Locked plate fixation for proximal humerus fractures in elderly osteoporotic patients

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Background
Proximal humeral fractures in elderly osteoporotic bones represent a challenge to orthopedic surgeons; many options for treatment are now available; yet, the optimum method with best results and minimal complications is not well established.

Patients and methods
Twenty-six osteoporotic or osteopenic patients with three-part or four-part proximal humerus fractures according to the Neer classification who underwent surgical fixation with locked plates through the standard deltopectoral approach were included in the study. The clinical outcome was evaluated with the Constant–Murley score.

Results
The average Constant score corresponds to 76.5 points, and the mean patient age in this study was 61 years. The average Constant score for pain was 13 points, strength 17 points, activities of daily living 17.9 points, and range of motion 28.6 points. All 26 fractures healed with a mean time of 11.5 weeks (8–16 weeks) and were followed for an average of 17 months.

Conclusion
Locked plate fixation for three-part and four-part fractures of the proximal humerus in osteopenic or osteoporotic patients is a good and reliable method of fixation with limited complications.

Keywords:
locked plates, Neer classification, proximal humerus

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Introduction

Proximal humeral fractures represent 4–5% of all fractures and 45% of all humeral fractures [1,2]. The injury typically occurs in elderly patients and is associated with osteoporosis [3]. The incidence starts to increase at the age of 60 years [4].

Treatment of three-part and four-part proximal humerus fractures in patients with osteoporosis is considered as a clinical challenge [5].

Many surgical options for treatment are available, including extramedullary or intramedullary fixation techniques or hemiarthroplasty [6,7].

The application of locked plates increases fracture stability, and their superior mechanical stability over nonlocked plates was proved by mechanical studies [8–10].

Using locking plates, many humeral head fractures with low bone quality treated previously with hemiarthroplasty are now amenable to be treated with open reduction and internal fixation preserving the humeral head, which has better clinical outcomes than replacement [5].

Percutaneous pinning allows fracture fixation with minimal soft tissue disruption and a low rate of avascular necrosis, but each fragment must be fixed by multiple wires to achieve stability in the elderly osteoporotic bone [11].

Patients and methods

From April 2009 to October 2010, 32 patients with proximal humeral fractures underwent surgical fixation with locked plates in the Mansoura Emergency Hospital; of these, two patients died because of causes other than the fractures, four patients were lost to follow-up, and only 26 patients were included in the study.

Patient inclusion criteria included adults with three-part or four-part proximal humerus fractures according to the Neer classification [12], and those who had low bone mineral density with a *T*-score less than -1 by dual-emission X-ray absorptiometry (DEXA), where a *T*-score between -1 and -2.5 indicates osteopenia and a *T*-score less than -2.5 indicates osteoporosis.

The axillary nerve function was assessed before surgery. Patients were also evaluated at day 1, 2 weeks, 6 weeks, 3 months, 6 months, 1 year, and some of them at 2 years after the surgery.

The physical examination included wound evaluation, axillary nerve sensory and motor function, and

glenohumeral range of motion. Plain radiographs of the shoulder were obtained before surgery. Computed tomography scans were needed in some cases. The clinical outcome was evaluated with the Constant–Murley score [13]. Postoperative radiograph films were taken at each follow-up visit and DEXA scans were performed every 6 months.

All fractures were fixed within 4 days of the injury. Under general anesthesia, the patient was positioned supine on a radiolucent operating room table in a position in which anteroposterior and axillary views of the proximal humerus can be easily obtained using C-arm fluoroscopy. The fracture was exposed through the standard deltopectoral approach.

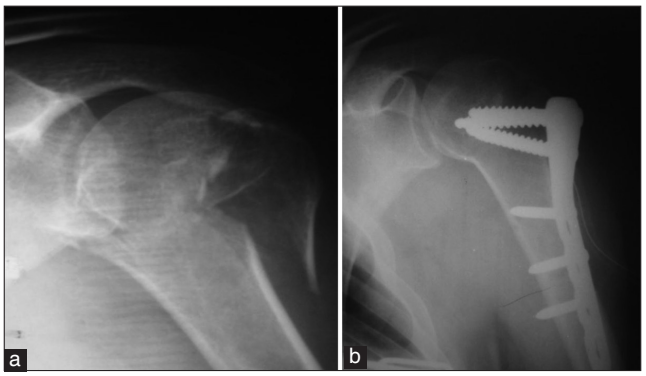
Kirschner wires were used as joysticks to reduce and fix the fracture. The reduction and implant placement should be verified on C-arm fluoroscopy. The locking plate was applied once the fracture was reduced, taking care that the plate is not too proximal that subacromial impingement may occur. Four-hole or five-hole 3.5-mm locking compression proximal humerus plates were applied.

