Management of proximal humeral fractures by proximal humeral internal locking system plate: a prospective case series

Mahmoud Abdel Karim[a], Khaled Farouk[b]

[a]Lecturer Department of Orth, Cairo University Hospitals M.D., Cairo, [b]El Helal Hospitals Tr & Orth, Egypt

Correspondence to Mahmoud Abdel Karim, MD, 33A Kasr Al Ainy Street , 7th Floor, Cairo, Egypt. Tel: +20 114 604 6049; e-mail: mabdelkarim@hotmail.com

Received 11 December 2018
Accepted 27 December 2018

The Egyptian Orthopaedic Journal 2018, 53:237–243

Introduction
The objective of this study was to evaluate the functional and radiological outcome after open reduction and internal fixation of proximal humeral fractures with the proximal humeral internal locking system (PHILOS) plate.
Patients and methods
This prospective case series included 30 patients. All cases were managed by open reduction of the fractures and internal fixation by the PHILOS plate. The inclusion criteria included patients with displaced two, three, and four-part fractures. Six (20%) patients had two-part fractures, 12 (40%) had three-part fractures, 12 (40%) had four-part fractures. There were 18 male patients and 12 female patients. The mean patient age was 49 years (22–74 years). The average follow-up period was 9 months (6–12 months). The functional outcome was assessed using the constant score at 6 months. Radiological evaluation was carried out immediately postoperatively, at 6 weeks, 3 months, 6 months, and 1 year.
Results
Most of the series patients had a satisfactory outcome. The mean constant score was 72.4 points (range, 46–94 points) at 6 months' follow up. Healing of the fracture occurred uneventfully in 83.4%. However, some complications were found in this patient series. In two (6.6%) patients, the humeral head collapsed due to avascular necrosis after fracture healing. In one (3.3%) patient, fracture healing occurred with varus displacement, but the patient was satisfied with the outcome. No implant failure and no delayed union or nonunion was noted.
Discussion and conclusion
Management of proximal humeral fractures with PHILOS plates achieves a good reduction and satisfactory clinical and radiological outcomes; however, some complications might be expected in some patients.

Keywords:
internal locking system, plate, proximal humeral fractures

Egypt Orthop J 53:237–243

1110-1148

Introduction

With regard to treatment of proximal humeral fractures, much controversy and confusion still exist, and no single treatment protocol or algorithm has been proved to be universally effective. Areas still in question include radiographic diagnosis, operative or nonoperative treatment, consideration of patient age in treatment decision making, surgical approach, fracture fixation, and type of internal fixation [1].

The main advantage of surgical treatment is the possibility of mobilising the joint at an early stage. Conventional plate fixation has stood the test of time for many years. Besides a possible impairment of perfusion leading to humeral head necrosis, the main problem is the anchoring of the screws in osteoporotic bone. A typical resulting complication is the loosening of the implant [2].

Recently, one of new trends that has been described for fixation of proximal humerus fractures is proximal humeral internal locking system (PHILOS) plate [3]. The locking plate is far superior to a proximal humerus nail with regard to both varus bending and torsional stability [4]. The locking proximal humerus plate is contoured to the anatomy of the lateral aspect of the proximal part of the humerus and ensures stable fixation of the humeral head and its fragments, even in the presence of osteoporosis. This is achieved by the angular stability of screws locking in the plate and their three-dimensional distribution in the humeral head [5].

Despite the effectiveness of this method, there are a number of complications attached to it. Screw penetration has been the major one. This happened more frequently in cases wherein anatomical reduction

of the fracture had not been achieved and when the most distal screws has not been inserted. The authors concluded that, to achieve better outcome, satisfactory reduction of the fracture is mandatory [6]. The objective of this study was to evaluate the functional and radiological outcome as well as complications encountered after open reduction and internal fixation of proximal humeral fractures with the PHILOS plate.

