



Functional outcome and complications following PHILOS plate fixation in proximal humeral fractures

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Objectives: Proximal humeral fractures account for approximately 5% of all fractures. New plating techniques have been developed to improve stability. The purpose of this study was to evaluate functional outcome following plate fixation with the Proximal Humeral Internal Locking System (PHILOS) and to analyze potential implant-related complications.

Methods: The PHILOS plate was used for internal fixation of displaced proximal humeral fractures in 28 patients (20 females, 8 males; mean age 60.7±12.9 years). Fractures were caused by low-energy trauma (fall from standing height) in 21 patients, and by an accident while skiing or cycling in seven patients. Involvement was on the right in 16 cases and on the left in 12 cases. According to the Neer classification, 8, 12, and 8 patients had displaced 2-, 3-, or 4-part fractures, respectively. All patients received a similar physical therapy program following internal fixation with the PHILOS plate. The patients were assessed clinically and radiographically after a mean follow-up of 25.2±11.8 months. Functional outcome was assessed using the Constant-Murley score adjusted for age and gender. Range of motion and shoulder abduction strength were measured. The patients were also evaluated with the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and a visual analog scale (VAS). Complications during the follow-up period were recorded.

Results: Twenty fractures (71.4%) healed in good anatomical position. At the end of the follow-up period, the mean Constant-Murley score was 57.9±21.7, and the mean age- and gender-adjusted Constant-Murley score was 67.5±23.6. The results were excellent or good in 16 patients (57.1%), moderate in one patient (3.6%), and poor in 11 patients (39.3%). The mean DASH and VAS scores were 28.3±24.3 and 75.4±21.2, respectively. Eleven complications (39.3%) were seen during the follow-up period. Reoperation was required in eight patients (72.3%). Complications included avascular necrosis of the humeral head in two patients (7.2%), subacromial impingement in six patients (21.4%), loosening of a locking head screw in one patient (3.6%), and transiently decreased radial nerve sensation in two patients (7.2%). Subacromial impingement was mainly caused by the superior plate position.

Conclusion: Our results demonstrate that the PHILOS plate provides sufficient fracture stabilization in the treatment of proximal humeral fractures of elderly patients.

Key words: Bone plates; fracture fixation, internal/methods; humerus/injuries; shoulder fractures/surgery; treatment outcome.

Proximal humeral fractures account for approximately 5% of all fractures.^[1] Within the last three decades, the age-adjusted incidence of proximal humeral frac-

tures increased by 15% per year. Increased incidence of proximal humeral fractures is associated with more complications.^[2]

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Up to 80% of proximal humeral fractures can be treated nonoperatively, resulting in satisfactory results.^[3] However, different techniques have been described for fixation of comminuted and displaced proximal humeral fractures, including sutures, cerclage wires, K-wires, screws and plates, intramedullary devices, and shoulder arthroplasty.^[4-7]

The complication rate can be as high as 50% or higher.^[8,9] Several complications have been reported, such as cut-out or back-out of the screws and plates, nonunion, avascular necrosis, nail migration, rotator cuff impairment and impingement syndrome.^[10,11] Even shoulder arthroplasty in proximal humeral fractures may yield functionally poor results.^[12]

In order to decrease the incidence of complications, particularly fixation failure and loss of stability, and to improve stability and enable early post-operative mobilization, new plating techniques such as the Proximal Humeral Internal Locking System (PHILOS, Synthes, Solothurn, Switzerland) have been developed.^[13]

Since there is a high correlation between the holding capacity of screws and regional bone morphology (e.g. cortical thickness and bone mineral density),^[14] osteoporotic bone is implicated in the occurrence of complications in proximal humeral fractures.

The aim of the present study was to evaluate the clinical results of PHILOS plate fixation in proximal humeral fractures and to analyze potential implant-related complications.

