



Complications of locked plating for proximal humeral fractures—are we getting any better?

Florian Haasters, MD, PhD^{a,b,*}, Georg Siebenbürger, MD^a, Tobias Helfen, MD^a, Mark Daferner, MS^a, Wolfgang Böcker, MD, PhD^a, Ben Ockert, MD, PhD^a

^aDepartment of Trauma Surgery, Ludwig-Maximilians-Universität, Munich, Germany

^bDepartment of Knee, Hip and Shoulder Surgery, Schön-Klinik Munich-Harlaching, Munich, Germany

Background: Complication rates reported after locking plate fixation of proximal humeral fractures still range up to 40%. Whether modifications of surgical techniques, use of primary shoulder arthroplasty, or a fracture-specific management resulted in decreased complication rates during recent years remains unclear. Therefore, the aim of this long-term observation study was to analyze the incidence of complications and revision surgery after locked plating.

Methods: Between February 2002 and December 2013, 788 patients (aged 67.4 ± 17.3 years) with displaced proximal humeral fractures were treated with locking plate, primary hemiarthroplasty (HA), or reverse shoulder arthroplasty (RSA). Standardized follow-up included radiographs at 1 day, 6 weeks, and 3, 6, and 12 months. Complications and unplanned revision surgery were prospectively recorded over the complete follow-up.

Results: Of 788 patients, 646 (82%) were treated with locking plate, 82 (10.4%) with HA, and 60 (7.6%) with RSA. Mean follow-up was 14.8 ± 3.8 months. The mean complication rate associated with locked plating was 12.8%, and revision surgery was necessary in 11.6%. Within the last 5 years, the loss of fixation rate markedly decreased from 14.3% to 4.8%; simultaneously, an increased use of RSA was observed.

Conclusion: The overall complication rate of locking plate osteosynthesis for proximal humeral fractures has been decreasing considerably within the last years. Among others, this might be due to an increased use of primary RSA for complex fracture types. In addition to a precise surgical technique, choosing the adequate treatment for each individual fracture to avoid complications and revision surgery is of utmost importance.

Level of evidence: Level IV; Case Series; Treatment Study

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This study was conducted according to the Declaration of Helsinki and was approved by the Ethical Committee (No. 156-12) of Ludwig-Maximilians-Universität, Munich, Germany.

*Reprint requests: Florian Haasters, MD, PhD, Department of Knee, Hip and Shoulder Surgery, Schön Klinik Munich-Harlaching, D-81547 Munich, Germany.

E-mail address: f.haasters@web.de (F. Haasters).

Proximal humeral fractures are the seventh most common fracture in adults and the third most in patients older than 65 years.¹⁹ Most proximal humeral fractures are attributable to low-energy trauma in elderly patients.^{3,17} Therefore, these fractures show a steady increase in incidence as the elderly population expands.^{17,19} Most proximal humeral fractures are nondisplaced or mildly displaced and result in appropriate

functional outcome after nonsurgical treatment.^{13,14} Approximately 15% to 20% of all fractures are displaced and treated operatively according to the Neer criteria.^{8,14} Various surgical treatment options are described and still discussed controversially. However, open reduction and internal fixation (ORIF) with locked plating is the most popular treatment of choice.²⁶

Although anatomically precontoured locking plates have been routinely used for more than 1 decade, significant complications related to surgical treatment are still described.¹⁸ Typical complications of locked humeral plating include secondary varus displacement, with or without concomitant cutting out of screws into the glenohumeral joint, avascular necrosis (AVN) of the humeral head, varus malunion, subacromial impingement, hematoma, or infection. The rate of complications described varies widely between 3% and 54%.^{21,24,27} This wide range of reported complications might be due to different study setups (design, follow-up, patient number), different patient populations (age, gender, fracture type and pattern, vascular supply), patient specifics (osteoporosis, other comorbidities, compliance), and the surgeon's personal experience and preference.

