

The external fixation in the treatment of humeral diaphyseal fractures: Outcomes of 84 cases

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ABSTRACT

We retrospectively review 84 cases of diaphyseal humeral fractures (24 type A, 38 type B, 22 type C of the AO/OTA classification) treated with external fixation (Hoffmann II frame) between 1995 and 2007. Six of these fractures were complicated with radial nerve palsy. Four cases were open fractures. All reductions were achieved closely or through minimal open approaches. All fractures achieved consolidation with an average of 95 days (range 58–140). The six radial nerve palsies had complete spontaneous recovery. According to the Constant score excellent shoulder function was recorded in 54.6% of the cases, good results in 25%, fair in 13.6% and poor in 6.8%. The elbow function according to the Mayo elbow performance index was excellent in 81.8% of cases, good in 13.6%, fair in 2.3%, and poor in 2.3%. We observed superficial pin tract infections in 12% of the patients. There was no cases of deep infection.

External fixation of humeral diaphyseal fractures as recorded in this case series, represents a management option, which allows straightforward fracture reduction and adequate stability, with a short operative time, excellent consolidation rate and good functional results with no major complications secondary to this type of surgery.

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Introduction

The humeral diaphyseal fracture involves the segment of bone between the inferior limit of the insertion of pectoralis major and the upper limit of the insertion of the muscles at the medial and lateral epicondyles.¹⁶ They represent the 3% of all the fractures. The average age of both genders with a humeral shaft fracture is 68 and 53 years for females and males respectively.¹⁰

The humerus is surrounded by deep muscle layers and the forces acting on the bone are not creating a large displacement moment on the fragments, when the elbow is flexed to 90° and the forearm is suspended with a sling.³⁹ The reported results of conservative methods of treatment for diaphyseal fractures (including braces or hanging casts) are mostly excellent.^{4,5,25} The incidence of non unions following conservative methods varies between 1% and 4–5%.^{5,31,35,37} However, most of these studies are based on the radiological bone healing and do not consider the long period of immobilisation, patient's discomfort resulting in a low patient compliance, at some degree the resulting shoulder and elbow stiffness, and the consequential extended time off work with its socioeconomic consequences.

Considering these important factors, a number of authors^{2,3,6,9,11,13,28,32,36} have extended the indications of surgical treatment besides the cases of open injuries, polytrauma, of fractures with neurovascular compromise or associated pathologic lesions, or failed non-operative management, to almost all humeral mid-shaft fractures. The gold standard surgical treatment was considered by most of the authors the open reduction and plate fixation (ORIF), following the AO/ASIF²⁴ principles. Other adopted techniques, include intramedullary nailing antegrade^{1,12–15,19,23,33,36} or retrograde,^{17,28,29} or external fixation.^{20,26,38} The latter combines some of the advantages of conservative management (closed reduction, preserving fracture hematoma) with that of internal fixation (stability), with a lower incidence of some of their complications (i.e. prolonged immobilisation, deep infection, iatrogenic nerve injuries, joint stiffness, post-operative pain, implant impingement).

For these reasons it represents the standard of treatment for displaced humeral shaft fractures at the Orthopaedic Department of the Hospital of Lecco. Aim of this study is to present the mid-term results of treating all such fractures, in terms of clinical healing, functional recovery and complication rates.

Patients and methods

A retrospective analysis of all cases treated at the Manzoni Hospital of Lecco at two centres over the period between of August

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of 1995 to March 2007 was undertaken. Humeral shaft fractures treated with the application of an external fixator (Hoffman II, Stryker®) were all included, after excluding pathologic fractures and cases of established non-union or delayed union.

Demographic details, mechanism of injury, fracture classification according to the AO/OTA system,²¹ operative details, post-operative course for an average period of 25 months, were recorded for all patients (Fig. 1).

