Functional outcome after combined osteosynthesis and osteosuture for proximal humeral fractures

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Background
Proximal humeral fractures account for ~5% of all fractures. Many different techniques have been described for the treatment of comminuted fractures of the proximal humerus. To decrease the incidence of complications, particularly fixation failure and loss of stability, new plating techniques such as the Proximal Humeral Internal Locking System (PHILOS) have been developed.

Objectives
The purpose of this study was to evaluate the functional outcome after combined osteosynthesis and osteosuture for proximal humeral fractures.

Patients and methods
Twenty patients (eight men and 12 women) underwent surgical treatment for proximal humerus fractures using proximal humeral locking plate for fixation (not original PHILOS plate). The mean age of the patients was 62.4 years.
According to Neer, seven patients had three-part fractures, 11 patients had four-part fractures (one patient had fracture dislocation), and two patients had associated fracture of proximal humeral shaft.

Results
Of the 20 patients, anatomic or near-anatomic reduction was obtained in 17 patients (85%). All fractures united in a mean of 3 months (range 2–5 months). None of the patients had avascular necrosis, implant failure, superficial or deep infection, or neurovascular injury. The mean constant score for all patients was 77.

Conclusion
The results showed that rigid fixation of the proximal humeral fractures using locking plate with preservation of the vascularity of the fracture fragments of the humeral head through minimal soft tissue dissection and preservation of soft tissue of fracture fragments were important in decreasing the complications following surgical treatment of the proximal humeral fractures.

Keywords:
locking plate, osteosuture, proximal humeral fractures

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Introduction

Proximal humeral fractures account for ~5% of all fractures [1,2].

Three-part and four-part fractures represent 13–16% of all proximal humeral fractures [3]. These fractures have a dual-age distribution occurring either in young people following high-energy trauma or in those older than 50 years of age with low-velocity injuries like simple fall. Three-fourths of the fractures occur in older individuals with an occurrence three times more often in women than in men [1]. Within the last three decades, the age-adjusted incidence of proximal humeral fractures increased by 15% per year. Increased incidence of proximal humeral fractures is associated with more complications [4].

Although one or more fragments may be totally displaced in 15% of the patients, fragments may still keep their attachments through preserved soft tissue composed of the intact rotator cuff, capsule, and uninjured periosteum [5]. Preservation of this intact soft tissue envelope during surgery is of the utmost importance in all fractures, particularly high-energy and/or comminuted fractures, to achieve reduction without endangering vascularity of the fragments and restore revascularization of the humeral head [6].

Up to 80% of proximal humeral fractures can be treated nonoperatively, resulting in satisfactory results [7]. Many different techniques have been described for the treatment of comminuted fractures of the proximal humerus, including closed reduction and percutaneous K-wire fixation; open reduction followed by fixation with bone sutures; tension band; cerclage wire; T plate, intramedullary nails, or locking plate; and prosthetic replacement [1,8–12].

The complication rate can be 50% or higher [8]. Several complications have been reported, including implant failure, avascular necrosis, nonunion,

malunion, nail migration, rotator cuff impairment, and impingement [6,9,10]. The incidence of these complications has been reported to be higher in elderly patients than in younger age groups [5].

To decrease the incidence of complications, particularly fixation failure and loss of stability, and to improve stability and enable early postoperative mobilization, new plating techniques such as the Proximal Humeral Internal Locking System (PHILOS; Synthes, Solothurn, Switzerland) have been developed [11].

Patients and methods

Between the years 2008 and 2009, 20 patients (eight men and 12 women) underwent surgical treatment for proximal humerus fractures using proximal humeral locking plate for fixation (not the original PHILOS plate). The mean age of the patients was 62.4 years and the median was 60.5 years, with a range of 48–97 years. The mean age for female patients was 65 years, with a range of 48–97 years, whereas the mean age for male patients was 58.6 years, with a range of 50–67 years.

According to Neer, seven patients had three-part fractures, 11 patients had four-part fractures (one patient had fracture dislocation, with associated pseudarthrosis of the ipsilateral clavicle and no effect on the function of the shoulder before the fracture of the proximal humerus) (Fig. 1a–d), and two patients had associated fracture of proximal humeral shaft.

