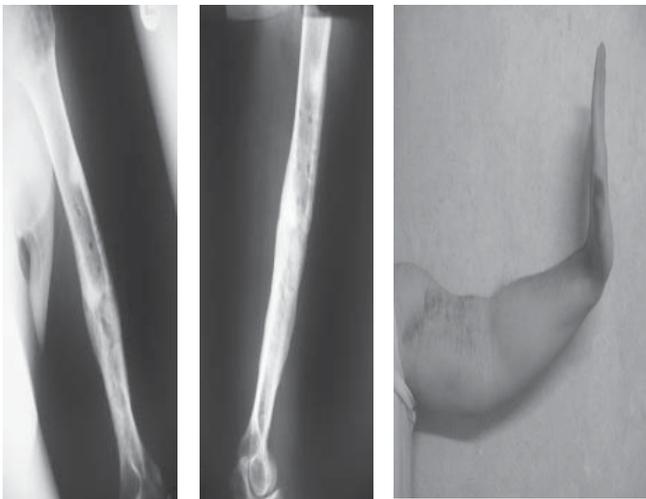


Fig. 3a.

Fig. 3b.

Fig. 3a. Follow-up X-ray showing full union of the fracture site in case 1. Fig. 3b. Clinical photo of the same patient with good range of elbow extension

treatment is to eradicate the infection and prevent recurrence. It is difficult because of (1) inadequate exteriorisation at the site of infection, and thus inadequate removal of necrotic and infected tissue, (2) failure to eradicate infection and (3) recurrence attributable to failure to fill the resulting bone defect. To eradicate the infection, the first step is to remove the implant, do radical debridement, sequestrectomy and removal of infected bone ends.

The remaining bone should have visible evidence viability with punctate bleeding. In this series, all the debridements were extensive, with no attempt to preserve the diseased bone or soft tissue. Radical debridement, however, created bone gap ranging from 1 to 3 cm (average, 2 cm) which was closed by compression.

It was possible to achieve stable fixation with the Orthofix external fixator, even in the presence of osteopenia, by using

Hydroxyapatite coated pins in 4 cases. As the pins can be placed away from the site of the fracture, the frame can be applied after excision of the infected non-union. Union was achieved without bone grafting in all 8 cases. A further advantage of the method is that it allows both compression and distraction, which may stimulate healing.^{31,32}

In our series, all the cases united with the application of the Orthofix external fixator which achieved both compression and maintaining the alignment of the fracture, while eliminating shear forces. Our clinical outcomes with the Orthofix external fixator in infected cases are comparable to those of open reduction and internal fixation (ORIF) in non-infected cases. The rate of bone union following ORIF in the treatment of non-infected distal humeral non-unions has been reported to range from 64% to 100%.³³⁻³⁵ Our results are contrary to those of Ring and colleagues,³⁶ who reported on 5 patients with infected distal humerus fractures treated with static compression using a thin-wire external fixator; 1 patient had also received a vascularised fibular bone graft.³⁶ Four of the 5 patients in their series required a second operative procedure (ORIF, bone graft, or both) to achieve bone union; the fifth patient did not achieve bone union and refused further operative intervention. All 8 patients in our series achieved bone union after treatment with the Orthofix external fixator acute compression technique. The amount of shortening following treatment in our patients was less than 3.0 cm in all cases (average, 2 cm). Acute shortening of the upper extremity of 3 to 4 cm is generally well tolerated.^{37,38}

Osseous and soft-tissue infection is a challenge to the surgeon and is rather intractable, especially in combination with instability. In our series, there was a month-to-year delay in treatment. Prolonged immobilisations and tissue

scarring may further compromise the residual, if any, joint function. Aggressive management and early rehabilitation should be started as soon as possible. The one-stage protocol is recommended for the treatment of infected humeral non-union because it shortens the duration of hospitalisation and immobilisation. Physical therapy thus starts earlier. The functional result is encouraging.

Ethical approval:

The Research Ethics Committee at the Faculty of Medicine (FWA 00006444) approved the study for publication.

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