Review Article

Treatment of Proximal Humerus Fracture with Minimally Invasive Osteosynthesis (MIO)

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Abstract

Objective
To report our experience in the treatment of 2 and 3 part fractures of the proximal humerus fixed with locking angular stability plates, with minimal invasive technique (MIO), and the factors that improve patient outcomes.

Materials and Methods
A prospective descriptive study of serial cases where 22 patients underwent surgery (13 women and 9 men) in the period between February 2010 and August 2012. The average age of patients was 50.8, ranging from 24 to 82 years old. The lateral acromial approach with the patient in the beach chair position under fluoroscopic vision was used. The minimum follow-up period was 24.3 months (11-32 months). Follow-up included review of radiographs for fracture union, avascular necrosis and functional evaluation of the Constant-Murley score.

Results
In all cases, we observed fracture union within six months after the surgery. No cases of avascular necrosis were found. Two patients developed a varus deformity (109°). Two patients suffered subacromial impingement due to placement of the plate at the proximal edge of the humerus. The functional outcome according to the rating scale Constant-Murley was 68.8 points. No associated neurological injuries occurred.

Conclusions
A minimally invasive fixation technique for proximal humeral fracture with a locking plate is an alternative surgical treatment. The preservation of the anatomy results in a higher probability of consolidation, with decreased avascular necrosis and early rehabilitation in patients with poor bone quality.

Level of Evidence: IV

Keywords: Proximal Humeral; Locked Plate; Minimally Invasive

Introduction
Proximal humeral fractures are common injuries, in older adults, is the third most frequent fracture, associated with bone fragility in females [1-13]. In patients older than 60 years of age, 70% of fractures are into three and four parts [4]. Although the majority of proximal humeral fracture are either non-displaced or minimally displaced, they can be treated with sling immobilization and physical therapy. Approximately 20% of displaced proximal humeral fractures may benefit from operative treatment [1,5,6]. Most surgical maneuvers have the risk of mechanical failure due to bone quality resulting in varus deformity of the humeral head. Hertel et al [14], describe the fracture patterns and the risk of ischemia related with the disruption medial hinge of the metaphysis. These complications are reported in 10% of the patients [1,2,5,6,13].

The use of locking plates improves the fixation and decreases the risk of bone collapse and avascular necrosis gaining angular stability. Open reduction and extensive approaches in the shoulder affects bone vitality; The minimal incision (MIO) approach is preferred preserving the soft tissues and early rehabilitation, and also present complications including axillary nerve injury and subacromial impingement [1,3,11,15,16].

There are studies with adequate short term results with MIO techniques [1-3,6-9,17,16,18,19]. To perform minimally invasive osteosynthesis, it is necessary to know the anatomy of the proximal humerus and be available to perform an open surgery. The purpose of this study is to analyse our experience from the surgical treatment of fractures of the proximal humerus using the MIO technique with an angular stable plate. We aim to investigate the exact indications and contraindications of this approach and how can affect the outcomes.

Materials and Methods
This was a descriptive case report study (Level of evidence IV), conducted from November 2010 to October 2012 at the Clínica Carlos Ardilla Lulle-Fundación Oftalmológica Santander (FOSCAL), in patients with proximal humeral fracture classification NEER II-III or AO 11B1-11B2 with an minimum follow-up of 11 months, using the Proximal Humerus Internal Locking System (PHILOS (De Puy Synthes, Switzerland). Preoperative x-ray standardized by

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a true AP view, a scapular Y view and in some cases an axillary lateral view were taken; at least two perpendicular x-ray [true AP and a scapular Y view] were necessary to identify the fracture type. CT scans (computed tomography) were taken when we suspected joint involvement.

Inclusion criteria were: patients over 18 years of age, proximal humeral fracture classification NEER II or III- AO 1143, 11B1 and 11B2; no more than two weeks of evolution, and closed fracture without neurological or vascular injury. Also, patients with fractures combined with dislocation, open fractures, fractures with a split head or a compromised particular surface greater than 40%, patients who refused to undergo the procedure, and those that did not meet the minimum time of follow up were excluded.

The functional outcomes was measured with the Constant score [20]. X-rays were used to assess the fracture healing and the cervicodiaphyseal angle. Complications were associated with the implant and avascular necrosis. Intraoperative complications were recorded, such as conversion to larger incision, surgical time, and infection. There was no source of funding for this study and none of the authors have a conflict of interest with the orthopedic industry.