The average duration from the time of trauma to the time of surgical intervention was 6 days with a range of 2–15 days.

The mean duration of follow-up was 20 months with a range of 12–28 months.

All patients were evaluated preoperatively with plain radiographs (anteroposterior and lateral); in addition, computed tomography was used in 12 patients in whom the articular surface and fracture configuration could not be fully assessed on plain radiographs (Fig. 2a–e).

Operative technique

The operation was performed in the beach chair position through deltopectoral approach.

Minimal soft tissue dissection of the fracture fragments was done so as not to impair the vascularity of the fracture fragments. The bone fragments were not exposed from their soft tissue attachments. The subscapularis muscle was left intact.

Using image intensifier, the height and position of the proximal humeral locking plate were checked. The plate was placed anterolateral 5–10 mm distal to the greater tuberosity and 2–3 mm posterior to the bicipital groove, leaving adequate space between the plate and the long head of the biceps tendon.

In eight cases with severe comminution and osteoporosis, the bone fragments were fixed to the plate using ethibond number 5 nonabsorbable sutures (osteosuture) (Fig. 3). The sutures were tied to the plate after the proximal locking screws were inserted to the humerus head and the distal screws were inserted into the humeral shaft or diaphysis.

Bone graft was used in two cases with severe osteoporosis and comminution.

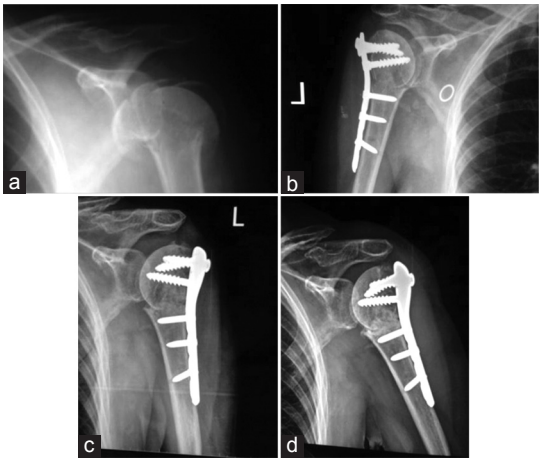
A broad arm sling was used postoperatively, and the patients were discharged on the third day postoperatively (range 2–6 days).

Assisted active and passive exercises of the shoulder were initiated on the second postoperative day. Active range-of-motion exercises of the shoulder were initiated on the third postoperative week.

Follow-up was designed at biweekly interval for the first 6 weeks, then at monthly interval for the next 4 months, and then every 6 months for the next 18 months.

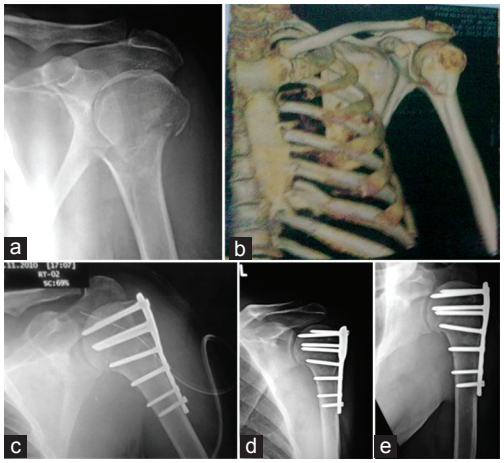
The results were assessed using the constant shoulder score at the final follow-up visit.

Figure 1



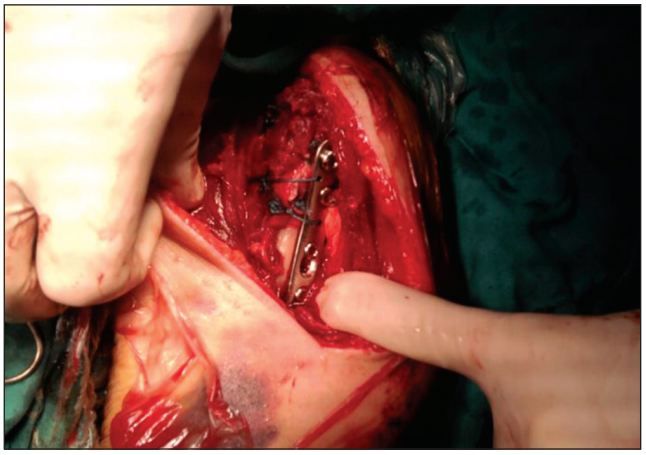
(a). Plain X-ray AP view of patient with fracture dislocation of proximal humerus preoperative, (b). one month postoperative (c). 3 months postoperative, (d). 12 months postoperative.