Patients and methods

Between June 2011 and December 2012, a prospective study was conducted involving 30 cases with proximal humeral fractures. This study was approved by ethical committee of Cairo University. All patients signed an informative consent form. There were 12 (40%) male patients and 18 (60%) female patients. All cases were surgically managed by open reduction of the fractures and internal fixation by proximal humeral locked plates; the mean follow-up period of the cases was 9 months (range, 6–12 months).

The inclusion criteria

This study included patients with displaced two-part surgical neck fractures, two-part anatomic neck fractures in the patient younger than 40 years, three-part surgical neck fractures with involvement of the greater or lesser tuberosity, fracture dislocations in the patient younger than age 40 years, and four-part fractures. The exclusion criteria consisted of patients with nondisplaced or minimally displaced fractures, most head-splitting fractures, patients less than 18 years of age, open injuries, and patients with pathological fractures.

Six (20%) patients had two-part fractures, 12 (40%) had three-part fractures, and 12 (40%) had four-part fractures according to the Neer's classification. The mean patient age was 49 years (range, 22–74 years). The mean preoperative period was 2.3 days (1–6 days).

Surgical technique

All patients were operated upon under general anaesthesia, in beach chair position and under C-arm control. The arm was draped separately to allow abduction and rotation in order to facilitate fracture reduction. A standard deltopectoral approach was used, the deltopectoral interval identified, and the cephalic vein protected. Throughout fracture-site preparation, care was taken to avoid damage of the ascending branch of the anterior circumflex humeral artery located laterally in the bicipital groove, as this provides the primary blood supply to the head fragment. After adequate exposure of the fracture site with the least possible soft-tissue dissection, the fragments were reduced and provisionally stabilized with the use of Kirschner wires. The tubercles were additionally secured with 1–2 No. 2 Ethibond sutures passing through the bone–tendon junction and inserted in the appropriate plate holes. Correct plate positioning in both the mediolateral and cephalocaudal direction was controlled with the image intensifier.

Plates were placed at least 5–8 mm inferior to the upper end of the greater tuberosity to avoid subacromial impingement and 2–4 mm lateral to the bicipital groove, ensuring that a sufficient gap was maintained between the plate and the tendon of the long head of the biceps muscle. Positioning the first screw in the centre of the slotted gliding hole found in the distal part of the plate facilitates accurate plate placement by allowing for minor adjustments. The divergent locking screws were placed in the humeral head through the proximal part of the plate and thereafter, the distal screws were placed. The placement of the calcar screw in the angular stable plate fixation of proximal humeral fractures is associated with less secondary loss of reduction by providing inferomedial support. The required screw length was determined with depth gauge measurement. The reduction was finally confirmed with anteroposterior and lateral axillary views on the image intensifier. The skin was closed over suction drains that were removed after 24 h.

The arm was placed in a shoulder sling. Intravenous antibiotics were administered for 24 h postoperatively. Elbow and wrist range of motion exercises were commenced on the first postoperative day, whereas passive motion and pendulum exercises of the shoulder were encouraged as soon as pain had subsided. Active-assisted range of motion activities were initiated about 6–8 weeks postoperatively, whereas unassisted active motion was allowed at 12 weeks postoperatively.