In all cases surgery was performed under general anaesthesia, with the patient in the supine position under image intensification control. The adopted fixator was in all cases a unilateral Hoffmann II frame. The proximal fixation was achieved with three conical half pins of 5 or 6 mm diameter (depending to the size of the humeral diaphysis), inserted at the antero-lateral surface of the proximal humeral shaft. In osteoporotic bone hydroxyapatite coated half pins were used. The distal fixation was achieved with three half pins positioned postero laterally or posteriorly through the triceps muscle fibers (Figs. 1 and 2).

The fracture was then manipulated using the proximal and distal half pins as joysticks under image intensification. When the reduction was obtained the half pins were connected with two bars. In case of interposition of soft tissues impeding the reduction, a small incision was performed allowing the mobilisation of the bone ends, often by inserting just one finger and blunt release of the entrapped soft tissues (Fig. 2). In case of open fractures, irrigation and debridement of the wound was urgently performed and intravenous antibiotic therapy was started immediately. In case of concomitant vascular injury, the brachial artery was repaired with the use of a saphenous vein interpositional graft. In one case an intercondylar distal humeral fracture occurred after a fall of the patient having the external fixation on was treated with

closed reduction and fixation with a new half pin connected to a scaffold bridging the elbow (Fig. 3).

In almost all the cases, the mobilisation of the upper limb was initiated immediately after the operation. The patients following their discharge followed a consistent rehabilitation program and were reviewed clinically and radiographically on a monthly basis until completion of fracture healing. The clinical evaluation was performed using the Constant score⁸ for the shoulder function, and the Mayo Elbow Performance Index²² (MEPI) for the elbow function. Radiographic fracture consolidation was decided in the presence of cortical bridging in at least 3 out of the 4 cortices as evident in the anteroposterior, lateral and oblique views.

The Constant score⁸ takes into account eight parameters with a maximum summation of 100 points. It records pain (max 15 points), daily life activities capacity (max 10 points), joint movement (max 10 points), abduction (max 10 points), internal rotation (max 10 points), external rotation (max 10 points), anterior elevation (max 10 points), and strength (max 25 points). The recorded results are characterised as “excellent” if >95, “good” if between 75 and 94, “fair” if between 60 and 74, and “poor” if <60.

The MEPI score²² measures 45 points in the absence of pain, 20 points for full ROM, 10 points for normal elbow stability, 25 points for normal function, reaching a maximum of 100 points. Excellent elbow function was considered with a MEPI > 95, good if between 75 and 94, fair if between 60 and 74, and poor if <60 points.

Results

Data from a cohort of 84 patients with a humeral diaphyseal fracture treated with an external fixator over a period of 11 years