Figure 2



(a). Preoperative plain X-ray AP view showing 3 part proximal humerus fracture, (b). 3 dimension CT scan for proximal humeral fracture, (c). immediate postoperative, (d). 1 month postoperative, (e). 6 months postoperative.

Figure 3



Intra-operative picture showing, the bone fragments fixed to the plate using number 5 nonabsorbable.

Results

Of the 20 patients, anatomic or near-anatomic reduction was obtained in 17 patients (85%).

In the remaining three patients, because of failure to restore the medial column support due to medial comminution, we impacted the humeral head in the shaft in mild varus to support the medial cortex and increase the medial contact surface and stability.

All fractures united in a mean of 3 months (range 2–5 months).

None of the patients had avascular necrosis, implant failure, superficial or deep infection, or neurovascular injury. None of the patients required implant removal. We had three cases of partial collapse of the humeral head with the screws being subchondral with no penetration into the joint; however, the three patients had fair outcome.

At the final assessment, the results were from good to excellent in 14 patients and fair in six patients.

The mean constant score for all patients was 77 (range 56–91), the mean constant shoulder score for patients having three-part fracture was 82 (range 56–91), and for those with four-part fracture was 72.6 (range 59–91). The mean constant shoulder score for patients who had osteosuture was 72.8.

Discussion

Operative treatment of comminuted and displaced proximal humeral fractures, especially in osteoporotic bone, has been a complex and challenging problem. Different techniques have been described for fixation of comminuted and displaced proximal humeral fractures [11,12].

There is controversy concerning both the surgical indications and treatment algorithms for proximal humeral fractures [5,6,12].

Functional outcome depends not only on the quality of bone stock but also on the stability provided by the implant [11].

The management of three-part and four-part fractures is even more complicated; open reduction and internal fixation using conventional or locking plates have been recommended [5,13–17].

Locking periarticular plate fixation offers more advantages than many implants and has been shown to be superior to nonlocking plates [18]. These plates enclose the fracture well, have a low profile, allow insertion of multidirectional proximal screws, use locking plate technology for angular stability, and have a greater reliability in osteoporotic bones [19,20].

Our study demonstrated the clinical outcome of osteosynthesis and osteosuture in proximal humerus fractures using proximal humeral locking plates.

Meticulous care must be taken to preserve the overlying soft tissues during open reduction and internal fixation because damage to these soft tissues may disturb the vascularity of fracture fragments [13,17,21].

Wijgman *et al*. [17] pointed out the importance of obtaining a stable osteosynthesis and preservation of vascularity of the fragments through meticulous surgical

handling of soft tissues. Thus, the ideal incision to be chosen is controversial; some authors favor the standard deltopectoral incision [13,15,16,22,23], whereas others recommend the anterolateral acromial incision on the grounds that the former may cause injury to the anterior circumflex artery, which has an important role in vascularization of the humeral head [5,14].

In our study, we used the deltopectoral approach, with minimal dissection of the fracture fragments to preserve the overlying soft tissues and the vascularity of the fracture fragments.

Conventional radiographs are usually adequate to evaluate the comminution of the fracture, displacement of the fragments, and congruity of the articular surface in proximal humeral fractures. However, computed tomography has been recommended in fractures where plain radiographs fail to provide adequate information to assess articular surfaces and extent of fracture comminution [14,15].

We used computed tomography in 12 patients in whom the articular surface and fracture configuration could not be fully assessed on plain radiographs.

Following surgical treatment of proximal humerus fractures, numerous complications may develop and may have an adverse effect on functional outcome. These complications may be associated with incorrect evaluation of the fractures, inappropriate indications, inadequate operation room conditions and surgical experience, advanced osteoporosis, and inappropriate postoperative follow-up and rehabilitation [5,19].