Clinical and radiological evaluation

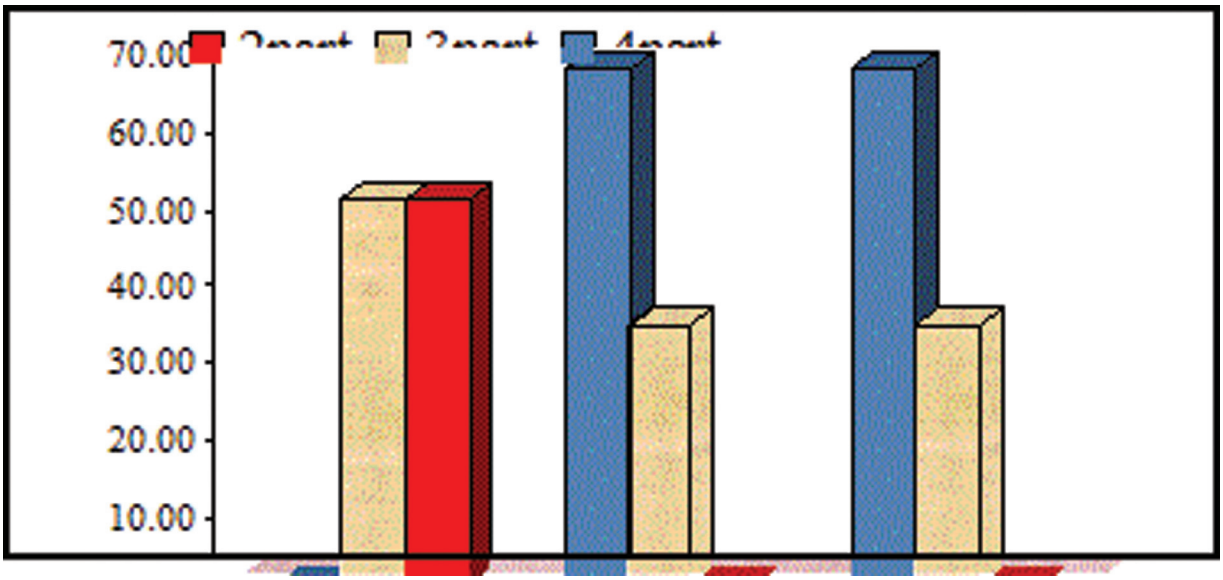
All patients had clinical evaluation postoperatively at 2 weeks, 6 weeks, 3 months, and 6 months. The constant score was used to assess shoulder function at 6 months. Radiological evaluation was carried out by shoulder radiographs taken (postoperatively, at 6 weeks, 3 months, 6 months, and 1 year) after surgery. Fracture healing and maintenance of reduction were evaluated in the anteroposterior and lateral shoulder radiographs. The appearance of callus in radiographs and/or the disappearance of fracture lines were considered evidence of fracture healing. Radiographs were further

Table 1 Showing relation between pain score and type of fracture in the patients' group

	Pain [n (%)]			
Type of fractures	No	Mild	Moderate	Total
2 part	6 (50.00)	0 (0.00)	0 (0.00)	6 (20.00)
3 part	6 (50.00)	4 (33.33)	2 (33.33)	12 (40.00)
4 part	0 (0.00)	8 (66.67)	4 (66.67)	12 (40.00)
Total	12 (100.00)	12 (100.00)	6 (100.00)	30 (100.00)
χ^2				
χ^2		11.873		
P value		0.018*		

*Significant *P* value.

Figure 1



Relation between pain score and type of fracture in the patients' group.

assessed for identifying signs of humeral head osteonecrosis and implant cut-through or cut-out.

Statistical analyses

Statistical presentation and analysis of the present study was conducted using the mean, SE, Student's *t* test, χ^2, linear correlation coefficient, and analysis of variance (ANOVA) tests by SPSS, version 17.0 (SPSS; SPSS Inc., Chicago, Illinois, USA). Unpaired Student's *t* test was used to compare between two groups in quantitative data. Linear correlation coefficient was used for detection of correlation between two quantitative variables in one group. ANOVA tests: were carried out according to the computer program SPSS for Windows. The ANOVA test was used for comparison among different times in the same group in quantitative data.

Results

The mean follow-up was 9 months (range, 6–12 months). Functional assessment using constant scoring system was used to assess every patient at 6 months postoperatively. The mean constant score was 72.4 points (range, 46–94 points).

Functional outcome: The relation between pain score and type of fracture in the patients was as follows: no pain in six cases with two-part fractures and in six cases with three-part fractures; mild pain in four cases with three-part fractures and eight cases with four-part fractures; moderate pain in two cases with three-part fractures and in four cases with four-part fractures. Table 1 and Figure 1 show that there was a statistically significant difference between type of fracture and pain score (P=0.018).

Relation between pain score and final constant score in the patients: in the group with no pain, the range was 76–94 by mean±SD 87.66±6.62. In the mild pain group, the range was 52–72 by mean±SD 61±8.92, and in the moderate pain group, the range was 46–86 by mean±SD 64.6±20.1.