**Surgical Technique**

Under general anesthesia, with the patient in the supine beach chair position, the anterolateral (acromial) approach -deltoid split- was performed without exceeding more than 5 cm distally to the acromion. This incision was placed between the clavicular part and the acromial part of the deltoid muscle. After exposing and dissecting the humeral head, preliminary and temporary fracture fixation with K-wires was performed. Lesser and greater tuberosities were reduced with percutaneous wires and fixed to the head transiently using the k-wire like a joystick. The correct reduction was confirmed by fluoroscope (Figure 1). The plate was placed on the skin, making a pressure foot print to determine the length of the distal incision (Figure 2). Upon palpation and dissection of the axillary nerve (Figure 3), the plate was placed by sliding it underneath the axillary nerve and fixing it with four locked screws to the proximal end of the bone. The correct reduction and position of the screws was confirmed under fluoroscopic vision and then a cortical screw was used to attach the bone to the plate making an indirect reduction of the metaphysis. Afterwards, a cortical or locking screw was placed in the diaphysis as well as a distal locking screw (Figure 4).

Proper patient position is crucial. Correct positioning permits all necessary arm and shoulder motions, and allows necessary imaging in multiple planes.

**Postoperative Management**

Patients were required to use an immobilization sling for 10 days, then perform a regimen of passive shoulder exercises and active flexion exercises of the elbow and finger movements for edema management. Therapy strengthening to increase mobility began after two weeks. X-rays were taken in the AP and axillary views at six and twelve weeks and again at six and twelve months to review the evolution of the union and avascular necrosis. Implant removal was performed only in situations in which the patient suffered discomfort, or for other reasons if requested.
Results

Twenty-two patients met the criteria for comprehensively monitoring, with average age of 50.8 years (24-82 years), nine men and thirteen women. Thirteen had fractured the left shoulder and nine the right shoulder. The average follow-up time was 24.3 months (11-32 months).

The average time of surgery was 64.9 minutes (38 minutes to 124 minutes). Intra-operative complications of the procedure, axillary nerve injury or postoperative conversion osteosynthesis were not reported in any of the patients. In addition, no avascular necrosis of the humeral head and no surgical site infections were reported. X-ray results showed 100% of fracture healing; however, two patients had developed a varus deformity consolidation (9%). Two patients suffered problems due to large proximal screws in higher positioned plates with subacromial impingement (9%) (Figure 5). These patients required removal of the plate, one in the fourth month and the other sixth month after surgery. The average Constant–Murley score was 68.6 (range: 25-94).

Discussion

Proximal humeral fractures are controversial regarding their management and are considered challenging. Several methods of fixation in young patients have shown good results; however, in elderly patients, complication rates are higher [2, 4, 5, 9, 11, 12, 17]. Avascular necrosis may occur in up to 45% of patients that are treated using the deltopectoral approach for open reduction and plate fixation [1, 2, 6, 9, 11]. This occurrence may be related to the degree of the initial trauma and vascular compromise of the the circumflex artery [2]. Performing a cutaneous incision and removal of the periosteum of bone fragments can further enhance the initial vascular injury [1, 8-11, 18, 16]. The deltopectoral approach can affect the blood supply at the level of the anterior circumflex artery, requiring the substitution of proximal humeral irrigation [3, 8, 11, 13].

Loss of fixation is another concern in the open reduction surgical procedure, and has been reported in 4% to 25% [2]. The use of locking plates has decreased the possibility of this defect [2, 5, 6, 8, 10, 21, 17, 22]. Patients with osteoporosis are at increased risk of loss of fixation and implant failure associated to this bone pathology. The biomechanical effect that occurs in this region can be associated with muscle attachments and the possibility of misdirecting the screws in the wrong direction [2, 3, 5, 8, 10]. Therefore, it is recommended to placed 5-10 mm to the subchondral region, using at least four divergent proximal screws. Every effort should be made to use the maximum number of screws in the head fragment in order to allow and improve the biomechanical effect of support at the inferomedial region [2, 6]. One of the objectives is to try to restore the medial column, which is related to clinical and functional outcomes. Failure to reorganize the medial column can result in varus deformities of the fracture in 11% to 25% of patients treated by this method, as well as an increased risk of perforation of the humeral head in 3% to 59% of cases [5, 6, 7, 10].