Taking these variables into account, whether there is any improvement of our complication rate after locked plate fixation for proximal humeral fractures over the last decade remains unclear. However, we hypothesize that the complication and revision rate has decreased due to a deeper insight into this fracture entity, the identification of risk factors for failure,^{4,5} the use of primary arthroplasty,¹⁵ and the overall learning curve. The aim of the study was to evaluate the complication and revision rate after locked plate fixation of proximal humeral fractures under an invariable institutional study setup over 12 years.

Materials and methods

The study included all patients with unstable proximal humeral fractures according to the criteria by Neer¹⁴ who were treated between February 2002 and December 2013 with ORIF using a PHILOS (Synthes, Oberdorf, Switzerland) or NCB-PH (Zimmer, Warsaw, IN, USA) locking plate, with a primary hemiarthroplasty (HA) using the Aequalis Fracture Shoulder (Tornier, Warsaw, IN, USA), or reversed shoulder arthroplasty (RSA) using the Aequalis Reversed Fracture system (Tornier). Patients were prospectively observed from the time of operation and longitudinally followed up. Informed consent was obtained from all patients.

Perioperative data, including patient characteristics and fracture-specific features were recorded at the in-patient stay. Standard shoulder radiographs were taken routinely at day 1, week 6, and at months 3, 6, and 12 postoperatively to verify fracture alignment and healing. In any case of postoperative complication or if revision surgery was necessary, additional radiographs were obtained until the final treatment had been accomplished. Fractures were classified according to the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association and the Neer classification.^{10,11,13}

The following complications were recorded: loss of fixation, infection, hematoma, or nerve injuries. Loss of fixation was defined

as a decreased head-shaft angulation of $>10^\circ$ in the anteroposterior or lateral plane according to the measuring technique described previously.¹ Any unplanned revision surgery was analyzed. The above-mentioned follow-up was accomplished in 76.4% of all patients included.

Operative technique

An experienced senior trauma surgeon performed the operations, as published previously.¹⁶ Surgery was performed under general anesthesia with the patient in the beach chair position on a radiolucent table. An interscalene block was used as standard perioperative analgesia unless the patient refused it. All patients received prophylactic intravenous antibiotics before the procedure. ORIF was conducted via a deltoid-pectoral approach. The rotator cuff was evaluated for full-thickness tears, and predominant tuberosities were sutured to the plate using nonresorbable FiberWire No. 5 (Arthrex, Naples, FL, USA). Screws were meticulously placed in the subchondral layer not penetrating the articular surface (Fig. 2). No bone grafts or cement augmentation were used to support the fixation. Accurate fracture reduction and correct position of screws were checked during the surgical procedure by use of multiplane fluoroscopy in at least 3 views.

The postoperative rehabilitation protocol consisted of supervised passive and active assisted range of motion starting from postoperative day 1. Abduction and elevation up to 60° , without forced external rotation, were allowed for the first 6 weeks; thereafter, active exercises with full range of motion were started. HA and RSA (Fig. 4) were performed as published elsewhere.^{7,15}

Statistics

Continuous variables are described by means, standard deviation, and percentage of total numbers. Statistical analyses and graphs were performed with SPSS 20 software (IBM Corp, Armonk, NY, USA) and Excel 2011 (Microsoft Corp, Redmond, WA, USA). The χ^2 test of independence was used to test for statistically different distributions of categorical variables.

Results

Demographic data

The study included 788 patients (67.8% women) with displaced proximal humeral fractures. Mean age at surgery was 67.4 ± 17.3 years. The mean age of the population from 2002 to 2004 was 67.2 ± 15.8 years, with 59.3% women, and from 2009 to 2011 was 68.6 ± 14.9 years, with 52.6% women. These differences were statistically not significant ($P = .21$ and $P = .55$, respectively). None of the patients had an open or a pathologic fracture. During the observation period, the number of patients treated operatively increased, although undulations were noticed. Between 2006 and 2008, patient numbers reached a lower plateau. Since 2009, a steadily increasing number of patients with proximal humeral fracture and subsequent surgical treatment were recorded (Fig. 1).

The overall fracture patterns according to the Neer classification were 2-part in 38.3%, 3-part in 39.8%, 4-part in 9.8%,

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