Clinical Results of Using the Proximal Humeral Internal Locking System Plate for Internal Fixation of Displaced Proximal Humeral Fractures

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Abstract

Proximal humerus fractures are accounting for 4-5% of all fractures with increasing incidence.

Proximal Humeral Internal Locking System (PHILOS) plate is a new plate which permits early mobility and lowers the risk of complications. The aim of this study was to evaluate the functional outcome and the complication rate after using this plate.

Between 2006-2008, 37 patients with displaced 2-, 3- and 4-part fractures of the proximal humerus were operated on using PHILOS plate. The mean range of follow-up was 12 months. Twenty patients were 60 years and younger, and 17 patients were older than 60 years. The average American Shoulder and Elbow Surgeons (ASES) score at the final follow-up was 77.62. According to Michener and colleagues classification, 5.4% of patients had an excellent outcome, 72.9% were minimally functionally limited, 16.2% were moderately functionally limited, and 5.4% were maximally functionally limited. The average ASES score between patients 60 years and older and those 60 years and younger was not significantly different. One patient developed avascular necrosis of the humeral head, 2 patients developed an infection, and no patients developed a nonunion.

Fixation with PHILOS plate can be considered a good method with high union rates for this kind of fracture, especially in the older population with osteoporotic bone.

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Proximal humerus fractures account for approximately 4% to 5% of all fractures,[1,2] and their incidence is increasing, especially in the elderly.[3-7] The aim in managing these fractures is to obtain a painless, functional shoulder. This result depends on patient age and expectations, medical condition, bone quality, and good evaluation of current fixation techniques.

Stable, minimally displaced fractures can be treated nonoperatively with good results,[8] but the management of displaced and unstable fractures remains controversial. Various techniques have been proposed, including open reduction and internal fixation (ORIF) with proximal humeral plates, hemiarthroplasty, percutaneous or minimally invasive techniques (eg, pinning, screw osteosynthesis), and use of intramedullary nails,[9-17] but these techniques have been associated with several complications. Painful frozen shoulder, avascular necrosis (AVN), malunion, nonunion, and implant insufficiency are common.[18-20]

Locking plates, fracture fixation devices with threaded screw holes that allow screws to be threaded to the

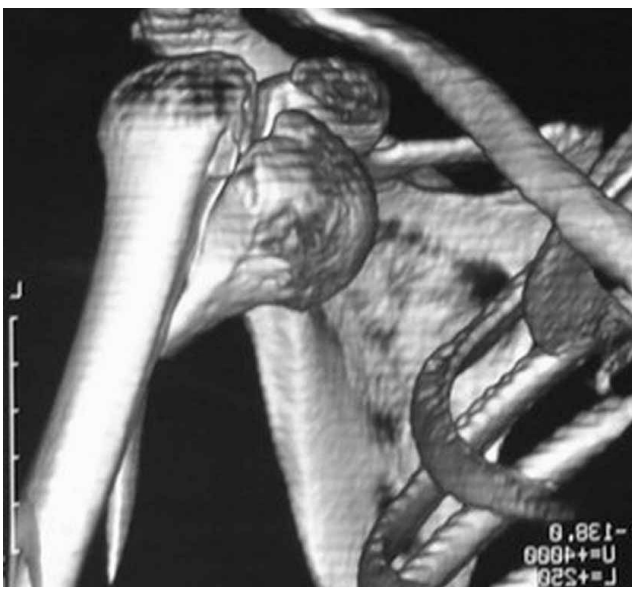

Figure 1. Three-dimensional computed tomography scan of 40-year-old patient shows 4-part fracture of proximal humerus.