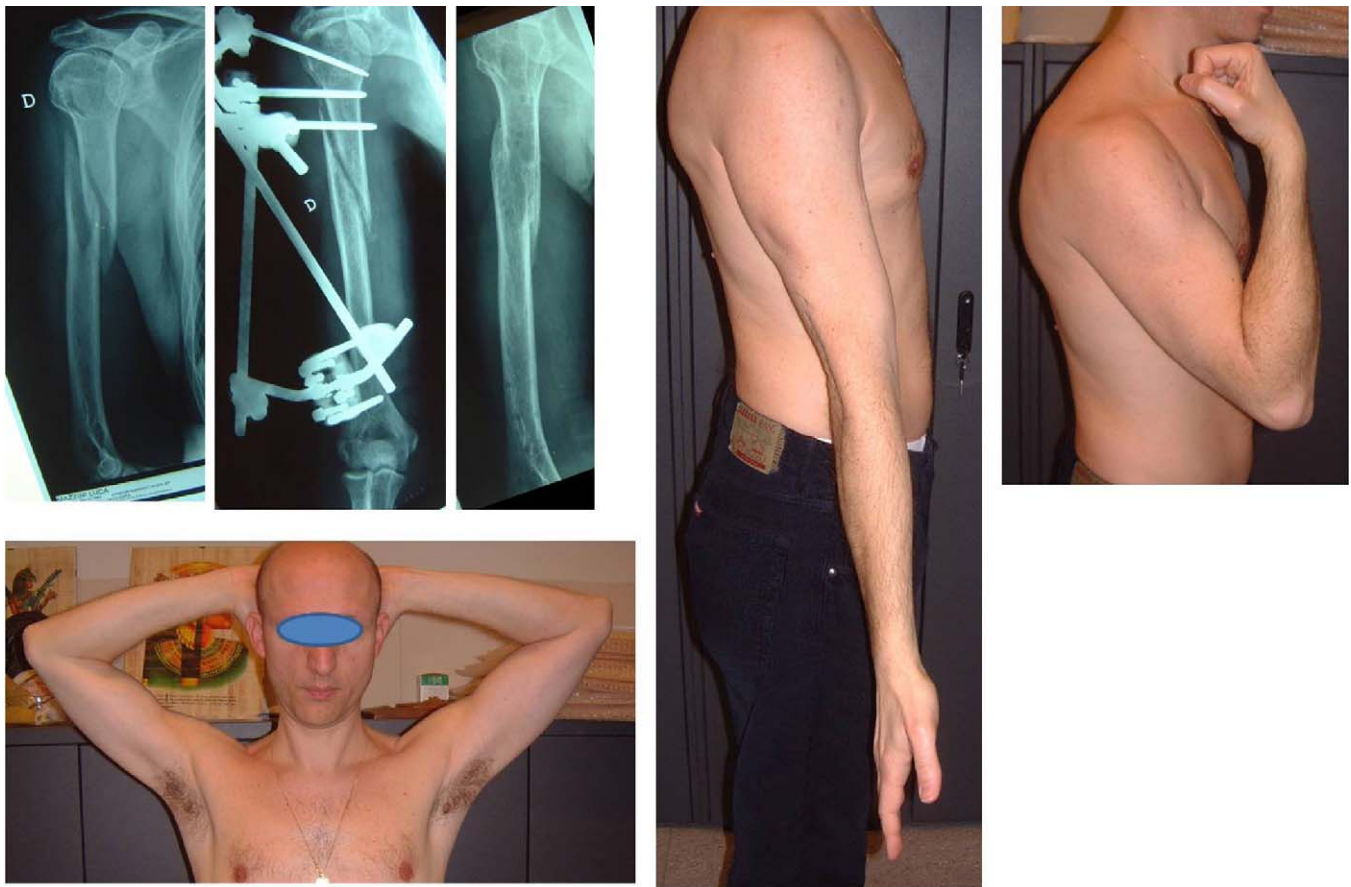


Fig. 1. Type A humeral shaft fracture, consolidated in 3 months after closed reduction and unilateral Hoffmann II external fixation. Excellent shoulder and elbow function were recorded at the 3 months post-operative follow-up visit.