Patients and methods

The study was approved by the local ethics committee and written informed consent was obtained from each patient. The PHILOS plate was used for internal fixation of displaced proximal humeral fractures in 28 patients (20 females, 8 males). The mean age was 60.7 ± 12.9 years, being 56.4 ± 19.0 years in males, and 62.5 ± 9.6 years in females. Patients were identified by reviewing the theater coding registry. Inclusion criteria were as follows: (i) closed proximal humeral fracture (two-, three-, or four-part according to the Neer classification system),^[15] (ii) failed nonoperative treatment, and (iii) age older than 18 years. Pathological fractures and open fractures were excluded. The fractures were classified according to the Neer classification as displaced 2-, 3-, or 4-part fractures

based on radiographs and, when available, computed tomography.^[15]

Fractures were caused by low-energy trauma (fall from standing height) in 21 patients, and by an accident while skiing or cycling in seven patients. Involvement was on the right in 16 cases and on the left in 12 cases. Eight patients had a two-part fracture, 12 patients had a three-part fracture, and eight patients had a four-part fracture. The mean body mass index was 28.2 ± 6.5 kg/m², being 27.9 ± 5 kg/m² in males, and 28.3 ± 7.2 kg/m² in females.

Surgical procedure was carried out using a standard deltopectoral approach, with the patient in a beach-chair position. Postoperatively, the shoulder was immobilized in an arm sling. On the third post-operative day, passive motion and pendulum exercises were initiated to prevent stiffness. Active assisted motion was limited to 40 degrees up to six weeks. Resistive strengthening was begun after fracture union had been ensured. All patients received a similar physical therapy program.

Clinical and radiographic evaluation

The patients were assessed clinically and radiographically after a mean follow-up of 25.2 ± 11.8 months. Complications during the follow-up period and functional outcome were noted. At the latest follow-up standard anteroposterior and lateral plain radiographs were obtained (Fig. 1). Radiographic evaluation was performed to assess union, non-union, avascular necrosis, implant loosening, and hardware-related complications. The patients were examined by one of the authors who had not been involved in their primary surgical treatment. Functional outcome was assessed using the Constant-Murley score.^[16] Range of motion was measured with a goniometer. Shoulder abduction strength measurement was carried out using a dynamometer as suggested previously.^[17] Measurements were performed three times, each for a period of three seconds. The mean value for all measurements was then calculated to define the strength in kilograms. Failure to reach 90° abduction of the shoulder force measurement was rated as zero, as suggested by Bankes et al.^[18] Because strength of the normal shoulder decrease with age and may differ by gender, we adjusted the Constant-Murley score for age and gender as previously described.^[19] The Constant-Murley score was graded as poor (0-55 points), moderate (56-70), good