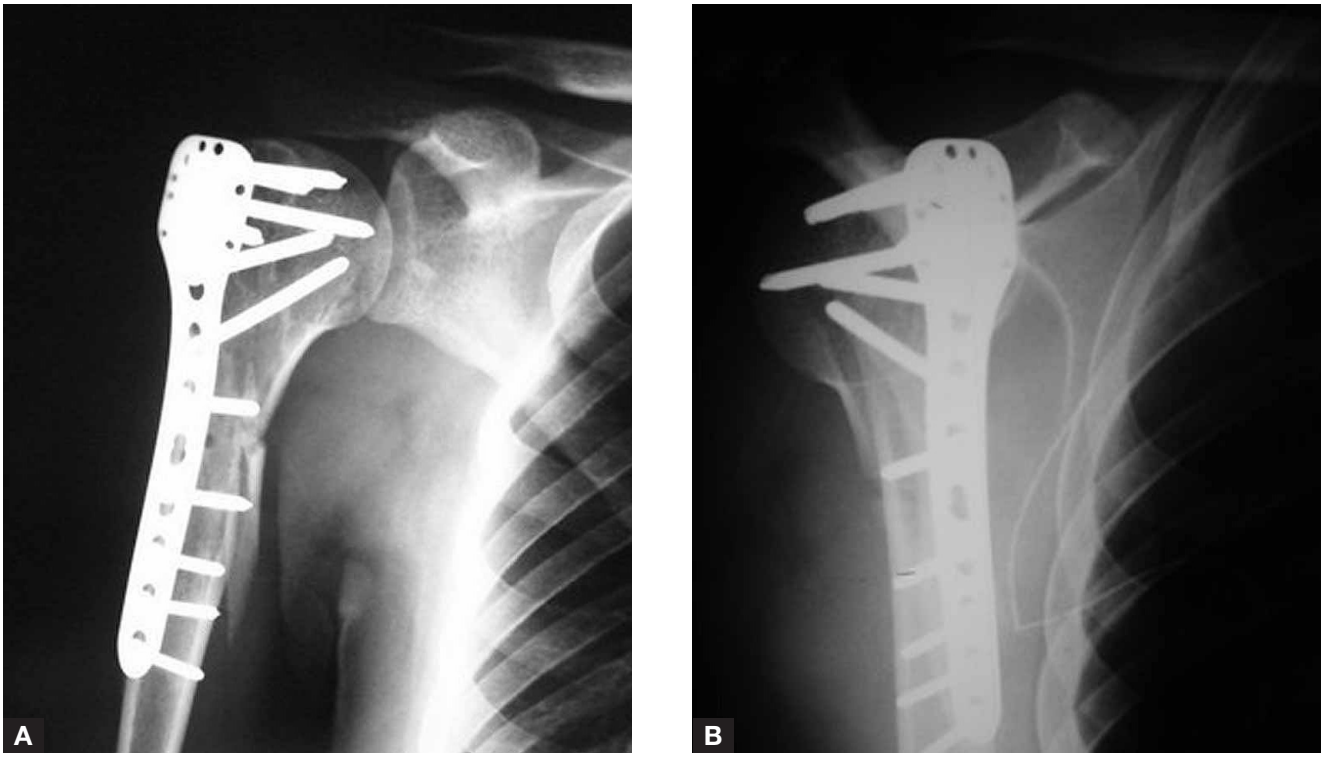

Figure 2. (A) Plain anteroposterior radiograph of 40-year-old patient shows 4-part fracture of proximal humerus fixed with PHILOS (proximal humeral internal locking system) plate. (B) Plain lateral radiograph of 40-year-old patient shows 4-part fracture of proximal humerus fixed with PHILOS plate.

plate, function as fixed-angle devices.[21-23] The load at which failure occurs is higher for locking plates than nonlocking plates.[24] The proximal humeral internal locking system (PHILOS) plate is a new locking plate that can be applied with a minimally invasive method, permits early mobility, and lowers the risk for complications. In a PHILOS plate, all forces are transmitted from the bone through the locking head screws to the blade, and vice versa. The device provides excellent fixation to the humeral head, even in osteoporotic bone. Angular stability, adequate buttressing, and load-sharing support prevent the fragments from collapsing. This plate can be used for 2-, 3-, and 4-part fracture fixations.[11]

As all the reports on the clinical results of using the PHILOS plate are new, we conducted a study to evaluate the functional outcomes and complication rates of internal fixation of proximal humeral fractures with the PHILOS plate in our center.

Table I. Complications at Final Follow-Up

Complication	No.	%
Avascular necrosis	1	2.5
Deep infection	2	5
Malunion	3	7.5
Stiffness	3	7.5
Frozen shoulder	2	5
Pain	2	5

Materials and Methods

At a referral orthopedic hospital, Dr. Norouzi used the PHILOS plate to treat 37 patients (27 men, 10 women) with displaced 2-, 3-, or 4-part fractures of the proximal humerus between January 2006 and December 2008. Mean patient age was 50.1 years (range, 20-87 years); 20 patients were 60 years old or younger, and the other 17 were older than 60. Mean follow-up was 12 months (range, 9-24 months). Causes of injury were low-energy trauma (simple falls; n = 19) and high-energy trauma (road traffic accidents; n = 18). All fractures were closed, had no associated injuries, and were classified as 2-part (n = 13), 3-part (n = 20), or 4-part (n = 4) fractures, according to the classification by Neer.[25]

Patients who underwent ORIF with a PHILOS plate were followed prospectively. Study inclusion criteria were age 18 or older, skeletal maturity, and maximum 10-day delay from injury to definitive ORIF. Candidates with comprehensive personal and medical backgrounds and with a follow-up of at least 9 months were invited to participate in the study.