Table 2 and Figure 2 show that there was a statistically significant difference between final constant score and pain score, wherein the *P* value is 0.003. Moreover, there was a significant difference between no pain and mild pain ($P \leq 0.003$) and no pain and moderate pain ($P=0.029$), but there was no significant difference between mild and moderate pain ($P=0.884$).

Radiological outcome

Healing of the fracture occurred uneventfully within 6 months. Fractures healed satisfactorily in 83.4% of cases. Some complications were reported in five (16.6%) patients. In two (6.6%) patients, the humeral head collapsed due to aseptic necrosis after fracture healing. In the third (3.3%) patient, fracture healing occurred with varus displacement. In the last two (6.6%) patients, healing of the fracture occurred, but there was a head screw perforation into the glenohumeral joint. No implant failure and no delayed union or nonunion was noted (Fig. 3).

Complications

In this study, some complications were encountered in six cases representing 20% of the study cases. One patient developed humeral head collapse due to aseptic necrosis that occurred after fracture healing. The patient was reoperated upon, and the implant was removed, leading to symptom subsidence and clinical improvement. In another patient, the head collapse led to severe limitation of shoulder range of motion and pain due to head screw perforation into the glenohumeral joint. The patient was then scheduled for plate removal and shoulder arthroplasty. One patient had varus displacement due to malreduction. Strictly passive mobilisation was continued for 6 weeks, by which time, signs of fracture healing without further displacement were noted. The functional end-result of this patient was satisfactory on final follow-up. In one patient, healing of the fracture occurred, but there was a head screw perforation into the glenohumeral joint, but the patient did not opt for surgical intervention to remove the metalwork. Two patients had superficial surgical wound infection, which was resolved conservatively with antibiotic therapy, according to the culture and sensitivity.

Table 2 Relation between pain score and final constant score in the patients' group

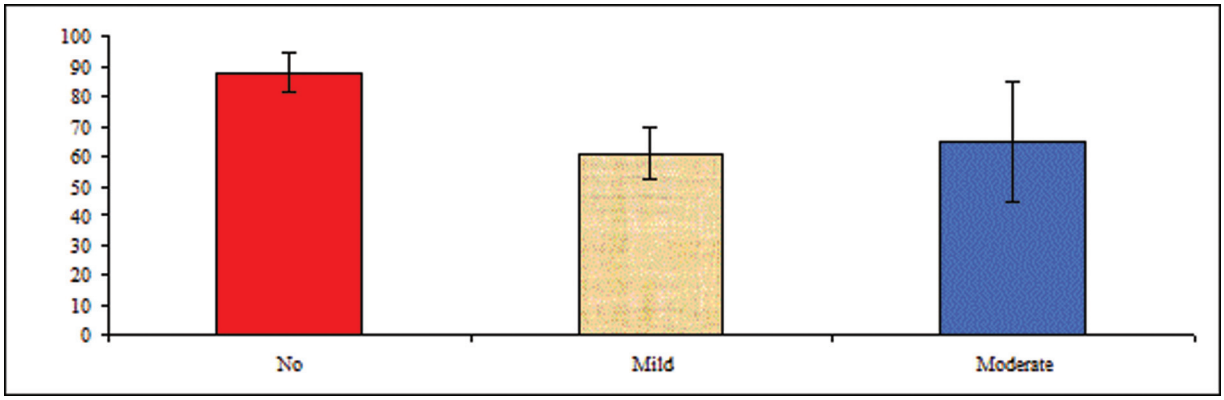
	Final constant score		ANOVA	
	Range	Mean±SD	*F*	*P* value
No	76.0–94.0	87.667±6.623	9.906	0.003*
Mild	52.0–72.0	61.000±8.922		
Moderate	46.0–86.0	64.667±20.133		
Tukey's test				
No and mild		No and moderate	Mild and moderate	
0.003*		0.029*	0.884	

ANOVA, analysis of variance. *Significant *P* value.

