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Original article

External fixation for proximal humerus fractures neer type 3 and 4: results of 17 cases

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Summary. *Background:* Proximal humeral fractures (PHF) account for 4-6% of all fractures and 25% of humeral fractures. While conservative treatment is the gold standard for simple fractures, there is no consensus about the best treatment choice for complex PHF in the elderly. Recently a new external fixator was introduced in clinical practice for treatment of complex PHF. Aim of the study was to evaluate the functional results of this therapeutic approach. *Methods:* Data were retrospectively analyzed. Inclusion criteria were: three- and four- part PHF according to Neer, treatment with closed reduction and external fixation, normal Abbreviated Mini Mental Test score, independence in the daily living, non-pathological fracture, glenohumeral joint with moderate osteoarthritic changes and availability of clinical and radiological follow-up. For each patient demographic data, comorbidities, surgery time and estimated blood loss were recorded. Clinical and radiological evaluation were performed at 1, 2, 6, 12 months. *Results:* 17 patients were enrolled. Mean age was 69.7 years. Fractures were classified according to Neer as type III in 10 cases and type IV in 7 cases. The mean operating time was 22 minutes. Mean Constant score value at follow up was 74 ± 11,52 at 2 months, 82 ± 11,16 at 6 months and 85 ± 9,86 at 12 months. *Conclusion:* These preliminary results show that the studied system is easy to use, minimally invasive, effective in reducing surgical and hospitalization time. The results in terms of functional recovery are encouraging, showing a reduced number of complications. (www.actabiomedica.it)

Key Words: External Fixation; Proximal Humeral fractures; Neer classification.

Introduction

Proximal humeral fractures (PHF) account for 4- 6% of all fractures and about 25% of fractures affecting the humerus (1-3). They are the third most common fracture in patients older than 65 years and are the third most frequent osteoporotic fractures after wrist and hip fractures in the general population. The incidence has tripled in the last 30 years and it is expected to grow in the next 20 years due to the increase in life expectancy (4). After 50 years of age the male-to-female ratio is 1:3-4 (1, 5-10). Osteoporosis is identified as the main risk factor (11). The incidence of PHF in the general population shows a bimodal distribution. In elderly patients this fracture follows a low-energy trauma, such as an accidental fall and approximately half of all PHF occur at home (8, 12,13). In individuals over 60 years of age over 90% of PHF follows a fall from a standing height (1). In younger individuals PHF often follows a high-energy trauma in an external environment, such as falls from a height, motor vehicle accidents, sports or aggression (1,14).

The choice of the treatment depends upon various factors, in particular must be considered: age, bone quality, fracture pattern (degree of comminution and number of main fragments), involvement of the articular surface and, somewhat, surgeon's preference.

In the elderly conservative treatment remains the treatment of choice for most proximal humeral fractures, but approximately 20% requires surgical man-

agement (15-18). Comminuted fractures involving articular surface or complex fracture (three- and four-parts fracture according to Neer classification) seem to benefit from primary prosthetic replacement, that is addressed as the treatment of choice for older and osteoporotic patients (19-22).

Two- and three- parts fractures are treated with different surgical techniques: closed reduction and percutaneous fixation with Kirschner wire, open or minimally invasive reduction and internal fixation with plate and screws or intramedullary nails (23-24). The surgical approach to three- and four-parts fractures is still debated (25). The main goal of surgical treatment is to preserve the vascularization of the humeral head to prevent avascular necrosis (26-30). Kirschner's wires provide a minimally invasive approach and ensure a lower risk of avascular osteonecrosis, but fixation stability is low, especially in four-parts fractures (31-32).

External fixation is generally thought to be burdened by complication as pin tract infection and loosening. The rate of pin tract infection in the literature is reported around 2 – 9 %; for this reason in the surgical planning it is important to evaluate patient comorbidities such as diabetes, which is a known risk factor for infection (25,33-34).

Aim of this study was to evaluate clinical and radiological outcomes at 1, 2, 6 and 12 months of three- and four- parts fractures of the proximal humeral treated with closed reduction and percutaneous fixation with an external fixator (19).

Material and methods

The study was conducted in accordance with the Declaration of Helsinki and was approved by the IRB. Authors set up the study following the ethical recommendations of National Law Guidelines for Clinical Study. The enrolled patients gave their informed consent before surgery and during clinical examination.