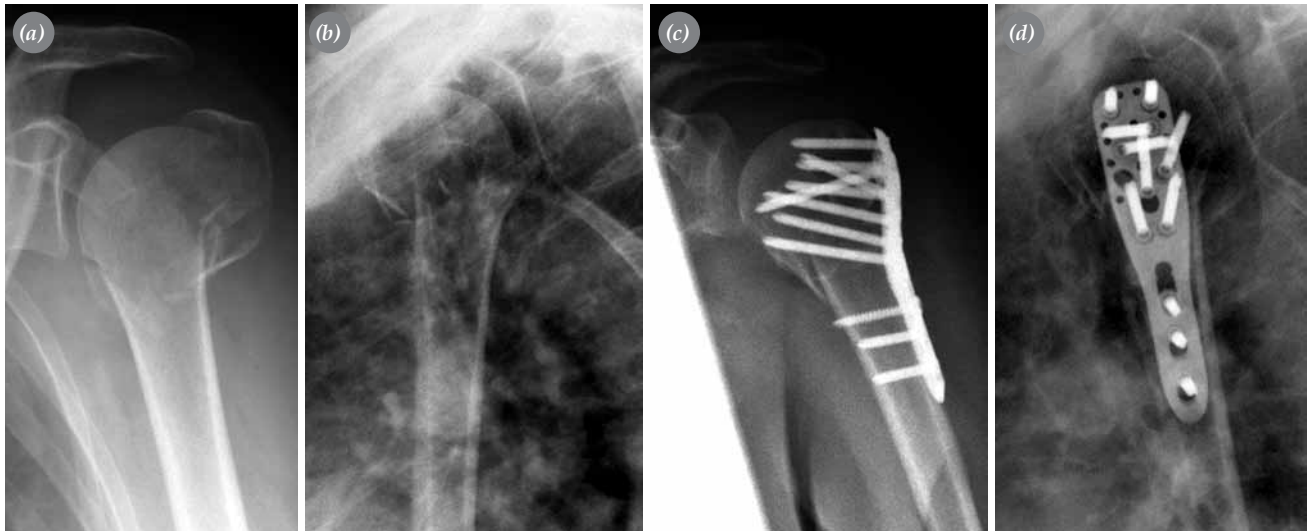


Fig. 1. (a, b) Preoperative radiographs of a 65-year-old woman who sustained a three-part fracture after a fall. The anteroposterior view shows impaction of the humeral head and consecutive dislocation of the major tubercle. (c, d) Postoperative radiographs show anatomic reduction of the fracture and adequate positioning of the PHILOS plate.

(71-85), or excellent (86-100).^[11] Moreover, we used the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire^[20] as a measure of disability and a visual analog scale (VAS) to assess overall satisfaction of the patients on a 0 (poor) to 100 (excellent) mm range.

Data analysis

Data were recorded and analyzed with use of the SPSS 11.5.1 software package. Continuous variables were expressed as mean and standard deviation (SD). The means and interquartile ranges were calculated for ordinal variables.

Results

Of 28 fractures, 20 (71.4%) healed in good anatomical position. At the end of the follow-up period, the mean Constant-Murley score was 57.9 ± 21.7 , and the mean adjusted Constant-Murley score was 67.5 ± 23.6 . The results were excellent or good in 16 patients (57.1%), moderate in one patient (3.6%), and poor in 11 patients (39.3%). The mean DASH and VAS scores were 28.3 ± 24.3 and 75.4 ± 21.2 , respectively.

During the follow-up period, 11 complications (39.3%) were encountered, of which eight (72.3%) required reoperation (Table 1). Avascular necrosis was observed in two patients (7.2%), both having 4-part fractures. One patient who developed partial necrosis of the humeral head refused revision surgery, while

the other underwent revision surgery with hemiarthroplasty. Six patients (21.4%) developed subacromial impingement, essentially caused by the superior positioning of the PHILOS plate. One patient had subacromial impingement due to severe calcifying tendinitis, and one patient had osteophyte-induced extrinsic impingement. All patients with impingement recovered after plate removal and acromioplasty. Loosening of a locking head screw was seen in one patient (3.6%) four months after surgery. This fracture healed uneventfully after removal of the loosened screw. Postoperatively, two patients (7.2%) complained about decreased radial nerve sensation, which recovered completely after a few months without the need for surgical intervention.

	n	%
Total number of complications	11	39.3
Total number of revision surgeries	8	28.6
Avascular necrosis of the humeral head	2	7.2
Partial	1	
Complete	1*	
Subacromial impingement	6*	21.4
Decreased nerve sensation	2	7.2
Loosening of screw	1*	3.6

*Complications requiring revision surgery.

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.^[4-7] All these techniques have been associated with a varying rate of complications such as cut-out or back-out of the screws and plates, nonunion, avascular necrosis, and fractures distal to the plate.^[8,9,21] Functional outcome not only depends on the quality of bone stock, but also on the stability provided by the implant. In an internal locking system like the PHILOS plate, all forces are transmitted from the bone via the locking head screws to the blade, and vice versa. Hence, the principle of fixed angle plates enables a gain in torsional stiffness and stability, and may therefore promote a superior outcome.^[22]

