Surgical management of complex humerus head fractures

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Abstract

The locked plate systems provided adequate fixation of osteoporotic fractures of the proximal humerus in the elderly. But is the PHILOS plate adequate for stabilization of high-energy fractures, and fracture-dislocations of the proximal humerus in relatively younger age populations? In this retrospective study, performed at a referral, academic supervised, level III-trauma center, all high-energy trauma patients under the age of 55 years, with closed, 3 part, 4 part fractures, and/or fracture dislocations, were included in this study. Patients with open fractures, osteoporotic low-energy fractures, as well as patients older than 55 years were excluded. Fifty-nine patients entered and completed the study. They were all managed by open reduction and internal fixation using the PHILOS plate system. Patients’ age ranged between 31-52 years, with a mean of 42 years. A minimal follow-up period of two years was a mandatory inclusion criterion in this study. All the patients who did not complete the follow-up period were excluded from the study. The results were evaluated using the Constant, Neer and DASH scoring systems, which revealed favorable results in 41 patients (69.5%). The results were comparable to the recent articles published in the literature in relatively older age groups. It was concluded that, despite the relatively high rate of complications encountered in the management of these complicated high-energy fractures, the PHILOS plating system could be considered an adequate management of polytrauma patients.

Introduction

The incidence of proximal fractures of the humerus is between 4-5% of all fractures.1 In people aged over 65 years, fracture of the proximal humerus is the third most common fracture, after hip fracture and Colles’ fracture.2 In younger more active patients, high-energy trauma is the cause, and displacement is often more severe. These patients usually have a fracture dislocation.2 Fractures and fracture dislocations of the proximal humerus constitute a spectrum of injuries ranging from non-displaced fractures to severe, 4 part displaced, anatomic neck, head-splitting, and head-impaction injuries.3

The Neer classification4 and the AO/ASIF classification5 are the most widely used systems to evaluate and determine treatment of proximal humeral fractures.

In high-energy fractures, the problem is even more pronounced. This might be due to severe soft-tissue injury, associated fractures or co-morbidity, comminuted fracture patterns, and dislocation of the joint in severe cases. Secure fixation of high-energy fractures of the proximal humerus remains a problem. Various methods of fixation for such complex fracture patterns have been described, including Kirschner (K)-wires, external fixation, tension band fixation, Rush pins, intramedullary nails and plating.3 The proximal humeral internal locking system (PHILOS) plate (Synthes, Stratec Medical Ltd, Mezzovico, Switzerland) has been described to improve screw fixation in osteoporotic bone and to minimize soft-tissue dissection.6

In high-energy fractures of the proximal humerus, the PHILOS plate would be of special value because the plate is pre-shaped and contoured for the proximal humerus and no compression of the plate is required, which reduces the risk of loss of reduction and preserves the blood supply of the bone. Locking the screws into the plate ensures angular as well as axial stability and reduces the risk of loss of reduction. The locked interface also provides fixed stability, which helps to prevent subsidence in the metaphyseal areas.7

This study was designed to evaluate the early clinical and radiological results of management of high-energy fractures of the proximal humerus in a relatively young, and more active population of patients with the use of the commercially available PHILOS plates.

Materials and Methods

Between March 2004 and October 2009, 59 patients under the age of 55 years (49 males and 10 females) presenting high-energy fractures of the proximal humerus were registered in the study. All the included fractures were closed fractures. Time lapse between trauma and surgery ranged from three to 14 days (time was needed to treat associated injuries and management of life threatening conditions). Cases managed after two weeks of injury were excluded from the study as well as open fractures. There were 12 cases with 3 part fracture proximal humerus, 29 patients had 4 part fracture, 10 fracture dislocations (3 or 4 parts of the fracture with dislocation of the fracture fragments from the glenoid cavity), and 8 patients with split head fractures, according to the Neer classification (Table 1).

Extension of the fracture line to the humeral diaphysis was recorded in 3 cases in this study.

In case #12, the patient suffered from a severe road traffic accident (RTA) that caused a split head fracture in the coronal plane, with associated dislocation of a fracture fragment from the glenoid cavity, as well as extension of the fracture to the proximal shaft of the humerus down to the level of the deltoid insertion (deltoit tubercle) (Figure 1). He also had internal hemorrhage and laparotomy was performed before orthopedic intervention. Surgery was performed ten days post-trauma.