Further injury can be reduced by using minimally invasive techniques, which theoretically attenuate vascular complications, taking into consideration the posterior and medial arterial irrigation [1, 7-9, 11, 13, 17, 18]. The transdeltoid approach presents the risk of injury to the axillary nerve, which is referenced to the distance of 5 cm +/- 0.7 cm from the tip of the greater tuberosity [3, 11, 13, 15-18]. Care should be taken when placing the most distal plate screws in the proximal part of the plate, associated with the...
greatest risk of axial nerve injury [11,18]. It is important to keep in mind the security zone for the placement of the plate, which is 5 cm wide and is close to the vascular income through the greater tuberosity, thus allowing the coupling of the greater tuberosity with diaphysis support. For this reason, it is recommended that the placement be made with a slight backward inclination to avoid the possibility of altering the anterior irritation [13]. The advantage of using locking plates is that they have a low profile, they promote internal fixation, provide angular stability on multiple planes, and they promote better overall results [1-3, 5, 6, 8-10, 21, 17, 16].

Papadopoulos et al., in their study on 27 patients with a minimum follow-up of 12 months, with a Constant-Murley score of 86 (58-112), 11.1% of patients experienced complications, such as aseptic collapse of the humeral head in 7.4% (two patients): in one patient (3.7%), varus collapse of the medial column occurred [2]. In a study by Barco et al., 25 patients over 18 years old were reviewed with fractures into three parts over a period of two years; it was found that all fractures consolidated and 91% obtained anatomical reduction, average flexion, internal and external rotation of 126°, 44° and L1, respectively. The final DASH score was 23 points. Barco reported complications in 52% of cases, such as cut out, stiffness, infection and varus deformity. No cases of avascular necrosis [1] were reported. Acklin and colleagues reported in a period of three years 68 fractures, which they treated using the anterolateral approach; these 29 patients were available for clinical and x-ray follow-up. Most patients had fracture A3 AO classification, and were followed-up for 12 months. The surgical time spent was 75 minutes on average (50 and 155 minutes). In all cases, only one fracture required the removal of a screw cut out. No avascular necrosis was evident and the Constant score was 78 [3]. Ricchetti et al. presented a study in which they had a minimum follow up of six months (average 13 months). The minimally invasive technique was utilized in 52 patients and the results showed mobility indices of 130° flexion and external rotation of 27°. They used the scales PENN (68.9) and ASES (70.8), which showed good results. The study reported minor complications in 5.6% of the 52 patients, major complications in 14.8% and two shoulders that had to be repeated on [6]. In a study by Ashok et al., in one year of follow-up, the results showed consolidation in all patients, no avascular necrosis and no loss of fixation, and a Score Constant of 82.24 [8].

When compared to our study, we observe that the surgical time was reduced to 68 minutes on average, which we relate to the expertise of the surgeons. The results of consolidation and no avascular necrosis are consistent with most of the leading authors on safe surgery. The Constant score, when compared to other studies with the same characteristics, shows that the results were good to excellent. Very few patients reported not being satisfied with the procedure. Our study found 9% of patients with complications, similar to rates reported by other authors.

Our study has some limitations; first, we have a low patient size, lack of comparison group with open reduction and internal fixation with larger approaches techniques, it was conducted by two different surgeons, both have trauma experience in upper limb surgery and in the use of locking implants so the technical differences may have affected the results.

However, we do not recommend this technique for all the proximal humeral fractures; only for metaphysical fractures without compromise of both tuberosities. Is not indicated for fracture dislocations, isolated tuberosities and fractures with severe values impactation with compromise of the medial hinge.

Conclusions

The minimally invasive technique in patients with two and three part fractures of the proximal humerus with polylateral locking plates has advantages in the process of fracture healing. The sizes of the two incision it decreases the rate of avascular necrosis due to the preservation of shoulder soft tissue. There should be a learning curve and surgeons should know the recommendations for performing this surgery to reduce the risk of operative failure. Complications related to implant impingement can be corrected with refinement of the technique and the use of a fluoroscope. When don’t recommend the application of this technique in fracture dislocations, and split head and complex fracture.

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