

The treatment of distal third humeral diaphyseal fractures: Is there still a place for the external fixation?

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Abstract

Introduction The treatment for humeral diaphyseal fractures is still controversial. The purpose of this study was to evaluate the clinical and radiographic outcomes of treating humeral distal third diaphyseal fractures by using external fixation technique.

Materials and methods We retrospectively review 65 cases of diaphyseal humeral fractures (31 type A, 23 type B and 11 type C of the AO/OTA classification) treated with external fixation (Orthofix FAD small) between 2008 and 2013. The mean follow-up was 48 months (24–72 months). There were 12 open fractures; however, no cases of concomitant vascular injury were described. The transolecranic traction was always applied to promote partial reduction through ligamentotaxis. In case of interposition of soft tissues impeding reduction, a small incision was performed allowing mobilization of bone ends.

Results All fractures resulted healed at a mean of 11 weeks (range 9–13 weeks); the average time of removal of the external fixator was 88 days (range 65–95 days). At the last follow-up, the mean elbow flexion was 132.6° (Min 126°–Max 137°) and the mean elbow extension was 6.4° (Max 0°–Min 13°). The Cassebaum's index rated as

excellent in 47.8 % (31 patients), good in 37 % (24 patients), fair in 9.2 % (6 patients) and poor in 6 % (4 patients). The mean DASH score at the final follow-up was 14.7 (range 0–33); 15 patients had a range score between 10 and 20, 43 had less than 10, and seven had more than 20. We observed three cases of superficial infections and two cases of acute radial nerve palsy recovered within 3 months.

Conclusion According to the excellent clinical results and full rate of consolidation, we state external fixation as a valid option in the treatment of distal third humeral diaphyseal fractures.

Keywords Humeral fracture · Diaphysis · External fixation · Safe zone · Radial nerve

Introduction

Humeral shaft fractures account approximately 3 % of all fractures [1]. Management of these lesions is still debated; conservative treatment continues to be recommended among authors [2, 3] with overall good results. However, non-surgical management is associated with delay in functional recovery, some residual morbidity and complications including non-union, as high as 20 % in some studies, malunion and persistent radial nerve deficits [3–7].

Moreover, there is no unique pattern of injury in humeral shaft fractures. Conditions of soft tissue envelope, fractures lines and localization along the whole diaphysis should be considered when planning for treatment [8]. The so-called distal extra-articular fractures have always been a matter of interest among orthopaedic surgeons. Some authors consider those as elbow fractures regarding their functional features [8, 9].

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Moreover, fractures of the distal third are significantly more likely than fractures of the middle third to have lacerated, interposed or entrapped radial nerve [10, 11]. Fitting this issue, some surgeons favour the operative treatment of distal diaphyseal fractures [12]; additional causes for operative treatment seem to be difficulty controlling fracture alignment and elbow stiffness after conservative treatment [13, 14]. Standard operative treatment for these fractures has traditionally been open reduction and internal fixation with plates and screws; other techniques include intramedullary nailing anterograde or retrograde or external fixation. The latter combines some of the advantages of conservative management (fracture haematoma preservation) with those of internal fixation (stability) reducing incidence of complications (prolonged immobilization, infection, nerve and vascular damage, joint stiffness, post-operative pain, implant impingement) [15].

External fixation is primarily used in damage-control situations where the patient is too unstable for more time consuming procedures. Additional indications include severe soft tissue injuries, vascular injuries requiring quick stabilization before repair, unstable elbow joint after bone fixation [16–18]. Authors agree humeral bone does not require anatomical reduction of its extra-articular fractures [19, 20]. Aware of this issue and looking at our belief in terms of minimally invasive osteosynthesis, we extended the use of the external fixators as definite treatment for fractures of the distal third of the humerus. External fixation may be considered a valid method not only in emergencies, but also for definitive treatment of such fractures.

We retrospectively reviewed 65 patients treated with this technique to make a statement about the value of this method of treatment.

Materials and methods

Between February 2008 and December 2013, 82 patients were treated with external fixation (Orthofix FAD small) for humeral shaft fracture at three different hospitals. The mean follow-up was 48 months (24–72 months). Sixty-five distal third diaphyseal fractures were recognized, and chart, radiological and operative data were retrospectively analysed. Fifty-seven patients returned for a follow-up visit, and the remaining eight were evaluated on the basis of medical records.