Associated skeletal injuries were recorded in 22 patients (37.2%) while 31 (52.5%) patients had had another non-orthopedic surgical intervention before the index surgery for proximal humerus fixation could be performed.

An anteroposterior (AP) view of the shoulder in the plane of the scapula, a supine axillary view, and a lateral view of the scapula (Y view) were made for all the patients. CT scan with 3D reconstruction was performed when feasible, in 46 patients (77.9%) to better evaluate fracture geometry and to plan reduction maneuvers. All the included patients underwent open reduction and internal fixation using a fixed angle locked plate of the proximal humerus’ within 14 days after trauma. A minimum follow-up period of two years was considered as an inclusion criterion in this study. All the selected cases were enrolled for locked plate system fixation (LPS); however, other fixation methods were available as a second alternative in case the planned fixation was not feasible.

Surgical technique

Patient positioning was crucial for good intraoperative fluoroscopy. A regular surgical
A table with a radiolucent footplate was used. The table was rotated 180° so that the patient's head was at the foot of the bed, and the shoulder rested on the radiolucent footplate. General anesthesia was given for all the patients, and the head of the patient was then elevated about 30° (modified beach-chair position). The large C-arm was positioned parallel to the patient at the head of the bed, thereby avoiding interference with the anesthesiologist who stood perpendicular to the table with the anesthesia apparatus.

Anterior deltopectoral approach was routinely used for all the patients. The cephalic vein was retracted laterally to prevent inadvertent injury during retractor placement. In 18 cases (30.5%), ligation of the cephalic vein was performed either because of injury (n=7) or because it was obstructing the view and further dissection of the proximal shaft of the humerus was needed (n=11). The subdeltoid space was then developed. After release of the subdeltoid space, a retractor was carefully placed under the muscle to facilitate exposure. The arm was then abducted to minimize the deltoid tension. The anterior one-third of the deltoid was dissected (if needed) off its insertion into the deltoid tubercle in cases with diaphyseal extension of the fracture. The clavipectoral fascia was then identified and released.

The subcoracoid space was then developed and the axillary nerve was identified by gentle palpation at the inferior margin of the subscapularis muscle. In 15 cases (25.4%), up to 25% of the lateral conjoined tendon was released off the lateral tip of the coracoid to facilitate exposure. The biceps tendon was then palpated deep to the pectoralis major muscle. Using the biceps tendon was useful as a landmark, because usually there was a fracture hematoma obscuring the normal anatomy. The biceps tendon was found interposed between the fracture fragments in 29 of the 59 cases (49.1%) and was freed. Care was taken to avoid injury of the ascending branch of the anterior circumflex humeral artery by meticulous dissection and cautious cauterization through the bicipital groove. This branch is located laterally in the groove and is the primary blood supply to the head fragment. This was of particular importance in cases of fracture dislocation, as the normal anatomy was disturbed. The rotator interval was opened by following the course of the biceps tendon to its attachment at the superior margin of the glenoid. Initial attempts were made to preserve the tendon for use as a landmark for correct plate placement. In fracture-dislocation cases, and in split head fractures, the head or a head segment was located anterior and medial to the glenoid along the glenoid neck. In these cases, the release of the pectoralis major tendon and the lateral conjoined tendon, as well as the subcoracoid and subdeltoid spaces were often released before any attempts at fracture reduction in order to preserve the blood supply for the head fragments and to avoid forcible reduction. A Cobb elevator was used for relocating the head fragment back into the joint. The greater and lesser tuberosity fragments were tagged with non-absorbable sutures. The tuberosity fragments were reduced to the lateral cortex of the shaft. Reduction of the

### Table 1. Classification of the patients according to the Near classification system and the final mean constant score.

| OTA classification | Number of patients | Percent | Final mean constant score |
|--------------------|--------------------|---------|---------------------------|
| 3 part fracture    | 11-C2.2            | 12      | 20.3                      | 75 (65-82) |
| 4 part fracture    | 11-C2.3            | 29      | 49.1                      | 67 (55-72) |
| Fracture dislocation (3 part or 4 part) | 11-C3.2 | 10 | 17 | 61 (44-69) |
| Split head fractures (3 part or 4 part) | 11-C3.3 | 8 | 13.2 | 62 (49-70) |
| Total              | 59                 | 100     | 65                        | (44-82)    |