Discussion

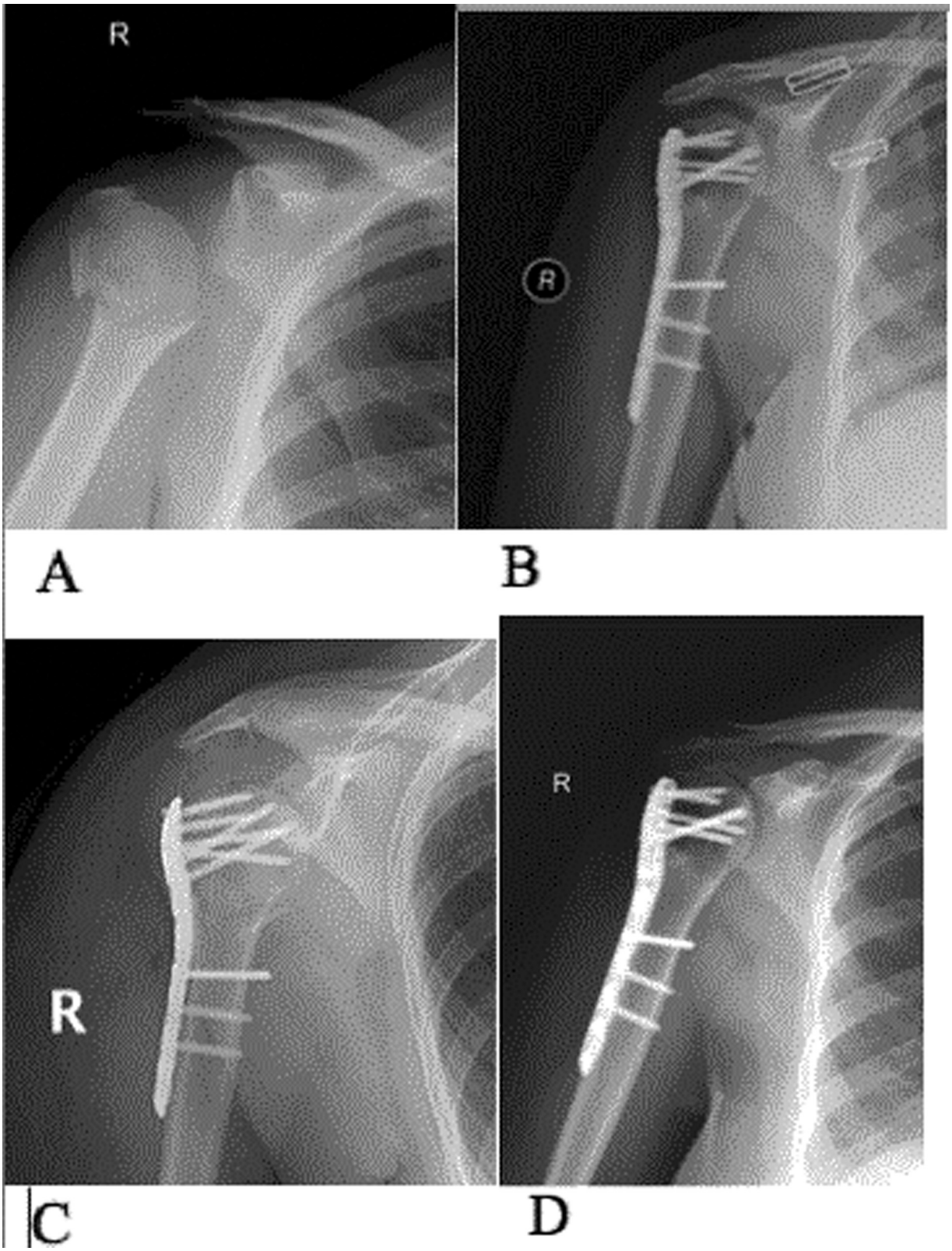
Proximal humeral fractures account for ~4–5% of all fractures. The incidence of proximal humeral fractures increases exponentially after 50 years of age, with ~80% of such fractures occurring in women. In the elderly population, most fractures of the proximal humerus are related to osteoporosis [7]. Several operative treatment modalities have been developed over the years, including fixation with wires and loops with minimal soft tissue dissection, different plate designs, nails, as well as percutaneous techniques [8]. In spite of the development of new techniques and implants, undesirable early and late sequelae may occur after both nonoperative and operative treatment of fractures of the proximal humerus

Figure 2



Relation between pain score and final constant score in the patients' group.