Demographics details, mechanism of injury, fracture classification according to the AO/OTA system and operative details were recorded for all patients (Tables 1, 2). Two cases of acute post-traumatic radial palsy were described. No cases of concomitant vascular injury were described. There were 12 open fractures. Pathologic fractures, delayed union and non-union were not included. Patients with cognitive disorders precluding participation

Table 1 Demographic details, mechanism of injury

Variables	Data
Gender (<i>n</i>)	
Male	41
Female	24
Age (mean ± SD)	48.4 ± 7.1
Side of fracture	
Left	28
Right	37
Mechanism of injury	
Low-energy injury	21
High-energy injury	44
ASA score, <i>n</i> (%)	
1	17
2	28
3	8
4	12
Comorbidity	
Diabetes	9
Cardiovascular disease and hypertension	6
Pulmonary disease	7
Osteoporosis	3

Table 2 Fracture classification according to the AO/OTA system

A1 Spiral	A2 Oblique (>30°)	A3 Transverse (<30°)
4	16	11
B1 Spiral Wedge	B2 Bending Wedge	B3 Fragmented Wedge
9	8	6
C1 Spiral	C2 Segmental	C3 Irregular
5	2	4

in the follow-up examination, bilateral fractures, pathological fracture and previous ipsilateral shoulder or elbow surgery were excluded from the study.

Surgery was performed under peripheral block in 45 patients, and the remaining 20 had general anaesthesia. Patient was in supine position, elbow flexed at 90°, forearm supinated and transolecranic traction always applied to promote partial reduction through ligamentotaxis (Fig. 1). Under image intensifier control, a unilateral Orthofix FAD external fixator was then positioned (Fig. 2a–c). The proximal fixation was achieved with two conical half pins of 4 mm and the distal fixation with two other conical half pins of 4 mm. Ruland rules to avoid mechanical irritation of soft tissue channels and respect of the safe corridors were always applied [8]. Careful dissection of wound tissue was always performed deep to the bone surface to avoid nerve damage.

Pins were then used as joysticks to obtain satisfactory reduction, and finally they were connected with the body of



Fig. 1 Example of intraoperative transolecranic traction



Fig. 2 45-year-old man. Fracture 12.B1.3

the external fixator and secured. In case of interposition of soft tissues impeding reduction, a small incision was performed allowing mobilization of bone ends. In the case of open

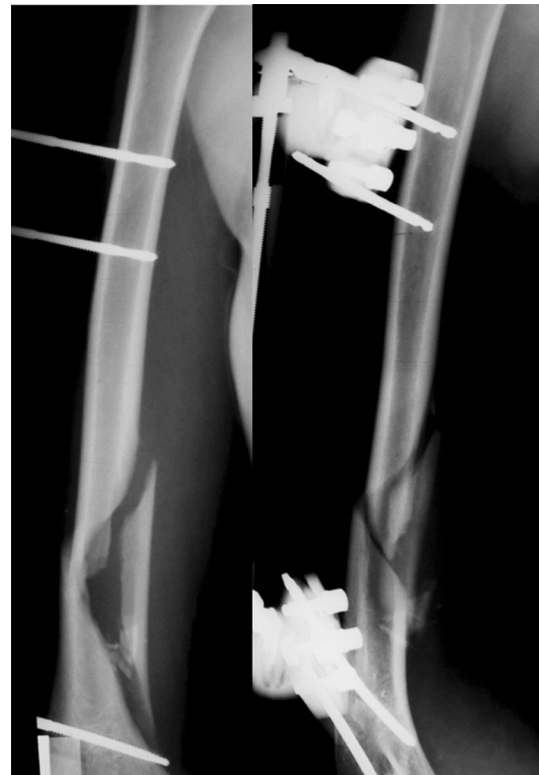


Fig. 3 Post-operative X-ray after a closed reduction

fracture, irrigation and debridement was urgently performed and large spectrum intravenous antibiotic therapy started. In the two cases of post-traumatic radial palsy, the radial nerve was exposed between the brachialis and the brachioradialis muscles through an oblique incision approximately 6 cm long; both the explored nerves were described as “stretched and contused”, but never as “interrupted” or “lacerated”.

Early mobilization of the upper limb was started on the first post-operative day. A consistent rehabilitation programme was then performed, and patients were reviewed clinically every 2 weeks and radiographically on a monthly basis until appearance of fracture healing (Figs. 3, 4a, b). At the latest follow-up, clinical evaluation was performed using Cassebaum’s functional rating system [21] and DASH questionnaire [22]. All patients were asked to give a categorical opinion about their condition. Radiographic fracture consolidation was defined when cortical bridging was observed in at least three out of the four cortices as evident in the anteroposterior, lateral and oblique views.