**Figure 1.**
A. Preoperative AP radiograph of a 35 years old, male patient (Case number 12), suffered from high-energy RTA, that led to a split head fracture, dislocation of a head fracture fragment outside the glenoid cavity, and diaphyseal extension of the fracture down to the level of the deltoid tubercle. The patient also suffered from internal hemorrhage that was treated on emergency basis.
B. Immediate postoperative AP radiograph after ORIF with an inter-fragmentary screw and a long Philos plate. A good quality of reduction was achieved.
C. D. E. AP, axillary lateral, and scapular Y view radiographs after 35 months of follow-up showing adequate fracture healing, no signs or avascular necrosis or early arthritis, but superior humeral migration was noted and rotator cuff insufficiency was found and affected the final clinical outcome. The patient had a good final clinical outcome based on the Neer classification system.
tuberosities may indirectly reduce the head fragment; alternatively, to restore the medial calcar of the proximal humerus, an elevator was inserted to disimpact the head fragment. The fracture was reduced and provisionally fixed into position using Kirschner wires (1.2-1.8 KW). Krackow sutures were passed through the rotator cuff and attached to the plate through the suture eyelets before permanent fixation with the contoured proximal humerus locking plate was performed. The sutures were passed through the proximal humerus plate, and the plate was positioned directly on the middle of the lateral cortex. These sutures could be passed into the suture eyelets even after plate positioning and fixation in the plate design used in this study. On the anteroposterior view, the plate was ideally placed 8-10 mm distal to the superior tip of the greater tuberosity; from the lateral view, the plate should have been centered against the lateral aspect of the greater tuberosity. An adequate gap was left between the plate and the biceps tendon to prevent disruption of the anterior humeral circumflex artery or entrapment of the tendon.

The initial screw was then placed in the elongated hole in the humeral shaft (in classic 3 or 4 part fractures), so that the height of the plate could be adjusted. In cases of proximal humerus fractures with diaphyseal extension, inter-fragmentary screws were sometimes needed to stabilize these long complex fractures, before plate fixation. Once appropriate fracture reduction and plate position had been achieved, the locked screws were inserted into the humeral head using the insertion guide and sleeve assembly. At least three distal shaft screws were inserted. A final fluoroscopic image was taken to ensure adequate reduction and proper medial support. No bone grafting was performed in this study. The wound was closed in layers and a suction drain was inserted and left for about 48 hours, then removed.

Post-operative management

The patient was placed in a shoulder immobilizer for 3-5 weeks post-operatively, with elbow and wrist range of motion allowed. After that, gentle pendulum and active assisted forward elevation with the contralateral extremity was permitted.

Passive and active-assisted range of motion activities were initiated afterwards. Unassisted active motion was allowed at eight weeks post-operatively or when callus formation was first noted radiographically. Muscle strengthening was instituted in the last phase of therapy, usually beginning at 12 weeks.

The functional Constant score (100 point score), the Neer scoring system and the disabilities of the arm, shoulder and hand (DASH) questionnaire were used for final evaluation of the studied patients at the final follow-up visit. Periodic radiological examination was performed till solid union was confirmed and about three months after that for early detection of any suspected complication. Statistical analysis was performed for all the gathered data and were analyzed and compared to other similar studies.

Results

Patients’ age ranged between 31 and 52 years, with a mean of 42 years. All the surgical wounds healed by first intention. Time of last follow-up ranged from 24 to 67 months with a mean of 42 months. The mean Constant score for the 3 part fracture group was 75 (65-82), and 67 (55-72) in the 4 part fracture group. The mean score was 61 (44-69) in the fracture dislocation group and about 63 months after that for the final follow-up visit. It was also found that the final follow-up visit. It was also found that the split head fracture group as well as the fracture dislocation group had the highest complication rate. This was of special significance as AVN and arthritis were only recorded in these 2 groups.