Exclusion criteria were pseudarthrosis, pathologic fracture, refracture, open fracture, concomitant fracture of ipsilateral elbow or distal radius, concomitant disorder affecting healing and function (eg, multiple sclerosis, paraplegia, another relevant neurologic disorder), multiple traumas, and posttraumatic brachial plexus injury or peripheral nerve palsy.

Table II. Details of Studies in Which PHILOS Plate Was Used to Manage Proximal Humerus Fractures

Study[a]	No. of Cases	Patient Age, y	Follow-Up mo	No. of Complications		
				Infection	Nonunion	Avascular Necrosis
Björkenheim et al[31] (2004)	72	67	>12	0	2	3
Hente et al[35] (2004)	31	60.7	18.5	0	0	5
Kettler et al[33] (2006)	176	66	9	3	1	14
Koukakis et al[11] (2006)	20	61.7	16.2	0	0	1
Charalambous et al[32] (2007)	25	63	6	1	2	1
Rose et al[34] (2007)	16	51	12	0	4	0
Fazal & Haddad[36] (2009)	27	56	13	0	1	1
Kiliç et al[37] (2008)	22	57	12	0	1	2
Korkmaz et al[38] (2008)	41	—	14.6	0	0	0
Present study (2012)	37	50.1	12	2	0	1
Totals	**467**	**—**	**—**	**6**	**11**	**28**

[a]The study by Björkenheim and colleagues[31] was retrospective; all other studies were prospective.

Dr. Hemmati Komasi examined all the patients. Their outcomes, including shoulder motions, infection, misalignment, nonunion, delayed union, and pain, were registered. Some patients had computed tomography scan with 3-dimensional representation (Figure 1), and all had plain radiographs. Previous radiographs were reviewed, and, at latest follow-up, standard plain anteroposterior and lateral radiographs were obtained (Figures 2A, 2B). These sets of radiographs were compared and results were recorded. Radiographs were evaluated for union, nonunion, AVN, implant loosening, and hardware-related complications. Callus formation and cortical continuity were considered evidence of radiologic union.

Patients were seen 2 and 6 weeks after surgery, and then at 2-month intervals until union was complete. In clinic at final follow-up, patients were evaluated regarding probable complications and were asked to complete the American Shoulder and Elbow Surgeons (ASES) questionnaire. The ASES score is derived from the visual analog scale score for pain (50%) and a cumulative score for several upper extremity–related activities of daily living (50%).[26] The ASES questionnaire has demonstrated reliability, validity, and responsiveness for several shoulder conditions.[27] The functional outcomes of patients older than 60 and patients 60 or younger were compared.

Dr. Norouzi performed the surgical procedure with the patient under general anesthesia. A deltopectoral approach was used with minimal soft-tissue dissection. The biceps tendon was identified and retracted, and the fracture was exposed between the tuberosities and behind the bicipital groove. In cases in which the greater tuberosity was displaced posteriorly, attempts were made to reduce it anatomically. Flexing the arm helped to reduce extension at the fracture site. The fracture was reduced and held temporarily with Kirschner wires. The reduction was checked fluoroscopically, and then a PHILOS plate was applied using a minimum of 4 proximal locking screws. In 2 patients with poor bone stock, autogenous bone graft was used. In 27 patients, AO (Arbeitsgemeinschaft für Osteosynthesefragen) cortical screws were used to hold the plate on the humeral shaft. In 10 patients with severely osteoporotic bone, locking screws were used.

This study was approved by the local ethics committee and written informed consent was obtained from each patient. Collected data were analyzed with SPSS 10 software (SPSS, Chicago, Illinois) using Student *t* test with 95% confidence intervals for comparing the groups. $P<.05$ was considered statistically significant.

Results

No patients were lost to follow-up. All fractures united clinically and radiologically. Mean time to union was 10 weeks (range, 8-24 weeks) and mean ASES score at final follow-up was 77.62 (range, 30-95). According to the classification system of Michener and colleagues,[27] 2 patients (5.4%) had an excellent outcome, 27 (72.9%) were minimally functionally limited with good result, 6 (16.2%) were moderately functionally limited with fair result, and 2 (5.4%) were maximally functionally limited with poor outcome. Mean ASES scores of patients older than 60 and patients 60 or younger were not significantly different ($P = .77$).