All patients received bisphosphonates and calcium therapy and were followed by DEXA every 6 months.

Statistical analysis

Data entry and analyses were performed using SPSS statistical package version 10 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were presented as mean and SD. The *t*-test was used to compare the mean and SD of two groups. The Pearson correlation test was used to correlate quantitative variables. *P* values of 0.05 or less were considered significant.

Figure 1



Preoperative (a) and 2-year postoperative (b) radiographs of a 63-year-old male patient with three-part fracture proximal humerus, showing complete healing with anatomic reduction.

Results

Twenty-six patients included in this study had an average Constant score that corresponds to 76.5 points (range 68–100 points), 12 patients had four-part fractures and had an average Constant score of 72.6 points, and 14 patients had three-part fractures with an average Constant score of 80.4 points.

The mean patient age in this study was 61 years (range 56–70 years), and 18 patients (69%) were female. Twenty-one fractures were due to simple falls and the other five were due to motor car accidents. The average follow-up was 17 months (range 16–35 months).

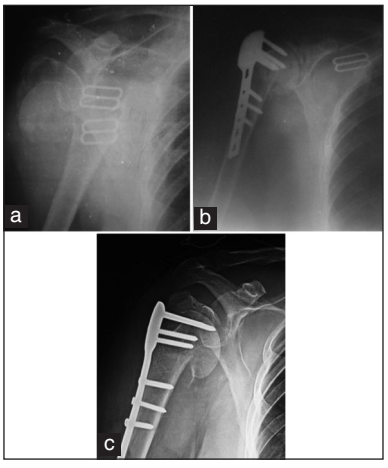
Twelve cases were osteopenic (a *T*-score between -1 and -2.5) and 14 cases were osteoporotic (a *T*-score less than -2.5); of these, two cases had vertebral fragility fractures and one had a history of trochanteric fracture due to a simple fall that was fixed with a dynamic hip screw; the average DEXA *T*-score was –2, which improved to –1.4 in the last follow-up.

Anatomic reduction was obtained in 21 patients (80.7%; Fig. 1) and nonanatomic reduction in five patients (19.3%; Fig. 2). All 26 fractures healed with a mean time of 11.5 weeks (range 8–16 weeks).

There was no loss of reduction and no cases with delayed union or nonunion. The patients had an average range of motion of 120° of shoulder abduction (range 105–180°) and 160° of anterior flexion (range 110–180°).

No implant-related complications were present, except for two cases (7.8%) with screw loosening that required reoperation for implant removal after fracture

Figure 2



(a) Preoperative radiograph of a 66-year-old female patient with four-part fracture of the proximal humerus. (b) Immediate postoperative radiograph shows the fracture reduced, with the head in varus. (c) The 14-month postoperative radiograph shows the fracture healed, with the head in varus without loss of reduction.

healing without affecting the results; one more case (3.8%; Fig. 3) had avascular necrosis that also required implant removal; this case had fracture dislocation at presentation with axillary and radial nerve palsy, which recovered 4 months later.

In this study, the six cases, including five patients with malreduction and the one with avascular necrosis, had a mean score of 71 points, which is to say that these complications did not affect their Constant scores much.

Statistical analysis of the results of our study revealed no statistically significant correlation between the sex of the patient and the functional Constant score or *T*-score, whereas there was a significant correlation between patients' sex and healing time ($P = 0.005$; Table 1).