From January 2018 to December 2019, 18 patients affected by proximal humeral fracture treated with closed or minimal invasive reduction and positioning of proximal humeral external fixator were selected. At Hospital admission, patients with diagnosis of displaced proximal humeral fracture were assessed by Abbreviated Mini Mental Test (AMMT) to investigate the cognitive state (35).

Clinical and radiological follow up were performed at 1,2,6 and 12 months for all patients. Data were analyzed retrospectively.

Inclusion criteria for the study were: displaced fractures of the humerus (Fig.1) with three- or four-fragments according to Neer, closed/minimal invasive reduction and external fixation, normal Abbreviated Mini Mental Test (routinely performed in every patient hospitalized), certain degree of independence without reliance on a caregiver, non-pathological fracture, glenohumeral joint with mild osteoarthritic changes (19).

Exclusion criteria included: proximal fractures of the humerus with 1 or 2 fragments according to Neer, treatment of PHF with open reduction and internal fixation (ORIF), medical or physical comorbidities that limited the functional of the shoulder, preexisting glenohumeral abnormality requiring reverse total shoulder replacement, pathological fracture secondary to malignant disease, or incomplete data at follow-up (19).

18 patients met the inclusion/exclusion criteria and were enrolled in the study.

For each patient were recorded: demographic data, comorbidities, duration of surgery and estimated blood loss. The mean age was 70 years ± 9,4 (range 45-80). Six patients were males (33%) and 12 females (67%). Eight cases (44%) involved the left humerus and 10 cases (56%) the right one (dominant arm). According to Neer classification, 10 cases were classified as three-parts fracture and 8 cases as four-parts fractures throughout x-rays and CT-scan (Fig. 2).

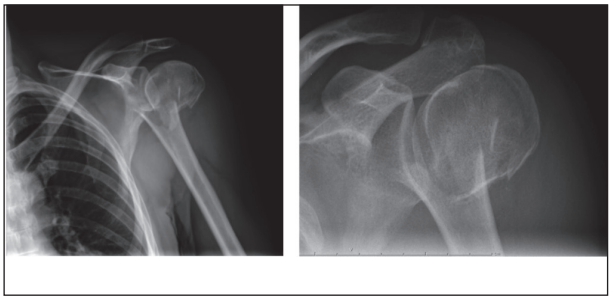

Figure 1 Displaced PHF with 3 fragments according to Neer's classification

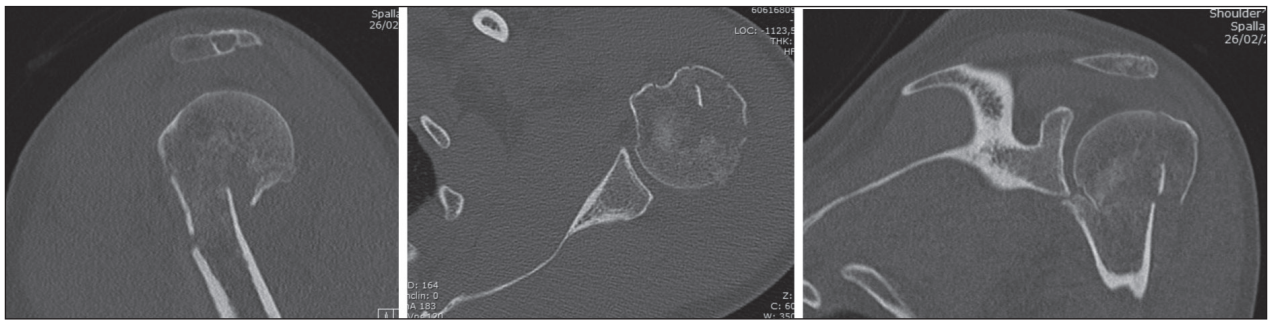

Figure 2. Shoulder CT scans.

Closed reduction was performed in 16 cases. In 2 cases a transdeltoid mini-invasive access was necessary to obtain a satisfactory reduction.

Surgical technique:

The patient is placed in "beach-chair" position with the affected shoulder outside the border of the table for free mobilization.

The image intensifier is positioned at the head of the patient, on the homolateral side. Fluoroscopy is carried out in anteroposterior and, when possible, axillary view to define fragment configuration, position, and size.

Attempts of closed reduction with external maneuvers are performed. When reduction is impossible, a transdeltoid 2-3 cm. incision is performed to obtain a satisfactory reduction. When the desired reduction is achieved, a percutaneous fixation begins.