Discussion

Three and 4 part proximal humeral fractures are difficult injuries to evaluate and treat. Internal fixation of such fractures with fixed-angled locked plating still warrants caution because of the lack of comparable data with other treatment methods.

Many recent articles were found in the literature reporting the early and middle term results of management of proximal humerus

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Table 2. The final outcome based on the Neer scoring system.

| Results   | Number of patients | %    |
|-----------|--------------------|------|
| Favorable |                    |      |
| Excellent | 14                 | 23.8 |
| Good      | 27                 | 45.6 |
| Unfavorable |                   |      |
| Poor      | 3                  | 5.0  |
| Fair      | 18                 | 25.5 |
| Poor      | 15                 | 25.5 |
| Total     | 59                 | 100  |

Table 3. Recorded complications in this series.

| Complication                                      | Number of patients | %    |
|---------------------------------------------------|--------------------|------|
| I. Radiographic complications                     |                    |      |
| Inadequate reduction, (varus-malalignment)        | 4                  | 6.7  |
| Hardware prominence                               | 5                  | 8.4  |
| Partial humeral head necrosis.                    | 4                  | 6.7  |
| Greater tuberosity malposition ± deficiency.      | 3                  | 5.0  |
| Superior humeral head migration                    | 4                  | 6.7  |
| II. Clinical complication                         |                    |      |
| Radial n. injury.                                 | 1                  | 1.6  |
| Axillary n. injury.                               | 2                  | 3.3  |
| Rotator cuff insufficiency.                       | 4                  | 6.7  |
| Secondary osteo-arthritis. (clinical & radiographic)| 4                  | 6.7  |
| Total number of complicated cases                  | 15                 | 25.4 |

Complications are shown in Table 3. It was noted that not all the recorded complications actually influenced the final clinical outcome, particularly the radiographic complications. It was also found that more than one patient had presented with more than one complication at the final follow-up visit. It was also found that the split head fracture group as well as the fracture dislocation group had the highest complication rate. This was of special significance as AVN and arthritis were only recorded in these 2 groups.
fractures using different PHILOS plating systems. Although the results were encouraging, it was found that most of the studies included only fragility fractures in older age groups. Studies describing the use of the PHILOS plates for the early management of high-energy proximal humerus fractures in active young age groups were not found. These types of fractures are not due to bone weakness but due to the higher magnitude of trauma and are usually comminuted and associated with dislocation.

Weinstein et al.16 found that the locking plate provided better torsional fatigue resistance and stiffness than a blade plate. Edwards et al.17 noted that a locking plate was far superior to a proximal humeral nail in regard to both varus bending and torsional stability. Given that most proximal humerus fractures fail because of rotational and bending moments, such added stability could potentially prevent many of the failures noted with other implant types.

Precise surgical technique is critical for a good result, as reported failures were due to impingement that resulted from proximal positioning of the plate.18

Kettler et al.19 reported on 225 fractures treated with the PHILOS plate. One hundred and seventy-six patients were available for review. Complications resulting from technical error included 24 screw perforations (11%), 8 implant dislocations (4.5%), and 25 cases (14%) of initial malreduction of the head and tuberosities. Other complications included loss of reduction with secondary screw perforations in 14 cases (8%), 2 infections, 2 hematomas, partial osteonecrosis in 9 cases (5%), and complete osteonecrosis in 5 (3%). Björkenheim et al.20 reported their early clinical experience of 72 patients treated with the PHILOS proximal humerus locking plate. At one year follow-up, 2 non-unions were noted and 3 patients developed osteonecrosis. Forty-eight patients had anatomic fracture healing. Nineteen fractures were noted to have mild post-operative settling; these subsequently healed in mild varus positioning. Traction sutures were used to aid in the initial reduction. However, the authors did not comment on whether they were tied to the plate to assist in maintaining the reduction. Patients in this study were subjected to immediate passive motion, with active motion started as early as four weeks. Fankhauser et al.21 reviewed their experience of 28 patients with 29 proximal humerus fractures treated with the locking proximal humerus plate. Twenty-four of these fractures were AO classification type B or type C. All fractures healed. Five complications were noted, with one broken plate and 4 instances of loss of reduction (one related to a deep infection). Two patients developed partial osteonecrosis, one after deep infection. In this series, traction sutures were incorporated into the plate, but active motion was initiated as early as two weeks. The authors did not comment on the use of bone graft. Owsley and Gorczyka22 presented their series of 33 patients treated with a locking plate with a minimum follow-up of one year. Nineteen patients (36%) had radiographic signs of complications, with intra-articular screw cutout in 12 (23%), varus displacement in 13 (25%), and osteonecrosis in 2 (4%). A higher incidence (43%) of cutout regardless of fracture type was seen in patients aged over 60 years. While tuberosity sutures were utilized in all cases, structural allograft was not incorporated.