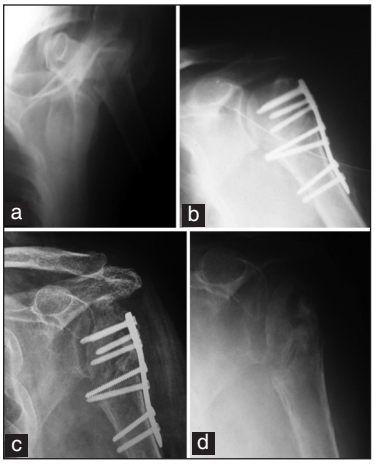
Also, there was no statistically significant correlation between the fracture type and the *T*-score or the healing time, whereas patients with three-part fractures had a better functional score (a mean of 80.2 points) than those with four-part fractures (a mean of 72.6 points), which was statistically significant ($P = 0.01$; Table 2).

In this study, the mechanism of injury did not affect the functional score, the *T*-score, or the healing time (Table 3).

The age of the patient did not affect the functional score, while patients below 60 years of age had better mean *T*-scores (mean -1.8) than those above 60 years of age (mean -2.3), which was not statistically significant.

The healing time for those below 60 years of age (mean time 11 weeks) was less than that for those above 60 years of age (mean time 12 weeks) without statistical significance (Table 4).

Figure 3



(a and b) Preoperative and 18-month postoperative radiographs of a 59-year-old male patient with four-part fracture dislocation of the proximal humerus; (c) avascular necrosis (AVN) of the humeral head; and (d) the humeral head after plate removal.

There was a significant negative correlation between the healing time and the functional score ($P = 0.05$), with no statistically significant correlation between the *T*-score and either the functional score or the healing time.

Cases with nonanatomic reductions had no significant difference with respect to the Constant score or the healing time.

The average Constant score for pain was 13 points, strength 17 points, activities of daily living 17.9 points, and range of motion 28.6 points.

Table 1 The relation between the sex of the patient and the functional Constant score, *T*-score and the healing time

	Male ($N = 8$) (mean ± SD)	Female ($N = 18$) (mean ± SD)	*P* value
Constant score	73.88 ± 4.52	77.94 ± 9.46	0.26
T-score at presentation	–2.23 ± 0.72	–1.90 ± 0.74	0.31
Healing time (weeks)	13.50 ± 2.27	10.56 ± 2.26	0.005

No statistically significant correlation was found between the sex of the patient and the functional Constant score or *T*-score, whereas there was a significant correlation between the sex of the patient and the healing time.

Table 2 The relation between the fracture type and the functional Constant score, *T*-score and the healing time

	Three-part fracture ($N = 14$) (mean ± SD)	Four-part fracture ($N = 12$) (mean ± SD)	*P* value
Constant score	80.21 ± 9.64	72.58 ± 3.94	0.014
T-score at presentation	–2.15 ± 0.73	–1.83 ± 0.72	0.27
Healing time (weeks)	12.36 ± 2.87	10.42 ± 1.88	0.051

A statistically significant correlation was found between the fracture type and the Constant score ($P = 0.01$).

Table 3 The relation between the mechanism of injury and the functional Constant score, *T*-score and the healing time

	Simple fall ($N = 21$) (mean ± SD)	Motor car accident ($N = 5$) (mean ± SD)	*P* value
Constant score	76.24 ± 9.08	78.60 ± 4.56	0.59
T-score at presentation	–2.02 ± 0.73	–1.90 ± 0.80	0.76
Healing time (weeks)	11.52 ± 2.73	11.20 ± 2.28	0.81

No significant correlation was found between the mechanism of injury and the functional score, the *T*-score, or the healing time.

Table 4 The relation between the age of the patient and the functional Constant score, *T*-score and the healing time

	≤60 ($N = 15$) (mean ± SD)	>60 ($N = 11$) (mean ± SD)	*P* value
Constant score	76.60 ± 9.40	76.82 ± –7.19	0.95
T-score at presentation	–1.79 ± 0.73	–2.29 ± 0.66	0.08
Healing time (weeks)	11.0 ± 2.20	12.0 ± 3.08	0.3

No significant correlation was found between the age of the patient and the functional score, the *T*-score, or the healing time.

Discussion

Proximal humeral fractures represent 4–5% of all fractures and 45% of all humeral fractures [1,2]. The injury typically occurs in elderly patients and is associated with osteoporosis [3]. The incidence starts to increase at the age of 60 years [4]. Treatment of three-part and four-part proximal humerus fractures in patients with osteoporosis is considered as a clinical challenge [5].