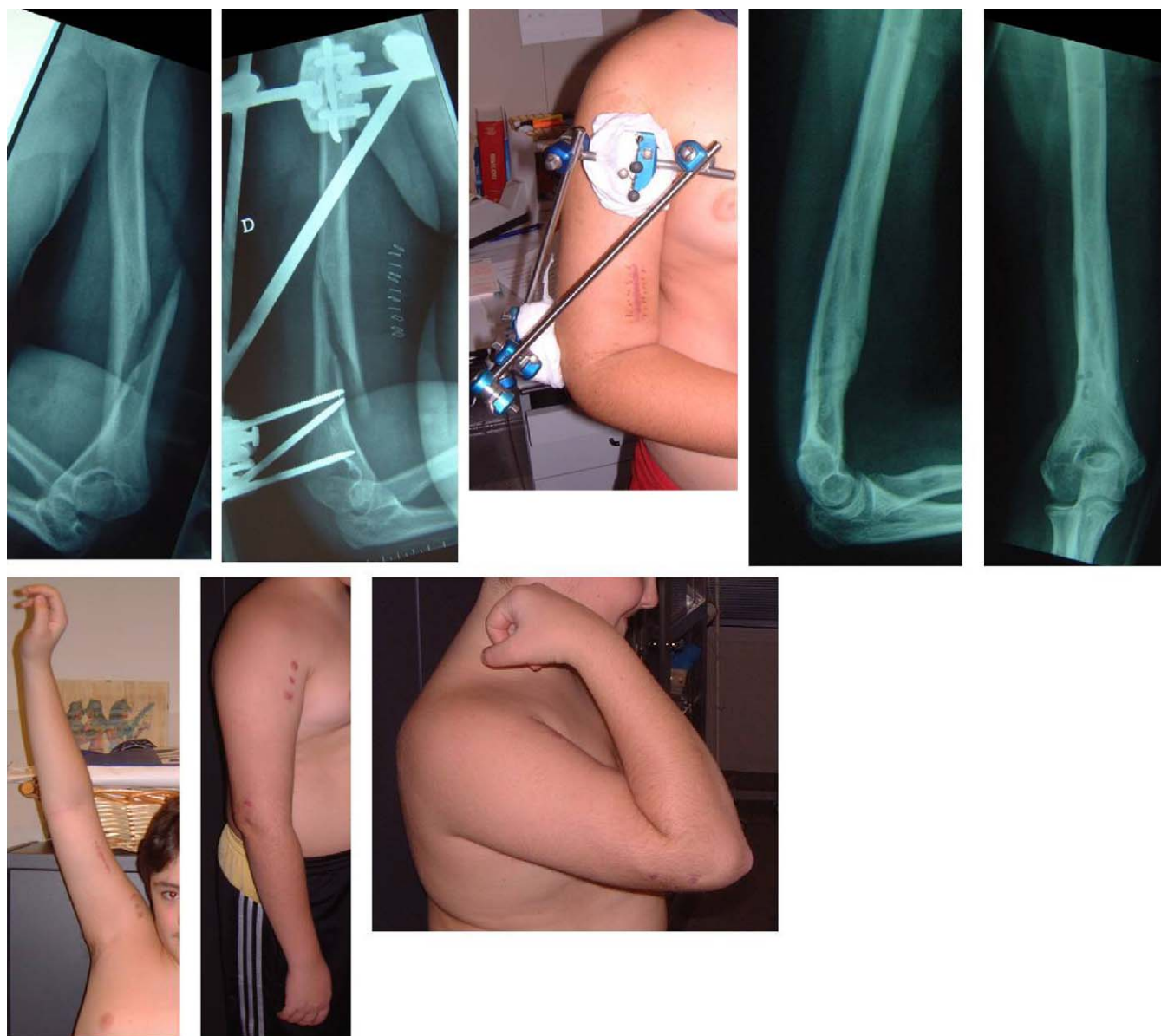


Fig. 2. Type A humeral shaft fracture, consolidated in 3 months after mini open reduction and unilateral Hoffmann II external fixation. Good shoulder and excellent elbow function were recorded at the 3 months post-operative follow-up visit.

are presented. There was equal representation of both genders and the average age was 53 years (range 8–96). Four of the fractures (4.8%) were open (one associated with an brachial arterial injury), and six (7.1%) presented with a radial nerve palsy. According to the AO/OTA classification²¹ there were 24 (28.6%) type A, 38 (45.2%) type B, and 22 (26.2%) type C. Half of the cases were attributed to a mechanical fall and the rest to road traffic accidents.

The average time of the operation was 30 min (range 18–50 min), while the average in hospital stay was 8 days (including polytrauma cases). The post-operative hospital stay for the isolated humeral fractures was 3.5 day (range from 2 to 5 days). The average time until removal of the external fixator was 95 days (range from 58 to 140 days). At 6 months all fractures were radiologically healed.

At the final follow-up visit, after an average period of 25 months, all the patients declared their satisfaction regarding the treatment, and had returned to normal work and social activities. The average Constant score at the latest follow-up was “good”—86 (range 34–100). In 67 cases (79.8%) the score was more than 80.

“Excellent” shoulder function was recorded in 46 cases (54.6%), “good” in 21 cases (25%), fair in 11 (13.1%) and poor in 6 (7.1%). The average elbow function index was 95 (range 55–100), with only 4 cases with score less than 74. Elbow function was characterised as “excellent” in 69 cases (82.1%), “good” results in 11 cases (13.1%), “fair” and “poor” in 2 cases each (2.3%).