Figure 3



(a) Preoperative radiograph of the proximal humeral fracture. (b) Immediate postoperative radiograph showing satisfactory fracture reduction. (c) Six weeks postoperatively radiograph shows fracture healing without fragment displacement. (d) Twelve months postoperatively, radiograph showing united fracture.

such as shoulder stiffness, heterotopic ossification, avascular necrosis, malunion, nonunion, and post-traumatic arthritis [9].

The optimal surgical management of three-part and four-part proximal humeral fractures in elderly osteoporotic patients remains controversial, with

many advocating prosthetic replacement of the humeral head, whereas other surgeons prefer to go for internal fixation [10]. The technique requires extensive soft tissue stripping, compromising the vascular supply to the humeral head. Minimally invasive methods of plate osteosynthesis may increase the risk of neurovascular structural damage. Percutaneous pinning requires advanced skills, good bone quality, minimal fracture comminution, and a cooperative patient [11].

PHILOS plating is a relatively new method of fixation and has increased in popularity in the past decade. The experience with this method of fixation so far has been comparable with the result in the literature [6]. Complications associated with the PHILOS plate fixation include screw perforations into the glenohumeral joint, screw loosening, backing out, secondary implant dislocations from the humeral head, avascular necrosis of the humeral head, pseudoarthrosis with a broken plate, subacromial impingement requiring plate removal, nonunion, malunion due to loss of purchase in the humeral head, broken distal screws with separation of the plate from the bone, and transient axillary nerve palsies [12].

In this study, PHILOS plate fixation was the optimum method of treatment not only for simple head fractures but also for three-part and four-part complex fractures, with good functional results, especially in young patients with intact posteromedial cortex of the proximal humerus. During dissection and head fixation with proximal locking screws, care should be taken to avoid damage of the anterior humeral circumflex artery and the axillary nerve. The proper reduction was achieved before plate fixation. The plate and screws' positions were checked intraoperatively with image intensification.

The best results are obtained if the fractures are well reduced and reduction is maintained until healing has occurred. It must, therefore, be the goal to select fractures for open reduction and internal fixation, which can be anatomically reduced. This is dependent on various factors such as the type of fracture, the quality of the bone, the technique of reduction and fixation, and the experience and skill of the surgeon [13].

Locking plates offer more advantages than conventional plates, especially when dealing with osteoporotic bone. It is recommended to use locking plate whenever an elderly patient is indicated for internal fixation. Precise reduction of the tuberosities using heavy sutures through the plate holes and positioning the plate in a way to buttress the greater tuberosity is desirable [8]. Decreasing preoperative lag period is essential to obtaining good results. Early passive motion and a well-scheduled rehabilitation programme have an obvious benefit on the final result. Fixation with PHILOS plates preserves achieved reduction, and a good functional outcome can be expected. However, complication incidence proportions are high, particularly due to primary and secondary screw perforations into the glenohumeral joint. Secondary screw perforation has already been described for PHILOS and for other locking proximal humerus plates [14]. The rigidity of these angular stable implants is responsible for screws cutting through osteoporotic bone, wherein humeral heads in older patients may subside due to a missing medial bone buttress or osteonecrosis, while the screws remain locked [15]. In order to prevent late cut-out of the screws because of head collapse, inferomedial support is probably the most important factor to avoid this frequent complication. To achieve this, a slight varus reduction can be accepted. Alternatively, inferomedial support screws can be inserted to reinforce comminution of the inferomedial metaphyseal region [8]. More accurate length measurement and shorter screw selection should prevent primary screw perforation. Awareness of obtaining anatomic reduction of the tubercles and restoring the medial support should reduce the incidence of secondary screw perforations, even in osteopenic bone.The critical arguments for the choice of a specific method will inevitably be its ability to preserve or improve bone perfusion and to eventually help achieve healing in the desired position while minimising the likelihood of complications. In this respect, the PHILOS plate represents a very satisfactory option in the operative treatment of proximal humeral fractures; it facilitates fracture reduction and offers adequate fixation stability even in an osteoporotic environment, thus leading to high union rates and allowing early shoulder mobilisation. This study's results might show that certain fracture types bear higher complication risks, and certain technical details during PHILOS plate application should be meticulously adhered to.