The external fixator composed by 6 threaded Kirschner wire with a 70 mm long thread is positioned. The first wire must be placed 9 cm distal to the lateral edge of the acromion and 1cm medial to this line. The entry point is 1 cm anterior, in line with the deltopectoral area approach, avoiding axillary nerve injuries. The wire is inserted in direction of the coracoid to rest on the humeral calcar. The second wire is inserted about 1cm far from the previous one, as parallel as possible to it to facilitate the final application of the terminals. The tip of the wire must be positioned in the subchondral area of the humeral head to avoid cartilage damaging. Then the arm is abducted to 40°, and the third and fourth wire are inserted 1 – 2 cm laterally to the acromial border towards the base of anatomical neck crossing the greater tuberosity. Finally, the fifth and sixth wire are inserted distally to the fracture into the humeral diaphysis (20 cm from the acromion), 1 cm apart from each other and both must cross both bony corticals (Fig.3).

Finally, the system is stabilized with bars and clamps.

Postoperative management

A simple sling is positioned for the first 3 weeks, that can be removed for personal hygiene and to begin an immediate rehabilitation program. Fixator dressing is performed weekly as outpatient. On the 2nd postoperative day, the patient starts flexion/extension of elbow, wrist, hand and fingers. On the 3rd postoperative day pendular exercises are started. At 15 days from surgery passive and active shoulder mobilization are performed: abduction and flexion must not exceed 90°. In the third to sixth week, isometric exercises and active assisted exercises ensuring glenohumeral movement were started. At 35 day from surgery x-ray examination is performed. The external fixator is planned to be removed at about 6 weeks. After removal patients start full active exercises in all range of motions, rotator cuff strengthening, closed chain and proprioceptive exercises.

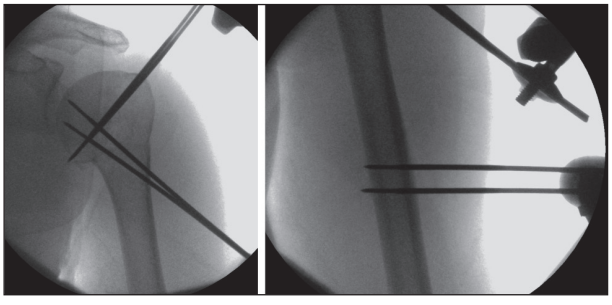

Figure 3. Intraoperative X-ray control.

Radiological assessment

Patients underwent radiological evaluation with plane X-rays at 1 month (Fig. 4), 2 months (Fig. 5) and 6 months (Fig. 6) including antero-posterior and oblique views to investigate any possible loss of reduction, fracture dislocation and fracture healing.

Clinical assessment

Clinical evaluation was performed at 1, 2, 6 and 12 months (Fig. 7) using the Constant score, useful to assess the patient's pain, range of motion, strength and ability to perform daily activities (34).

Results

Overall, 18 patients met inclusion criteria. One patient was lost to follow-up and was excluded from the final analysis. Data are shown in Table 1.

The mean Abbreviated Mini Mental Test (AMMT) score was 9,88± 0,3 (range 9-10,). The mean surgical time was 22 minutes ± 8,2 (range 15-45 min). The estimated blood loss was so low to be undetectable. External fixators were removed at 44,5± 2,9 days (range 40-49). At each clinical control patients were re-evaluated using the Constant score (Tab 2).

At 2 months the mean value was 74 ± 11,52 (range 45-90), at 6 months 82 ± 11,16 (range 55-100) and at 12 months 85± 9,86 (range 55-100).

Two cases (11,76%) with superficial pin tract infection were observed and treated with dressings; 1 case of loosening of a clamp was treated with retension of the external fixator and radiographic check that showed no significant displacement of the humeral head.

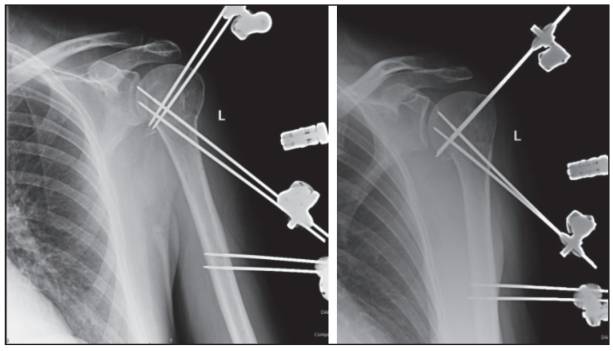

Figure 4. Post-operative X-rays.