In a single case it was necessary to reapply the frame at the second post-operative day due to loss of achieved reduction after a crisis to a psychiatric patient. All patients with radial nerve palsy presented complete spontaneous recovery over a period of 20–90 days. There were no cases that reported significant residual pain at the fracture site. In 10 cases (11.9%) superficial infections of the pin tracts were noted and have all recovered after a short course of oral antibiotics.

Discussion

There is a general consensus regarding the indication to conservative treatment of diaphyseal humeral fractures which is reported in the literature having a high success rates with

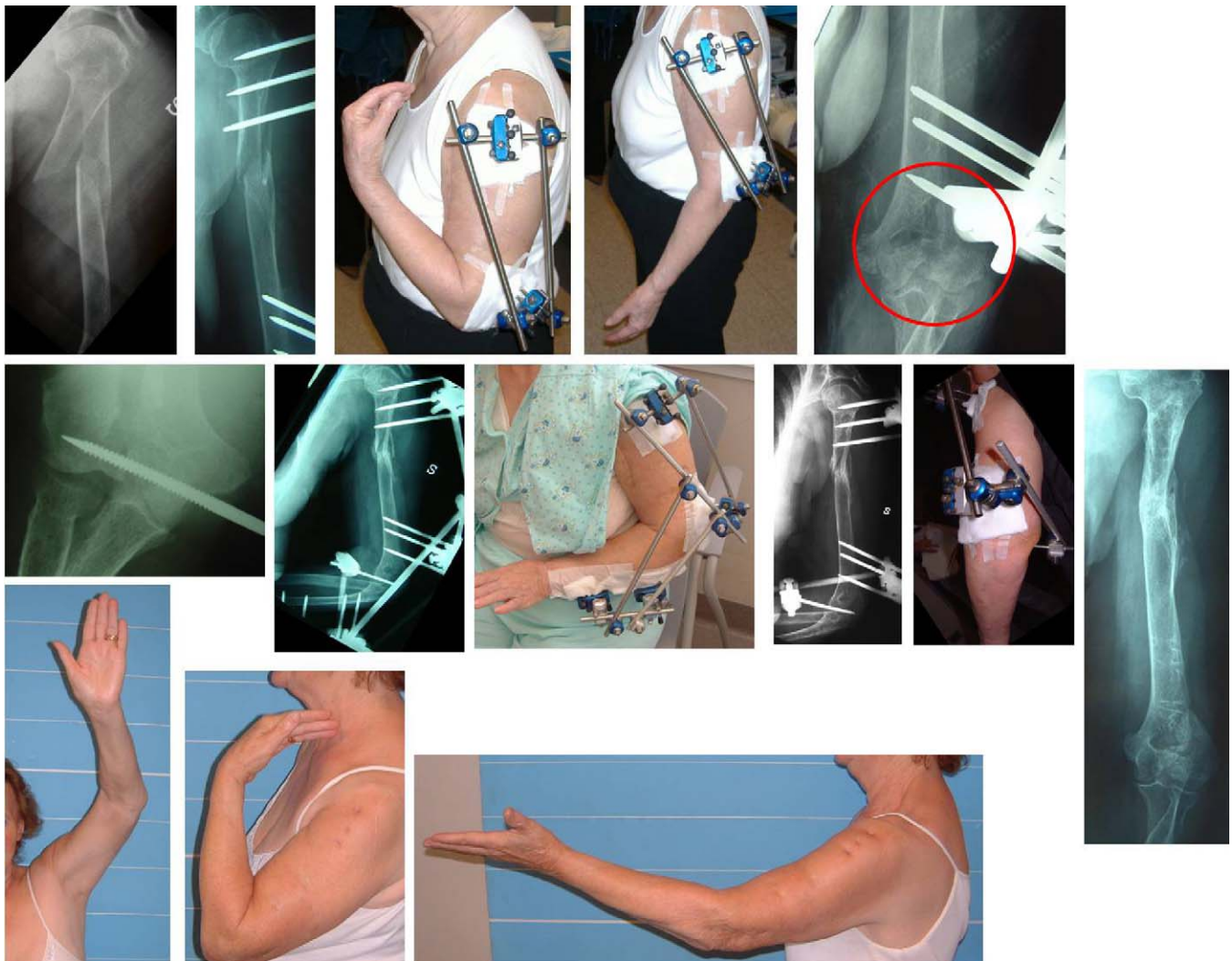


Fig. 3. Type C humeral shaft fracture, consolidated in 3 months after closed reduction and unilateral Hoffmann II external fixation. A new fracture (intercondylar distal humeral) occurred after a fall of the patient during follow-up, that was treated with closed reduction and incorporation of a new half pin insertion and its incorporation to the Hoffmann II scaffold bridging the elbow. Fair shoulder and good elbow function were recorded at the 2 months post-operative follow-up visit.

nonunion rates ranging from 1% to 4–5%.^{30,31,35,37} Advocating in favour of non-operative treatment of these fractures are the facts that the humeral bone is not a bear loading segment, can tolerate angular deformities up to 20° in procurvatum, 30° in varus, shortening up to 4 cm and translation up to 1 cm, therefore does not require anatomical reduction of its extra-articular fractures.¹⁸

Generally surgery is reserved for the failures of conservative treatment, open fractures or with neurovascular complications, multiple trauma, bilateral fractures, floating elbow, obese patients.^{26,32,36,38} The surgical treatment provides better reduction of the bone fragments, early mobilisation, is better while nursing elderly or multiple injured patients. Some authors advocate in favour of surgical treatment for the majority of diaphyseal fractures.⁹

Internal fixation (mostly ORIF and less IMN) is considered from the majority of surgeons as the gold standard. Nevertheless, they are associated with a number of complications related to the required extensive surgical approach, to failures of the implants, deep infections, impingement to soft tissues resulting to chronic pain, and often the need for a second operation for hardware removal.^{11,25,32} External fixation is generally indicated for severe open fractures, multiple injured patients (according to the principles of damage control orthopaedics), for co-existing skin problems (i.e. burns).^{26,38}