Results

Data on 65 patients treated with external fixator for distal third humeral shaft fractures over a period of 5 years were collected analysing charts, radiological films and operative reports.



Fig. 4 3-month follow-up

All fractures resulted healed at a mean of 11 weeks (range 9–13 weeks); the average time of removal of the external fixator was 88 days (range 65–95 days) (Fig. 5). The average time of the operation was 40 min (range 25–112), while the average in hospital stay was of 9 days (including polytrauma patients). We observed three cases of superficial infections of the pin tracks all treated successfully with oral antibiotics. Two cases of acute radial nerve palsy recovered within 3 months. We had one case of post-operative radial palsy secondary to intraoperative reduction manoeuvres; the nerve was inspected 2 days after and was found entrapped and stretched within the fracture site. It recovered at 2-month follow-up.

At the latest follow-up visit at an average period of 36 months, 57 patients were available for clinical evaluation. All patients declared satisfied and had returned to their work and daily activities (Figs. 4, 5). Two patients complained diffuse residual pain during heavy lifting.

Mean flexion at the elbow at the latest follow-up was 132.6° (Min 126°–Max 137°), and mean extension was



Fig. 5 Clinical examination at 6 months from the surgery

6.4° (Max 0°–Min 13°). The Cassebaum's index rated as excellent in 47.8 % (31 patients), good in 37 % (24 patients), fair in 9.2 % (6 patients) and poor in 6 % (4 patients).

The mean DASH score at the final follow-up was of 14.7 (range 0–33); 15 patients had a score range of 10–20, 43 had less than 10, and seven had more than 20.

When comparing ROM of the shoulder at the injured side with the non-injured one, no differences were observed.

Discussion

Non-operative treatment of diaphyseal humeral fracture has been largely adopted with high rates of union and acceptable functional outcomes [23]. Sarmiento et al. have published a relatively large series of 620 patients with 97 % union rates and high satisfaction results with functional bracing [4, 5]. However, fractures in the distal third of the humerus in adults can cause problems because of difficulty in controlling angulation and incidence of radial nerve damage and residual stiffness of the shoulder and the elbow. In 1944, Bohler [9] classified the distal extra-articular fractures as elbow fractures from the functional point of view. In the matter of those issues, some surgeons favour the operative treatment for this group of injury.

In addition, the general patient as well as the treating orthopaedic surgeon is less tolerant of the more labour-intensive methods of conservative management, and less tolerant of that was formerly thought to be acceptable deformity [24].

The main goal of treatment of extra-articular distal humeral fractures is to restore alignment and achieve stable adequate fixation to allow early elbow range of motion, which is important for good functional outcome [25–27]. It is often difficult to obtain rigid fixation of the distal fracture of the humeral diaphysis without compromising elbow function [28]. Plating the humerus posteriorly in order to utilize the flat posterior surface allows adequate distal fixation [29]; meanwhile, posterior approaches facilitate radial nerve exposure in the spiral groove [23]. However, very distal fixation is difficult due to impingement on the olecranon fossa as well as varus malreduction [29].

Moran used an oblique posterior plate orientation with a 5–8° angle off centre from the long axis of the humerus and directing the most distal screw proximally; while improving distal fixation, the obliquity of the plate limited proximal fixation which was problematic in comminuted or segmental fractures [30].

Fractures in the more distal humeral shaft benefit from use of precontoured periarticular plates that provide multiple points of fixation in small segments of bone. These holes utilize smaller screws with greater thread density and often permit use of compression or locking screws. 90–90° dual plating has been shown to give good alignment and union, with good range of elbow movement and without appreciable complication [23, 28, 31, 32].

Traditional plate fixation has the drawback of requiring larger incisions, violation of fracture haematoma and higher incidence of radial nerve palsy [24, 33]. Minimally invasive plate osteosynthesis (MIPO) has been developed to avoid these complications. This technique is generally indicated for fractures 6 cm below the surgical neck and 6 cm above the olecranon fossa. Using a two-small-incision approach, a 10–12-hole 4.5-mm plate is inserted submuscularly and provisionally stabilized through each incision [34]. Reduction is obtained through traction, arm manipulation and sometimes temporary use of an external fixator frame [35]. Three screws are then placed on each side of the fracture. Potential drawbacks include brachial scarring and subsequent loss of elbow motion, difficulty obtaining an adequate reduction and resultant increase in radiation exposure and operative time, and risk of nerve injury with percutaneous screw placement [36]. Recent studies evaluating outcomes of MIPO plating have been favourable [37, 38]; however, more prospective studies will be necessary before widespread use is recommended.