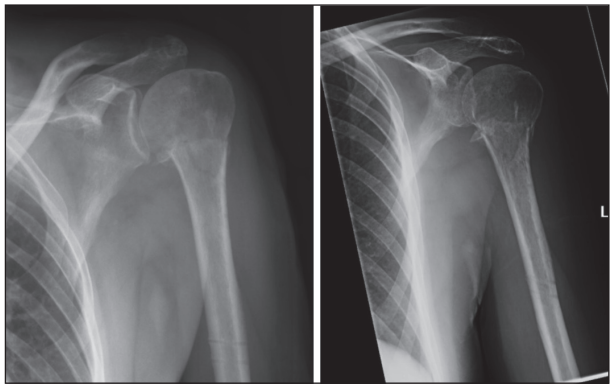

Figure 5. Radiographs performed 2 months after surgery showing bone healing processes.

Discussion

Three- and four-parts proximal humeral fractures according to Neer classification account for 13–16%

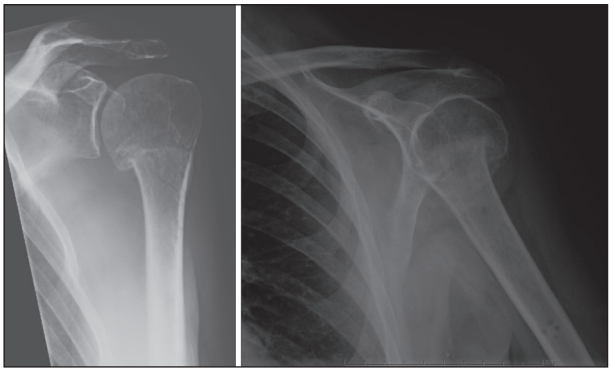

Figure 6. X-rays6 months after trauma.

Figure 7. Clinical evaluation at 12 months follow-up.

Table 1. Demographic and results of the case series of the study. AMMT (Abbreviated Mini Mental Test).

Variable	Mean	Range	Standard Deviation
Age	69,7	45-80	9,4
Gender	M 6 – F 11	-	-
AMMT	9,88	9 – 10	0,3
Surgery time	22 minutes	15 min - 45 min	8,2
Blood Lost	-	-	-
Constant score at 2 months	74	45-90	11,52
Constant score at 6 months	82	55-100	11,16
Constant score at 12 months	85	55-100	9,86