Many options are accepted as the treatment for proximal humerus fractures including percutaneous pinning, plating, nailing, tension band fixation, arthroplasty, etc. Improved fixation in osteoporotic bones is an advantage of locked plating, causing the results of locked plating for proximal humerus fractures to be generally very good, with low rates of nonunion and complications [6,7,14].

Application of locked plates increases fracture stability, and their superior mechanical stability over nonlocked plates was proved by mechanical studies [8–10].

Using locking plates, many humeral head fractures with low bone quality treated previously with hemiarthroplasty are now amenable to be treated with open reduction and internal fixation, preserving the humeral head, which has better clinical outcomes than replacement [5].

Percutaneous pinning allows fracture fixation with minimal soft tissue disruption and a low rate of avascular necrosis, but each fragment must be fixed by multiple wires to achieve stability in the elderly osteoporotic bone [11].

Locked plates have been developed specifically for osteopenic bones [1,15]. Before the invention of locking plates, fracture treatment with plating in elderly patients with osteoporosis had a high complication rate and hence nonoperative treatment was considered to be the standard option [1].

In locked plates designed for the proximal humerus, each screw acts as a blade-plate providing fixed angle support in multiple planes, decreasing the risk of varus collapse of the head compared with nonlocked plates [14].

Stability achieved by fixation with locked plates allows an early range of motion, avoiding stiffness and adhesions in the subacromial and subdeltoid spaces [16].

The locking screws resist backing out in osteoporotic bone, but because of the extreme rigidity of the construct, screws may cut through the osteoporotic bone. Also, locking plates and screws are more expensive than nonlocking hardware [16].

In this study, despite the low quality of the bone, all fractures healed within a mean duration of 11.5 weeks; there were no cases with malunion or delayed union, only two cases (7.8%) with implant-related complications causing impingement requiring implant removal, and one case (3.8%) with avascular necrosis that also required implant removal; this case had fracture dislocation at presentation with axillary and radial nerve palsy, which recovered 4 months later. Our results are comparable to previously reported results of Smith *et al*. [17], Fankhauser *et al*. [18], Koukakis *et al*. [19], and Moonot *et al*. [20], although older patients and patients with osteopenic or osteoporotic bones were selected in our study.

Smith *et al*. [17] noted that locked plates had a lower rate of malunion and implant malposition than other forms of fixation. They reported a mean Constant score of 74.6 points at the 1-year follow-up, and there were no cases of nonunion. Of the 29 patients included in their studies, there was a broken plate in one, loss of reduction in three, infection with loss of reduction in one, and subacromial impingement in two patients.

Koukakis *et al*. [19] reported a mean Constant score of 76.1 points in 20 patients. Complications included hardware failure in one patient, impingement requiring removal of the plate in one, avascular necrosis in one, and infection in one patient.

Moonot *et al*. [20] reported a 97% fracture healing rate occurring at a mean of 10 weeks in 32 patients, with a mean Constant score of 66.5 at 11 months after surgery. Complications included three patients (9%) who had symptoms of subacromial impingement requiring removal of the plate, two patients (6%) with poor outcomes because of malunion, screw breakage in one (3%), and nonunion with avascular necrosis in one patient (3%).

The reported rates of successful healing for fractures managed with locked plates are better than for conventional plating [18,21,22].

The Fankhauser *et al*. [18] study had no cases of delayed union. Agudelo *et al*. [21] reported only 1.8% of delayed union and 5% were reported by Thalhammer *et al*. [22].

The reported humeral head necrosis after plate fixation varied significantly. Agudelo *et al*. [21] reported a rate of 4.5%, Björkenheim *et al*. [23] reported a rate of 4.2%, whereas Thalhammer *et al*. [22] found signs of humeral head necrosis in 21% of the cases.

Most authors reported satisfactory or good functional results after surgical treatment of proximal humeral fractures using locked plates [18,23].

Fankhauser *et al.* [18] presented an average Constant score of 74.6 points. Björkenheim *et al.* [23] found an overall Constant score of 77.0 points.

This study still has its limitations because of the small number of patients in each group; hence, another study with a larger number of patients is required to obtain more statistically accurate results.

Conclusion

Locked plate fixation for three-part and four-part fractures of proximal humerus in osteopenic or osteoporotic patients is a good and reliable method of fixation with limited complications.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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