Minimally invasive deltoid splitting approach for fixation of proximal humeral fractures using locked proximal humeral plate

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Abstract

Background
open reduction and internal fixation of proximal humerus fracture through the classic deltopectoral approach has some disadvantages and complications. The purpose of the study was to assess the results of locked proximal humeral plate through a mini invasive anterolateral deltoid split incision in the management of proximal humerus fracture.

Patients and methods
Between January 2013 and November 2015, 23 patients (10 male and 13 female) with displaced proximal humerus fracture were treated with plating using proximal humerus locked plate through mini-invasive anterolateral deltoid splitting approach at Benha University hospital. The inclusion criteria included patients with displaced 2 part (15 patient), 3 part (6 patients) and 4 part (2 patient) proximal humerus fracture according to Neer classification. The average age of the patients was 45 years (+ 9.9) ranging from 32 years to 65 years. Functional outcomes were assessed according to the Constant- Murley scoring system, DASH Score, and Visual Analogue Scale Score for pain

Results
Mean follow-up period was 20.6 (±7) months ranging from 12 to 36 months. All cases united with a mean union time of 11.2 (±2.6) weeks. The mean postoperative shoulder flexion was 141.5° (±23.9°), extension was 49° (±6.9°), internal rotation 50.8° (±9.6°), external rotation was 67.3° (±15.3°) and abduction was 148.9° (±24.6°). The mean postoperative Constant Score was 79.4 (±11.7) ranging from 52 to 96. The mean DASH Score was 27.6 (±9.7) ranging from 5 to 52 and the mean pain Visual Analogue Scale Score was 0.95 (±0.93) ranging from zero to 3. Complication rate was low 8.6%. One case developed impingement and plate was removed after 12 months. Another case united in mild varus but without complaint. No patient developed avascular necrosis or screw cut-out with no recorded cases of axillary nerve injury or partial deltoid weakness.

Conclusion
the use of minimally invasive deltoid split approach is easy and safe method for fixation of proximal humerus fracture using proximal humeral locked plate with favorable outcome and low complication rates.

Keywords
Minimally invasive, Proximal humeral fractures, MIPO, deltoid split approach.

Introduction
Proximal humeral fractures account for 4-5% of all orthopedic fractures. In patients over 65 years of age, it is the third most common fracture after distal radial fractures and hip fractures (1). In elderly patients, they usually follow low-energy trauma such as a simple fall on an outstretched hand due to osteoporosis (2). In younger patients, they result from higher-energy injuries and sports injuries, and a fracture-dislocation may occur (3)

Although the majority of proximal humeral fractures are either minimally displaced or nondisplaced and can be managed using sling immobilization and physical therapy, approximately 20% of displaced proximal humeral fractures needs operative treatment.(4)

Many different techniques have been used to treat displaced or comminuted proximal humerus fractures. Percutaneous pinning and intramedullary nailing have been used with satisfactory results and low infection rate, minimal soft tissue disruption, and minimal blood loss. However, many of these methods are not enough stable with high malunion and nonunion rates, and potential for hardware migration. (5)

Conventional buttress plate fixation may showe fixation loss due to screw loosening and cutout in osteo-
porotic bone (6). Mechanical studies have shown that locked plates have increased stiffness and dynamic loading properties than conventional plates (6,7). Prior to the advent of locked plating, the treatment of choice for displaced three and four part fractures was hemiarthroplasty (6). However, hemiarthroplasty and more recently reverse total shoulder arthroplasty often had poor functional outcomes and should be used in selected cases when reconstruction cannot be achieved (8). Locked plating has been shown to be an advancement over previous fixation techniques in that it allows rigid fixation with low rates of fixation loss (9). Currently, locked plating is considered the treatment of choice for functionally active patients (10).

Using the traditional deltopectoral approach for fixation of proximal humerus fracture provides limited access to the posterolateral aspect of the shoulder with the difficulty in visualization and reduction of a retracted greater tuberosity fragment (11). And to gain adequate exposure to the lateral aspect of the humerus, the deltopectoral approach requires extensive soft tissue dissection and muscle retraction. Further devascularization of fracture fragments can occur during dissection and plating, and result in disruption of the blood supply of the humeral head (12). Various studies suggested that Good visualization of the posterolateral aspect of the shoulder could be obtained through the deltoid splitting approach, with identification of axillary nerve, without extensive soft tissue dissection or forcible retraction; however, when compared to the conventional deltopectoral approach there is an increased risk of axillary nerve injury (13).