Complications may have an adverse effect on functional results. The most important complications encountered in the treatment of three-part or four-part fractures are nonunion and avascular necrosis [17]. The incidence of avascular necrosis has been reported in a wide range of 4–75% [5,17].

The incidence of nonunion following open reduction and internal fixation using locking plates has been reported as 2.7–8% [5,15,16,22,23].

Parmaksizoglu *et al.* [5] reported that two patients developed avascular necrosis (6.3%) in a series of 32 patients, one with a four-part fracture and the other with a four-part fracture dislocation. They reported no cases of nonunion.

Avascular necrosis and nonunion were not observed in our study; we attributed these to the minimal soft tissue dissection of the fracture fragments, thus preserving the vascularity of the fracture fragments.

The incidence of infection is low following open reduction and internal fixation using locking plates. Egol *et al.* [16] observed only one case of acute infection in their series of 51 patients who mainly had three-part or four-part fractures. Moonot *et al.* [23] reported one superficial infection that healed with oral antibiotic treatment. Parmaksizoglu *et al.* [5] did not observe any case of superficial or deep wound infection in their study. They related this to appropriate antibiotic prophylaxis as well as to good preservation of soft tissues during surgery.

We did not have any case of superficial or deep infection in our study. We attributed this to proper antibiotic prophylaxis and proper sterilization of the operating theater.

Implant failure and loss of primary fixation of the implants occur in 2.7–13.7% following open reduction and fixation with a locking plate in proximal humeral fractures [5,9,16,23].

Agudelo *et al.* [24] found a statistically significant correlation between a primary varus malreduction, defined as the head-shaft angle of less than 120°, and loss of reduction. Gardner *et al.* [21] noted that the presence or absence of medial support had a significant effect on the degree of postoperative reduction loss.

Parmaksizoglu *et al.* [5] reported no reduction loss or implant failure following fixation of proximal humeral fractures, excluding two patients whose fractures were initially fixed in varus position.

We did not have reduction loss or implant failure in our cases. We attributed this to rigid fracture fixation using locked plate and anatomic or near-anatomic reduction of the fracture with restoration of the medial column support. In patients with medial comminution, we impacted the humeral head in the shaft to support the medial cortex and increase the medial contact surface and intrinsic stability.

Atalar *et al.* [25] used tricortical bone graft to support the impacted humeral head in patients with valgus-impacted fractures.

We used tricortical bone graft in two patients with severe osteoporosis and medial comminution.

Screws that penetrate may injure the humerus and glenoid cartilage when they exceed cartilage thickness and subsequently cause significant functional loss that may require revision surgery [19].

The incidence of screw penetration is greater in comminuted fractures [15].

In our cases, we had three cases of partial collapse of the humeral head with the screws being subchondral

with no penetration into the joint; however, the three patients had fair outcome. We related the collapse of the humeral head in these patients to osteoporosis and comminution of the fractures in them.

Many authors assessed the effect of early postoperative exercise on functional results following surgical treatment of comminuted proximal humeral fractures. Moonot *et al*. [23] allowed active exercises after 3 postoperative weeks in three-part and four-part fractures. Björkenheim *et al*. [9] initiated passive shoulder range-of-motion exercises on the first postoperative day, and active exercises at 4 weeks, and found the mean constant score as 78 in three-part fractures, 60 in four-part fractures, and the overall score as 77 at the end of 12 months.

In our study, passive range-of-motion exercises of the shoulder were initiated on the second postoperative day and active range-of-motion exercises of the shoulder were initiated on the third postoperative week. The mean constant scores for our cases were 82 and 72.6 in patients having three-part and four-part fractures of the proximal humerus, respectively, 72.8 for cases with associated osteosuture, whereas the overall score was 77.

Conclusion

Rigid fixation of the proximal humeral fractures using locking plate with osteosuture in cases with osteoporosis and comminution to minimize soft tissue dissection in order to preserve the vascularity of the fracture fragments of the humeral head was important in decreasing the complications following surgical treatment of the proximal humeral fractures; moreover, rigid fixation allows early postoperative rehabilitation that improves the functional outcome.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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