In our series these standard indications were extended to include all displaced humeral diaphyseal fractures. As a method it combines the advantages of the conservative treatment (retaining the fracture haematoma, the vascularity of periosteum and the endosteum) and of the internal fixation which are alignment of fracture and achievement of sufficient stability for rehabilitation with unrestricted mobility of the joints. As a true minimally invasive method does not require large surgical approaches or reaming of the medullary canal, and has low incidence of deep infections or damages to soft tissues. Among the advantages of external fixation there is also the possibility of correcting any possible defect or loss of reduction during the treatment and the removal without general anaesthesia in adult patients. The disadvantages of this method are mostly attributed to the need of inserting pins through the soft tissues, and to retain them for the whole healing period. This may cause restriction of motion of the shoulder and the elbow joint and increased risk of pin-track-infection (12% in our study). The age of the patient and delays on mobilisation were associated with worst prognosis, as all poor results according to the Constant and MEPI scores were recorded on elder patients (>60 years) with general poor mobility.

The recorded consolidation of 100% of this cohort of humeral shaft cases, and the good functional results of the 79.6% and

95.3%, as far as the shoulder and elbow joints respectively, are matching the best of the reported results in the literature.^{6,7,27,34} This cases series, indicates the value of external fixation for diaphyseal humeral fractures, as a fast, minimal invasive procedure, with short learning curve and optimal clinical outcome for the majority of the treated patients.

Conflict of Interest Statement

The authors of the manuscript entitled “The external fixation in the treatment of humeral diaphyseal fractures: outcomes of 84 cases”, disclose any financial and personal relationships with other people or organizations that could inappropriately influence his work. Neither him nor a member of his immediate family received from a commercial entity in support of the research for the preparation of this work any outside funding, payments or other benefits or a commitment or agreement to provide such benefits.

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