Recent studies have demonstrated the superiority of MIPO techniques via anterolateral deltoid splitting with double small skin incisions for the management of proximal humerus fractures (13,14). This minimally invasive technique, leads to less soft tissue injury, decreased functional loss and decreased postoperative pain, for that MIPO is considered an effective and safe method for the management of proximal humerus fractures (15). The aim of the current study was to evaluate the results of proximal humerus locking plates for treatment of displaced proximal humerus fracture through minimally invasive anterolateral deltoid splitting approach. As a new era in management it looks superior to classic open surgery regarding the functional outcome, cosmeses and the complications rate.

**Patients and methods**

Between January 2013 and November 2015, 23 patients (10 male and 13 female) with displaced proximal humerus fracture were treated with percutaneous plating of proximal humeral at Benha University hospital. The inclusion criteria included patients with displaced two part, three part and four part proximal humerus fracture according to Neer classification. Exclusion criteria were open fractures, fracture dislocation of the shoulder, associated vascular or neural injuries, pathologic fractures and fractures with head defect require grafting.

The mechanism of injury was fall on outstretched hand in 12 patients, road traffic accidents in 7 patients and sport related injuries in 4 patients. The average age of the patients was 45 years (+_9.9) ranging from 32 years to 65 years. The right side was affected in 15 patients and the left in 8 patients.

Patients were evaluated clinically and radiologically preoperatively. At least anteroposterior and lateral view were obtained. CT scan was obtained in all cases and was used to classify the fracture. According to Neer classification, 15 patient were 2 part fractures, 6 patient were 3 part fractures and 2 patient were 4 part fractures.

**Surgical technique:**

All patients were operated under general anesthesia with the patient seated in a beach chair position. Proximal humerus locked plates were used in this study through the minimally invasive anterolateral deltoid splitting approach (fig. 1). A straight 5 cm longitudinal incision was done from the anterolateral tip of the acromion downward in line with the humeral shaft. The deltoid muscle was exposed, identifying the fat between the anterior and the middle deltoid fibers where the deltoid muscle was splitted through this avascular raphe to expose the subacromial bursa. Partial resection of the bursa was done to expose the lateral surface of the proximal humerus.

**Figure (1): double deltoid split incision**
The fractured greater tuberosity fragment was identified and sutured with non-absorbable suture through the attached rotator cuff. An epi-periostial sub-deltoid tunnel was created using blunt elevator with the protection of the axillary nerve using surgeon’s finger or langenbeck retractor in slight arm abduction to decrease tension over the nerve. Distally, the anterolateral insertion of the deltoid may cause some resistance and needs to be released.

The indirect reduction was done using axial traction and manipulation, and the plate was introduced from proximal to distal with the arm in slight abduction under image control. Sutures were passed through the plate holes and the plate tip was adjusted below the greater tuberosity tip by 5 ml to avoid impingement. (Fig 2A) and preliminary fixed by K wire (fig. 2B).

Under image intensifier, a distal longitudinal 3 cm skin incision was made starting 7-8 cm distal to the acromion tip with blunt deltoid split and langenbeck retractor used to expose the plate.

A cortical screw was used to pull the shaft towards the plate (fig. 2 C,D), and the reduction was assessed under fluoroscopy in 2 planes, then the proximal locking screws in the head and distal locking screws were applied (Fig. 2 E,F). Cuff sutures were tied over the plate. The wound was closed in layers without a drain and arm sling was applied.

**Figure (2):** surgical technique; (A) the plate is introduced from proximal to distal. (B) Preliminary fixation of the plate to the head was done using a k wire. (C and D) a cortical screw is used to pull the shaft towards the plate. (E) Proximal locking screws in the head applied. (F) Distal locking screws were applied.

**Figure (3):** A. preoperative and B. postoperative X-ray. Note associated fracture clavicle fixed by clavicle locked plate

**Postoperative care:**

The arm was immobilized in a sling, and passive ROM shoulder exercises were started as tolerated from the first postoperative day. Active-assisted ROM exercises began after suture removal at 2 weeks (Fig. 4) and active exercises after about 6 to 10 weeks according to fracture healing under supervision of physiotherapist. Postoperative radiographed were obtained every 2 weeks till union (fig. 3).
Results

The mean operative time was 48.2 minutes (40-75 min). The mean follow-up period was 20.6 (±7) months ranging from 12 to 36 months. All the 23 cases were united in a period ranging from 8 to 18 weeks with a mean union time of 11.2 (±2.6) weeks (fig. 5).

Regarding the range of motion at the end of follow-up, The mean postoperative flexion was 141.5° (±23.9°) ranging from 100° to 170°, extension was 49° (±6.9°) ranging from 35° to 60°, internal rotation 50.8° (±9.6°) ranging from 35° to 65°, external rotation was 67.3° (±15.3°) ranging from 40° to 85° and abduction was 148.9° (±24.6°) ranging from 90° to 175°. (Figs 6,7,8).