Conclusion

Management of proximal humeral fractures with PHILOS plates achieves a satisfactory clinical and radiological outcome; however, some complications might be expected in some patients.

Financial support and sponsorship
Nil.

Conflict of interests
There are no conflicts of interest.

References

1 Crenshaw AH Jr, Perez EA. Fractures of the shoulder, arm, and forearm canale & beaty: Campbell's operative orthopedics. 11th ed. Springer Philadilfia USA: Mosby; 2007. 2985–3070.

2 Seide K, Triebe J, Faschingbauer M, Schulz AP, Püschel K, Mehrtens G, Jürgens CH. Locked vs. unlocked plate osteosynthesis of the proximal humerus – a biomechanical study. Clin Biomech 2007; 22:176–182.

3 Arya A, Garg S, Sinha J. Complex proximal humerus fracture fixation: is locking plate the answer? J Bone Joint Surg 2009; 91-B:206.

4 Wheeler DL, Colville MR. Biomechanical comparison of intramedullary and percutaneous pin fixation for proximal humeral fracture fixation. J Orthop Trauma 1997; 11:363–367.

5 Konrad G, Bayer J, Hepp P. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. J Bone Joint Surg Am 2010; 92:85–95.

6 Radha S, Senevirathna S, Saquib M, Harrison J. PHILOS plate fixation for proximal humerus fracture: experience at District General Hospital. Injury Extra 2011; 42:95–169.

7 Bengner U, Johnell O, Redlund-Johnell I. Changes in the incidence of fracture of the upper end of the humerus during a 3 year period: a study of 2125 fractures. Clin Orthop 1998; 231:179–182.

8 Thanasas C, Kontakis G, Angoules A, Limb D, Giannoudis P. Treatment of proximal humeral fractures with locking plates: a systematic review. J Shoulder Elbow Surg 2009; 18:837–844.

9 Hertel R, Fandridis E. Post-traumatic reconstruction for sequelae of fractures of the proximal humerus. Curr Orthop 2007; 21:422–431.

10 Solberg BD, Moon CN, Franco DP, Paiement GD. Surgical treatment of three and four-part proximal humeral fractures. J Bone Joint Surg Am 2009; 91:1689–1697.

11 Lau TW, Leung F, Chan CF, Chow SP. Minimally invasive plate osteosynthesis in the treatment of proximal humeral fracture. Int Orthop 2006; 31:657–664.

12 Kettler M, Biberthaler P, Braunstein V, Zeiler C, Kroetz M, Mutschler W. Treatment of proximal humeral fractures with the PHILOS angular stable plate: presentation of 225 cases of dislocated fractures. Unfallchirurg 2006; 109:1032–1040.

13 Resch H, Beck E, Bayley I. Reconstruction of the valgus-impacted humeral head fracture. J Shoulder Elbow Surg 1995; 4:73–80.

14 Fankhauser F, Boldin C, Schippinger G, Haunschmid C, Szyszkowitz R. A new locking plate for unstable fractures of the proximal humerus. Clin Orthop Relat Res 2005; 430:176–181.

15 Brunner F, Sommer C, Bahrs C, Heuwinkel R, Hafner C, Rillmann P, *et al.* Open reduction and internal fixation of proximal humerus fractures using a proximal humeral locked plate: a prospective multicenter analysis. J Orthop Trauma 2009; 23:163–172.