Table I lists the complications at final follow-up. One patient (2%), a 68-year-old woman who sustained a 4-part fracture of the proximal humerus after a low-energy trauma, developed frozen shoulder and AVN of the humeral head.

Based on self-reports, all patients returned to their preinjury level of activity; no patient lost independence in daily living because of the fracture.

Discussion

In this study, mean ASES score at final follow-up was 77.62 (range, 30-95). According to the classification system of Michener and colleagues,[27] most of the patients were minimally functionally limited with good

result. Furthermore, mean ASES scores for patients older than 60 and patients 60 or younger were not meaningfully different. Pain, malunion, and stiffness were the most common complications. Moreover, only 1 patient (2%) developed frozen shoulder and AVN of the humeral head.

The osteonecrosis rate was 2% (1/37); in other studies, it ranged from 0% to 6%.[28-33] It is noteworthy that early plain radiographic imaging was used to diagnose AVN in our patients, whereas, had magnetic resonance imaging been used, more cases of AVN might have been diagnosed.

Koukakis and colleagues[11] reported early results in a series of 20 patients and stated that this plate design achieves stable fixation, yields good results, and prevents failure. According to Charalambous and colleagues,[32] in 20 of a series of 25 cases, patients' fractures united, and none required revision because of implant failure or nonunion; the other 5 required revision because of implant failure or nonunion. Out of 25 implants, 4 had screw protrusion into the gleno-humeral joint, 4 had screw loosening and backing out, and 1 plate broke without further trauma. The authors stated that PHILOS is an effective system for stabilizing these fractures but warned against the potential complications of the implant.

Our study included more cases than the aforementioned studies,[11,32] but the incidence of complications was comparable. There were 2 infections, 0 nonunions, and 1 case of AVN in our study; 0, 0, and 1 in the study by Koukakis and colleagues[11]; and 1, 2, and 1 in the study by Charalambous and colleagues, respectively.[32]

In another study, Rose and colleagues[34] reported 0 infections, 4 nonunions, and 0 cases of AVN in 16 patients (mean age, 51 years) at 12-month follow-up. Their study was similar to ours with respect to mean patient age, mean follow-up, and use of PHILOS plates, and their results were comparable with ours, but our study had approximately twice as many cases. Table II summarizes the research studies that have been conducted on using PHILOS plates to manage proximal humerus fractures since 2004.

Friess and Attia[39] reported a mean ASES score of 73.8 at 53-month follow-up in 13 patients with isolated proximal humerus fractures managed with locking compression plates. ASES scores were significantly worse for patients 65 or older than for patients 35 or younger. In our study, mean ASES score was 77.6 at final follow-up, and there was no significant difference in ASES scores between patients older than 60 and patients 60 or younger.

In 2 series of patients with PHILOS plates, Kettler and colleagues,[33] and Charalambous and colleagues[32] detected 24 of 176 and 2 of 17 primary screw perforations, respectively. Secondary screw perforations have also been found with PHILOS and other locking proximal humerus plates.[11,33,40] There were no primary or secondary screw perforations in our patients.

Our results demonstrate several benefits of using PHILOS plates. Most importantly, they are easy to use, they are biological in the sense that blood circulation to the humeral head is not compromised, they do not need to be configured, and angular screw fixation ensures fixed-angle stabilization. Moreover, complications associated with these plates were few, and outcomes were comparable with those found in earlier studies.

Although PHILOS plates cost more than other fixation devices, the difference is offset by the low morbidity rate of PHILOS plates. Therefore, we recommend using PHILOS plates, especially in elderly patients with osteoporotic bones. More randomized studies are needed to validate the possible advantages of using these plates.

A limitation of this study is that there were no data on fracture types (A, B, C) and fracture patterns. Furthermore, 1 year is too short a follow-up for detecting all humeral head necroses. Use of the ASES questionnaire is another limitation. Although it has been validated as a reliable, responsive index for several shoulder conditions,[41] it has not been specifically validated for a traumatic population. We use this questionnaire because it is a self-report measure and is easy to administer.

Conclusion

Although the PHILOS implant is expensive, the associated complications and the need for revision surgery are minimal. Therefore, we recommend use of the PHILOS plate, especially in elderly patients with osteoporotic bones. In the management of proximal humerus fractures, fixation with this plate is considered to be a good method with high union rates.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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