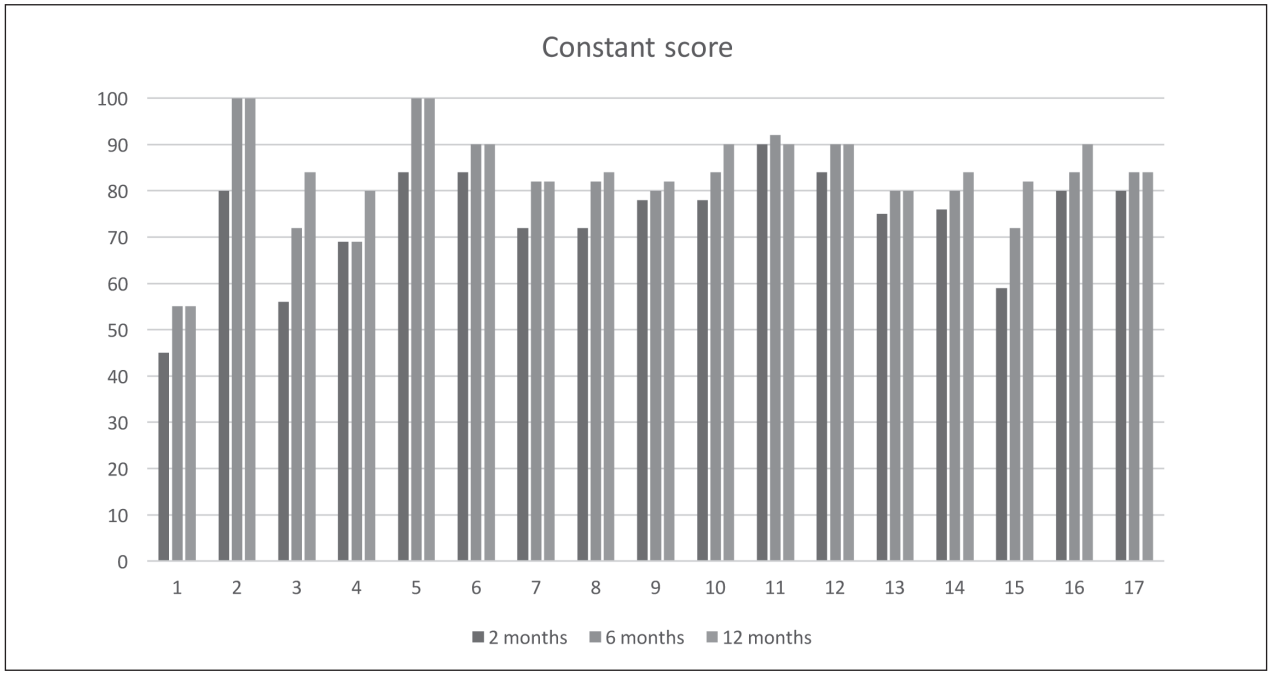

Figure 6. X-rays6 months after trauma.

of the fractures of the proximal humeral epiphysis and approximately 20% of them require surgical management (18). The rate of surgical treatment of proximal humeral fractures has significantly increased in the last years since patients are more active and require high functional results. Significant regional variations in the rates of surgical treatment suggest the need for better consensus regarding optimal treatment of this type of lesion, especially with type III-IV of Neer's Classification fractures (37). Displaced proximal fractures of the humerus, with three or four fragments, represent a challenge for orthopaedic surgeons because of the complexity of proper reduction, the precarious screws fixation in the spongy bone of the humeral head, which has a very low bone stock, especially in postmenopausal women, and the risk of necrosis of the head due to terminal vascularization (38-40). In the literature few studies comparing the clinical results of different surgical techniques can be found, while all the systematic reviews have underlined the paucity of evidence on this topic (41-42). Open reduction followed by internal fixation with plate has become the commonly preferred surgical choice (43-44). However, open plating using the conventional deltopectoral approach has a biological weakness due to soft tissue stripping and an increased risk of avascular necrosis of the humeral head and wound dehiscence. Regardless the used osteosynthesis, the aim of each operative procedure is to

preserve the vascularization of the humeral head and avoid avascular necrosis, so the use of a shoulder external fixator for the treatment of these fractures could be an excellent choice especially in elder patients (26-27). Furthermore, using a percutaneous treatment reduces blood loss and operating times, allowing easier fracture manipulation and reducing the risk of neurovascular lesions (45-50). D'Ambrosi et al. conducted a prospective study on external fixation for the treatment of three- or four-parts fracture of the proximal humerus (33). They recruited 32 patients with a mean age of 66.84 years, showing a significant improvement from 6 months to 1 year and from 1 to 2 years, with good-to-excellent results at the final follow up and a mean Constant score of 88.9 at 24 months. The postoperative indications were immobilization for three weeks followed by gradual and progressive mobilization of the shoulder. The wires were kept for an average of 41 days and at the final follow-up the average Constant score increased from 76 after 2 months to 85 at 12 months. External fixation procedures are bound to increased risk of pin or wires infection. D'Ambrosi showed at the final follow-up a pin tract infection only in three cases (9.38%) (33). Blonna et al. had one case of pin tract infection out of 50 patients (2%) that healed without the need of revision surgery (25).

The results of our study confirm that the treatment of proximal humeral fracture with 3 to 4-parts displaced fragments by external fixation is a good choice thanks to the minimally invasive technique; it is a modular, flexible system with a wide range of applications and provides good functional outcomes.

Limitations of this study includes the retrospective nature, the small number of participants, the unknow pre-trauma functional status and the short follow-up.

Conclusions

Osteosynthesis with external fixator can be considered today as a valid treatment for PHF to stabilize the fracture, preserve the humeral head vascularization and early mobilize the shoulder. In elderly patients, an early recovery of motion allows a faster functional recovery of the limb and therefore a faster return to everyday life. This study represents a preliminary experience with this system which has proved to be easy to use, minimally invasive, capable of a reduction of surgical and hospitalization times. The results in terms of functional recovery are encouraging with a reduced risk of complications.

Conflict of interest: Each author declares that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

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