At the end of the follow-up period, all patients were evaluated regarding the shoulder ROM and by using Constant-Murley Score (CMS), DASH Score and Visual Analogue Scale Score (VAS) for pain.
Figure (7): 55 years old Female patient with proximal humerus fracture (A,B) preoperative X-ray & CT (C) intraoperative image intensifier photo (D) postoperative X-ray (E) final X-ray after complete union (F) final range of motion.

Figure (8): final postoperative ROM in 32 years old patient.

The mean postoperative Constant Score was 79.4 (±11.7) ranging from 52 to 96. The mean DASH Score was 27.6 (±9.7) ranging from 5 to 52. The mean pain VAS Score was 0.95 (±0.93) ranging from zero to 3.

One case developed subacromial impingement from high plate, and was managed by plate removal after 12 month. Another case united in 15º varus but without complaint. No patient developed avascular necrosis and no recorded cases of axillary nerve injury or partial deltoid weakness.

Discussion

The goal of management of displaced proximal humeral fractures is a pain-free shoulder with the restoration of pre-injury function. Locked plate is the standard method of fixation of proximal humerus fractures (4).

The most common approach used for plating of proximal humerus fracture is the anterior deltopectoral approach. It allows adequate exposure for internal fixation but it requires extensive muscle retraction and soft tissue dissection to gain adequate exposure of the lateral and posterolateral aspect of the humeral head and leads to difficulty in reducing and fixing posterior parts of the greater tuberosity (16). Moreover, the deforming force at the fracture site may complicate the reduction and retractors may be positioned behind the humerus itself to keep the deltoid muscle away from the fracture zone and excessive
soft tissue retraction may devitalize the fracture fragment and increase the incidence of avascular necrosis (17).

In 2005 Gardner et al described the extended anterolateral acromial approach (ALA) for reduction and fixation of proximal humerus fractures with exploration and protection of the axillary nerve during plating or nailing of proximal humerus fractures (18). The anterolateral deltid-splitting approach is placed mainly over the main fracture parts and offers better access to the greater tuberosity. No large retractors are needed. This method has the advantage of less soft-tissue dissection and damage to the blood supply to the bone fragments (19). Recently, multiple authors described the mini invasive deltid splitting approach either through 2 small deltid splitting approach or through one proximal small deltid split and one distal small anterolateral approach to the humeral shaft. (6,13,-17,20,23)

When using the mini-invasive deltid splitting approach the main risk factor is the axillary nerve damage (20). But actually, the location of the nerve can be easily predicted (17). Previous anatomical studies have revealed that axillary nerve is located between 5.58 cm to 6.66 cm distal to the lateral acromion (21,22). In the current study, we did 2 deltid splits the proximal one no more than 5 cm distal to the acromion tip to avoid the axillary nerve damage. To place distal screws, we start the second deltid split incision 7-8 cm distal to the acromion, while Cheung (22) suggests 9 cm is safer. In the current study putting the arm was positioned in slight abduction during plate insertion to relax the nerve and avoid its injury, none of the patients in the current study developed axillary nerve palsy. Similarly, in the study by Acklin et al., only one case of 29 cases developed axillary nerve injury after MIPO through the anterolateral deltid splitting approach (23).

In 2008, Gartner et al published their result using the extended anterolateral acromial approach with identification of the axillary nerve for ORIF of a proximal humeral fracture over 23 patients 9 were treated using an intramedullary nail and 14 were treated with locked plating (average follow-up 28 months (12 to 49 months). The average age was 65 years (21-85 years). No patient developed avascular necrosis and all fractures healed. The authors did not mention the time to fracture healing. The average Quick DASH score was 25.2 (0 to 65.9). Forward flexion range of motion averaged 121° (30 to 170°), and average abduction was 104° (20 to 170°). Only 2 patient developed postoperative axillary nerve palsy with weakness of anterior part of deltoid muscle (19).

In 2009, Conrad et al. performed a study of 187 patients with proximal humeral fracture managed with ORIF with a locking proximal humeral plate using open deltopectoral approach. Twelve months after surgery, the mean Constant score for the injured side was 70.6 ± 13.7 points and the mean DASH score was 15.2 ± 16.8 points. But they reported high complication rate in 62 patient (34%). 25 complications (40%) mainly related to incorrect surgical technique. The most common complication, noted in 21patient (14%), was intraoperative screw perforation of the humeral head (24).