The present study was conducted to evaluate clinical outcome following PHILOS plate fixation and to assess potential complications during the follow-up. To date, early results of locking plate fixation of proximal humeral fractures have been reported.^[8,9,11,23-26]

Our study demonstrates the clinical results of osteosynthesis in proximal humeral fractures using the PHILOS plate. The cumulative complication rate was 39.3%. There was no early loosening of the implant. The main complication was subacromial impingement associated with superior positioning of the PHILOS plate, suggesting that the PHILOS plate be placed more distally to prevent subacromial impingement during abduction. In all cases, complaints resolved after removal of the plate. Excellent or good results according to the Constant-Murley score accounted for 57.1%, compared to 39.3% for a poor clinical outcome. Despite some inhomogeneity, our results are comparable with those reported for the PHILOS plate.^[25]

Frankhauser et al.^[9] evaluated 29 proximal humeral fractures in 28 patients treated with the Locking Proximal Humerus Plate (LPHP). They observed no nonunion and reported a low incidence of reoperation (n=2). The mean Constant-Murley score was 74.6 after 12 months. They suggested that outcome could be improved by enhanced positioning of the plate on the humeral shaft and placing the locking screws to

avoid redislocations, malunions, and implant-related impingement.

In a retrospective study, Björkenheim et al.^[11] reviewed 72 patients treated with the PHILOS plate. At final controls, 36 patients had a good or excellent functional outcome according to the Constant-Murley score, 31 patients had a moderate score, and five patients had a poor outcome. The authors advocated the use of the PHILOS plate, especially in osteoporotic bone.^[11]

In a series of 20 consecutive patients, Koukakis et al.^[26] showed favorable early results with surgical treatment of proximal humeral fractures using the PHILOS plate. After a mean follow up of 16 months, the mean Constant score was 76.1. The results did not differ with respect to age (<65 years vs. ≥65 years).

Hente et al.^[23] studied 31 patients with displaced 3- and 4-part fractures of the proximal humerus treated with the PHILOS plate. After a mean follow-up of 18.5 months, the mean Constant score was 76. The authors reported the mean strength as 22 kg, which has to be interpreted with caution, because they performed strength measurements by placing the strap of the spring balance next to the deltoid muscle at the proximal humerus. Furthermore, their strength measurements included patients who were not able to hold their arm in 90° abduction, whereas we rated these patients as zero as suggested by Bankes et al.^[18] Since strength is a major determinant of the total Constant-Murley score and varies with the measurement method (i.e. lever arm), it is of utmost importance to standardize the measurement method, as previously described.^[18]

In general, it is emphasized that bone quality be considered before deciding on treatment. Unfortunately, we did not have preoperative data on bone mineral density (BMD) to comment on the influence of reduced BMD on the outcome after PHILOS plate fixation in proximal humeral fractures. A review of the literature on PHILOS plate fixation showed that all studies had taken BMD into account and discussed osteoporosis without previously performed BMD measurements. Thus, the patients were only judged clinically as having osteoporosis based either on the standard radiographs or on the surgeon's intraoperative impression. Due to the retrospective design of our study, we could not evaluate BMD-associated complications and whether central BMD correlated with

functional outcomes or provided a basis to predict local complications. Therefore, though very challenging, measuring BMD directly at the time of the initial trauma and primary surgery remains the subject of an ongoing prospective study. This may enable us to exclude patients with secondary osteoporosis and to evaluate if there is an association between BMD and complications.

Based on our observations, inadequate positioning of the implant resulted in reduced functional outcome. Hence, to improve functional results, we consider plate positioning to be of utmost importance when using PHILOS plate fixation.

There are two major limitations to this study. Firstly, the number of patients was small. The reason for this is that we only included patients with complete data (i.e., radiographs, Constant-Murley score, DASH score). Secondly, information was lacking regarding BMD values due to the retrospective design of the study. Hence, the influence of BMD on the postoperative outcome could not be estimated.

In conclusion, the use of the PHILOS plate is a reasonable and feasible option in treating proximal humeral fractures of elderly people.

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