Given these reports, it was noted that the variation in the final end-results between different reports could be due to the following main points: i) different types of fractures were included in different studies and not all the studies focused on the 3 and 4 complex fracture patterns. Moreover, fracture-dislocations, and split head fractures were excluded from some studies, while others included open and closed fracture patterns; ii) the approach used and surgical experience and preference vary between different centers and the level of the trauma center at which the patients were treated influenced the final outcome; iii) different types of commercially available designs were used. It is of value here to mention that the plates which enable the surgeon to attach the rotator sutures to the suture eyes, after provisional fixation of the plate, provided more proper plate positioning and were easily applied; iv) bone grafting was obligatory in some series while others did not use any grafting, including the current study; v) the variation in the follow-up period was of great importance as some late complications were recorded in some middle-term studies, specially osteoarthritis and avascular necrosis of the humeral head; vi) lack of long-term comparative studies with other treatment modalities for such complicated fracture patterns, in particular the joint replacement option in older age groups; vi) finally, this study was introduced to test the efficiency of the PHILOS plate in fixation of complex 3 and 4 part fractures, split head fractures, and fracture dislocations in a younger active age population submitted to high-energy trauma.

Compared to other papers on the subject, there are much bigger series available on the use of the PHILOS plate. Other studies tend to reflect an older population than in this study, which predominantly seems to be due to the incidence of high-energy injuries in younger people rather than osteoporotic fragility fractures in older age groups. It is thought that the relatively higher Constant, DASH, and Neer scores recorded in this study are due to the better bone stock found in younger active patients. This might also be the reason why no bone grafting was needed. It is suggested that the hardware complications were dramatically reduced in this study due to the better bone quality of the studied young patients. It is of value to mention that the results recorded in this study will be useful to add to the pool for meta-analysis.

Finally, although this is a retrospective study with a relatively small number of patients included, and based on the results recorded, it is suggested that fixation of 3 and 4 part high-energy fractures using the PHILOS plating system is an adequate method of treatment, and when well performed is expected to give relatively favorable results. Nevertheless, this extensive type of surgery is technically demanding and is associated with many early, as well as late, complications and hazards. It should be mentioned that this type of treatment was found to be of special value in young active patients because of the early rehabilitation. Also, because of the relatively young age of the patients and high manual demands, arthroplasty was not an option. It is mandatory to stress on the meticulous soft-tissue dissection and fracture reduction, especially with good medial support, in such complex fracture patterns. Every single fracture should be thoroughly investigated, screened and studied before surgery. Treatment modality should be tailored to the fracture pattern and one should always remember that it is not only a bone problem but sometimes a massive soft-tissue injury as well. Other fixation options should always be prepared in the operating room to be used if needed. Other studies are needed to compare different types of fixations of such complex patterns of injury, as well as long-term studies to evaluate the adequacy of different fixation modalities.

Conclusions

The use of the PHILOS plating system for reduction of 3 and 4 part, split head, and fracture dislocation patterns due to high-energy trauma in a relatively younger more active age population proved to be an adequate alternative. This might be attributed to the better bone quality and better vascularity in this age group. The technique is technically demanding and is expected to be associated with a high complication rate. Meticulous soft tissue dissection is obligatory with special attention to the rotator cuff tears. Different plating systems are available commercially, and correct plate selection and pre-operative evaluation is mandatory for each case. The final clinical and radiographic outcomes of treatment of such complex high-energy fractures are promising but long-term studies are needed, as well as comparative studies with other forms of management, including arthroplasty in certain selected cases, and older age groups.
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