In 2009, Thanasas et al published a systematic review article on the result of locking plates in the treatment of proximal humerus fractures over 12 studies including 791 patients using mainly the classic deltopectoral approach. Patient’s improvement in these studies continued up to one year, with a mean Constant score of 74.3 which was 76.9 in 2 part fractures, 75.8 in 3 part fractures and 67.6 in 4 part fractures. The incidence of the reported complications was significant, screw cut-out in 11.6% of patients, avascular necrosis in 7.9%, and re-operation rate 13.7%. (25).

In 2012, Acklin and Sommer did a prospective study over 29 patients with proximal humerus fractures fixed by locked plate fixation of using the minimally invasive anterolateral deltid split approach with a mean age of 64 years. The mean follow-up time was 12 months (6–32 months). The mean operative time was 75 min (55– 155 min). All fractures healed in a timely manner. The median Constant score reached 78 points (28–93 points). In one case they found a lesion of the anterior branch of the axillary nerve. In 3 cases (10%), a screw had to be removed after secondary cut-out. One fracture developed progressive varus malalignment after 6 months and required revision surgery (26).

In 2015 Chen et al., published their result using percutaneous PHILOS plating through minimal invasive deltid splitting approach over 27 elderly patients with valgus impacted proximal humeral fractures. Average follow-up was 20.8 months (range: 11–34). An average surgery time of 52 min (range: 40–70min). All fractures healed without reduction loss or fixation failure, except for one case in an average union period of 7.2 (6 to 14) weeks. One case with cystic density decrease in the humeral head and screw cutout 6 months postoperatively and implant was removed 11 months postoperatively. In terms of function according to the NEER score, there were 17 excellent, 7 satisfactory, 2 unsatisfactory, and 1 poor outcome. The mean Constant-Murley score was 89.4 ± 4.35 points which is very high and they explained this due to minor soft tissue injury of rotator cuff muscles in valgus impacted fractures (17).
Lin et al in 2014 did a retrospective comparative study between minimally invasive plate osteosynthesis with a locking plate to open reduction and internal fixation, the MIPO technique was superior and caused less blood loss and required less surgery time when compared to ORIF, MIPO with a smaller incision, resulted in less scarring, and was cosmetically more acceptable than ORIF. In addition, patients had less pain, better functional results with better outcomes, higher range of motion and a higher satisfaction with daily living activities, when compared to ORIF group. The rate of complication was comparable between both groups. The average constant score after 1 year was 72.5 in MIPO group and 71.2 in ORIF but it was significantly higher in MIPO group at 3 and 6 months follow-up than ORIF group (15).

In the current study, fixation of proximal humerus fracture was done using minimally invasive anterolateral deltoid splitting approach through 2 proximal and distal deltoid windows instead of the classic deltopectoral approach. We found this approach having many advantage mainly direct approach to fracture fragment and easy reduction with minimal soft tissue dissection with preservation of the blood supply to the fracture fragment decreasing the incidence of AVN, less blood loss, less operative time (mean operative time was 48.2 minutes from 40 to 75min). Less soft tissue scarring and less postoperative pain and the wound is cosmetically better. The axillary nerve location was predicted and protected during the surgical steps, the fear of axillary nerve injury has been decreased in the current study and the nerve was intact postoperatively in the entire study patient. The use of locked plate allows for early rehabilitation and range of motion exercises and better functional outcome.

The patient’s functions continued to improve significantly up to 12 months postoperatively. Regarding the range of motion at the end of follow-up, The mean flexion was 141.5° (±23.9°), extension was 49° (±6.9°), internal rotation 50.8° (±9.6°), external rotation was 67.3° (±15.3°) and abduction was 148.9° (±24.6°). The mean Constant Score was 79.4 (±11.7) ranging from 52 to 96. The mean DASH Score was 27.6 (±9.7) ranging from 5 to 52 and the mean pain VAS Score was 0.95 (±0.93) ranging from zero to 3. These results were much better than previous studies using the classic deltopectoral approach or extended deltoid splitting approach and were comparable to the result of previous studies using the minimally invasive deltoid splitting approach. The complication rate in this study was low when compared to previous literatures as all cases were united and no patient developed avascular necrosis or screw cut-out with no recorded cases of axillary nerve injury or partial deltoid weakness. Complication rate were 8.6% and reopera-

tion in only one patient (4.3%) for plate removal after impingement.

The limitation of the study was the relatively small number of patients (23 patients) and the lack of direct comparison with another group of patients treated with a standard deltopectoral approach.

**Conclusion**

The minimally invasive deltoid split approach is an easy and safe approach for fixation of proximal humerus fracture using proximal humeral locked plate with favorable outcome and low complication rates.

**References**


