



# Minimally invasive percutaneous plating of proximal humeral shaft fractures with the Proximal Humerus Internal Locking System (PHILOS)

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**Background:** This study evaluated our results after minimally invasive percutaneous plating of proximal humeral shaft fractures with the Proximal Humerus Internal Locking System (PHILOS, Synthes, Switzerland).

**Materials and methods:** Between 2005 and 2008, 15 patients with unilateral displaced proximal humeral shaft fractures were treated and followed up over a median period of 27 months (range, 12-38 months). The final follow-up included anteroposterior and lateral x-rays, range of shoulder motion, pain by visual analog scale (VAS), the Constant-Murley shoulder score, the Disabilities of Arm, Shoulder and Elbow (DASH) score, and the Short Form 36 (SF36) assessment.

**Results:** No intraoperative or postoperative complications occurred. No secondary fracture displacement or radial neuropathy was observed postoperatively. One patient had open reduction and internal fixation for pseudoarthrosis 16 months after the initial surgery. At the final follow-up, the median range of motion of the operated shoulder was flexion, 145°; extension, 45°; internal rotation, 40°; external rotation, 70°; and abduction, 135°. Median results on outcome assessments were VAS pain score, 0 points; Constant-Murley score, 74 points, representing 87.5% of the median Constant-Murley score of the unaffected shoulder; DASH score, 34 points, and the SF36, 83 points.

**Conclusion:** Minimally invasive percutaneous plating with the PHILOS offers a valid option in the treatment of proximal humeral shaft fractures with comparable rates of nonunion and lower rates of radial neuropathy compared with open procedures. Furthermore, the results indicate that this method is associated with lower rates of wound infection and a shorter stay in the hospital for the patient.

**Level of evidence:** Level IV, Case Series, Treatment Study.

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**Keywords:** MIPO; minimally invasive; percutaneous; humeral fractures; PHILOS

Dr Brunner and Dr Thormann contributed equally to this work.

This study was approved by the Ethical Committee of the Canton of Lucerne (Internal Process No 779) and was in accordance with the Declaration of Helsinki.

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Fractures of the humeral shaft are common injuries, representing approximately 20% of all fractures of the upper extremities and roughly 3% of all fractures of the human skeletal system.<sup>16,38,44</sup> Several studies have shown that most of these fractures may be successfully treated by nonoperative methods.<sup>7,22,41</sup> In practice, however, conservative treatment requires extensive and committed patient compliance and is often associated with several complications such as

**Table I** Preoperative and postoperative clinical data

Pt	Sex	Age (years)	Side	OTA type	Time to consolidation (weeks)	Follow-up (months)	Angulation	Shoulder range of motion		
								Flex/Ext	Int/Ext	Abduction
1	F	66	L	12-A1	24	36	5° valgus	145°/45°	30°/90°	180°
2	F	51	L	12-B1	24	31	3° valgus	145°/60°	30°/85°	160°
3	F	40	R	12-C1	24	38	2° varus	160°/45°	40°/80°	145°
4	M	58	L	12-C1	6	34	0°	125°/45°	25°/55°	115°
5	M	41	L	12-B2	36	14	0°	100°/40°	35°/60°	120°
6	F	82	L	12-C1	20	33	0°	100°/40°	40°/85°	85°
7	F	71	R	12-B3	22	27	0°	160°/45°	50°/85°	170°
8	F	92	L	12-B1	12	30	0°	125°/45°	35°/85°	130°
9	F	96	R	12-A3	24	26	15° varus	95°/40°	40°/45°	80°
10*	F	43	R	12-B1	...	...	...	...	...	...
11	M	45	R	12-A1	12	25	0°	170°/50°	70°/85°	170°
12	M	74	L	12-B2	36	15	0°	160°/40°	35°/60°	140°
13	M	44	L	12-A3	12	22	0°	150°/45°	40°/45°	120°
14	M	60	R	12-B1	12	12	8° varus	170°/50°	55°/60°	170°
15	M	74	R	12-A1	20	12	0°	120°/40°	40°/60°	120°

\* Minimally invasive plating osteosynthesis was performed for nonunion after 12 weeks of conservative treatment; postoperatively revision was performed for pseudoarthrosis at 16 months with open reduction and internal fixation.

secondary loss of reduction, nonunion, and skin necrosis.<sup>40</sup> Indications for operative treatment include unacceptable alignment after closed reduction, multiple coinjuries, bilateral fractures, open fractures, and obesity.<sup>2,4,14,31</sup>

Open reduction and internal fixation (ORIF) of a plate and anterograde intramedullary nailing have become widely accepted methods of treatment.<sup>3,10,11,15,18,32,37</sup> However, ORIF is associated with extensive soft tissue dissection and bears the risk of iatrogenic injury to the radial nerve,<sup>2,14,20</sup> whereas anterograde intramedullary nailing has been associated with higher rates of intraoperative rotator cuff injuries which may lead to shoulder dysfunction in the postoperative follow-up.<sup>10,11,37</sup>

In 2004 Livani et al<sup>28</sup> proposed a minimally invasive anterior approach to perform indirect reduction and percutaneous anterior plate fixation of humeral shaft fractures. A number of authors have reported promising preliminary results after the use of this technique in the treatment of humeral midshaft fractures with conventional (DCP) or straight locked (LCP) plate systems.<sup>12,23,24,36,48,49</sup> In subcapital humeral fractures, anatomically pre-shaped locking plates (Proximal Humerus Internal Locking System [PHILOS]), Synthes, Switzerland) placed laterally have shown superior biomechanical stability compared with conventional plating systems.<sup>45</sup>

We believe that these biomechanical advantages may also lead to higher fixation stability in the treatment of humeral shaft fractures, especially in those that are located proximally or extend into the humeral head. Although a recent study showed the value of these plate systems in the treatment of proximal humeral shaft fractures by ORIF,<sup>46</sup> outcome data after minimally invasive fixation of humeral shaft fractures with the PHILOS system remain sparse.

The purpose of this retrospective study was to report our operative technique and clinical outcome after minimally invasive plate osteosynthesis (MIPO) of proximal humeral shaft fractures with the long PHILOS plates and to compare our results with data in the literature. We hypothesized that MIPO with the PHILOS plate is a safe and valuable option compared with conservative treatment, ORIF with plates, or intramedullary nailing when treating fractures of the proximal humeral shaft.

## Materials and methods

A series of 15 patients (7 men and 8 women) with unilateral displaced proximal humeral shaft fractures were treated in our department between 2005 and 2008 by closed reduction and percutaneous fixation with a long PHILOS plate (Table 1).

Indications for MIPO with the long PHILOS were fractures of the proximal third of the humeral shaft or shaft fractures that extended into the humeral head that showed an angulation of more than 20° in the anterior-posterior or lateral x-ray or an axial shortening of more than 3 cm after closed reduction. One woman was treated by MIPO for delayed union after initial conservative treatment.

Contraindications for MIPO were accompanying vascular or neural injuries, open fractures, multisegmental fractures, pathologic, and juvenile fractures. All 15 patients were included into this study. Patients' data were retrospectively reviewed from our institution's trauma database in which all humeral fractures are prospectively gathered.

The median age of patients at the time of the operation was 60 years (range, 40-96 years). According to the AO<sup>34</sup> and the Orthopaedic Trauma Association (OTA)<sup>30</sup> classification, 5 fractures were classified as type A (A1, 3; A3, 2), 7 as type B (B1, 4; B2, 2; B3, 1), and 3 as type C1. The mechanisms of injury included a fall while walking in 11 patients, a motorcycle accident

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