Another way to minimize complications with ORIF is the use of intramedullary nailing [39–41]. Nailing can be considered the ideal option; it is minimally invasive and offers the advantages of biomechanical load-sharing [42]. However, authors refer about the risk of rotator cuff damage during anterograde insertion. In addition, both anterograde

and retrograde nailing may not provide stable fixation at the level of the distal third of the medullary canal, resulting in potential non-union and malunion [43].

External fixation is largely indicated for open fractures, polytrauma patients and coexisting skin problems. Looking at our belief in terms of minimally invasive osteosynthesis, having an extensive experience in external fixation techniques and confident that such techniques can be used to achieve adequate reduction, we tried to extend its use to the fractures of the distal third of the humerus. The proper attitude of the humerus to heal was favoured by the retaining of the fracture haematoma, the vascularity of periosteum and the endosteum preserved by external reduction. Additionally, humeral bone is not a weight bearing segment and can tolerate angular deformities up to 20° in procurvatum, 30° in varus, shortening up to 4 cm and translation up to 1 cm for extra-articular pattern fractures [44]. However, we always provided quite satisfactory fracture alignment to achieve sufficient stability and allow early mobilization of near joints. Other advantages associated with external fixation are possibility of correction of any loss of reduction during the whole treatment and removal of the device without assistance of general anaesthesia.

One of the disadvantages of this method is the necessity to insert screws through the soft tissue envelope into the bone. Because of the shearing forces between muscle and bone during movement of the adjacent joint, there might be restriction of the movement in the shoulder and elbow joint. This mechanical irritation increases the risk of pin track infection, and loosening may result [8]. We had only three cases of pin track infection; two patients had comorbidities (diabetes), and all healed with oral antibiotic. Our groups of proximal pins were always positioned on the anterolateral margin of the humerus distal to the deltoid muscle insertion. This always assured retention of good shoulder mobility. Distal pin groups were positioned radially in the lower part of the intermuscular lateral septum. The recommended minimum distance of the pin positioning from the fracture line is 3 cm to avoid creating an access to the fracture with a pin track [8]. This rule was not always applicable in our patients, especially with the distal group of pins, but we did not observe complications linked to this issue. To avoid radial nerve damage and to achieve optimal force transmission, we positioned the distal group of pins respecting the Ruland rules [8]. Although the pins are placed close to the elbow, full active and passive movement of the joint with sufficient stability of the fracture site is possible.

Some authors describe the difficulty to guarantee a stable fixation when positioning distal pin close together to protect radial nerve, resulting in loss of force transmission through the fixator; according to Ruland, we strongly believe that the unique restriction for the use of the external

fixator for the distal third of the humeral shaft is an intact zone between the epiphysis and the superior margin of the olecranon fossa to obtain sufficient fixation of the distal pin group. As described by Wegmann et al. [45] to ensure safety, mini-open incision and drilling with adequate tissue retraction and placement of the pins under direct visual control should be performed.

In our study, all fractures healed at an average of 11 weeks (9–13). At the last follow-up, the mean elbow flexion was 132.6° (Min 126°–Max 137°) and mean extension was 6.4° (Max 0°–Min 13°). These results are in line with Morrey's opinion about the functional range of elbow motion [46].

A careful clinical evaluation of the radial nerve is mandatory when humeral shaft fractures occur. Literature provides support for almost any approach in treating patients with humeral shaft fracture and radial nerve palsy. Many authors advocated primary nerve exploration, especially when Holstein Lewis fracture occurs [47, 48]. We had two cases of acute post-traumatic radial nerve palsy; one was associated with an open fracture pattern. We proceeded with exploration in both cases, and no nerve interruption was observed, while resulting concussed and entrapped. We had one case of post-operative radial nerve palsy. This is a relatively uncommon complication, and authors advocated both exploration and observation relating to their personal experience and patient issue [10, 11, 48–52]. We proceeded with exploration 3 days after primary surgery; the nerve was found to be entrapped at the fracture site probably consequently to reduction manoeuvres.

According to clinical results and full rate of consolidation, we state external fixation as a valid option in the treatment of distal third humeral diaphyseal fracture. We preferred to explore the radial nerve in both cases of primary and secondary palsy considering the young age of our patients and the availability of an expert peripheral nerve surgeon; however, the nerve resulted always in continuity. At the latest follow-up, all patients were satisfied with their functional results.

The pin insertion must respect muscle masses with a careful wound dissection deep to the bone surface to avoid pin track infection and iatrogenic radial nerve damage.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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