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Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome

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Background: Locking plates for open reduction–internal fixation (ORIF) of proximal humeral fractures are widely used. We observed an unusually high number of patients with complications referred to our institution. It was the purpose of this study to report these complications, as well as their treatment and outcome.

Materials and methods: From 2003 to 2010, all patients treated for complications after ORIF with locking plates for proximal humeral fractures were prospectively collected and retrospectively analyzed. Patients were followed up clinically and radiographically.

Results: In total, 121 patients (67 women and 54 men; mean age, 59 years) were referred after primary locking plate ORIF; 80% had a 3- or 4-part fracture. A mean of 3 complications occurred per patient, including malreduction, primary screw cutout, malunion, nonunion, avascular necrosis, and infection. Secondary screw cutout was found in 57% of patients, causing glenoid destruction in 33% of patients. A mean of 1.5 revision surgeries were needed. Hemiarthroplasty, total shoulder arthroplasty, and reverse shoulder arthroplasty improved the mean Constant score (24 to 55 points, $P < .05$; 29 to 54 points, $P = .3$; and 25 to 48 points, $P < .05$, respectively) after a mean of 24 months. In 6 patients, glenoid implantation was no longer possible because of the destruction by perforated head screws.

Conclusion: In this negatively selected series, complications resulted in secondary arthroplasties in over 50% of the patients. Shoulder function, though improved, remained substantially restricted even after revision surgery. Glenoid destruction by locking screws was the most devastating and previously almost unseen complication, which limited the options of treatment.

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

Keywords: Angular stable implant; locking plate; complications; revision surgery; glenoid destruction; proximal humerus; revision arthroplasty

This retrospective study did not require approval of the institutional review board. All patients gave informed consent to have their data published anonymously.

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More than 80% of fractures of the proximal humerus are nondisplaced or minimally displaced and can be treated conservatively. For displaced and unstable fractures, various techniques of closed or open reduction and fixation are used.

Fracture reduction and anatomic healing become more difficult with a higher number of fragments, with greater

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displacement and comminution of the fragments. Thus, 3- and 4-part fractures, especially in elderly patients with osteopenia, are particularly challenging for surgical treatment.[26] Angular stable implants with rigid fixation of the head and shaft screws have been introduced to specifically address comminuted fractures and improve fixation in osteopenic bone. Today, these implants are increasingly used and widely accepted,[3,6,21,27] but a notable number of complications, with rates of up to 36%, are also reported.[20,25,29] Especially in the case of avascular necrosis (AVN) or secondary varus collapse, the rigid fixation of the head screws seems to be a problem, potentially causing cutout of sharp screw tips with possible joint destruction.[11,20]

During the last several years, an increasing number of complications after treatment of proximal humeral fractures with locking plates have been referred to our institution, which serves as a tertiary referral center for shoulder problems. Some of these complications seem to be new and clearly related to the implant. In particular, iatrogenic destruction of the glenoid due to perforated head screws was previously unknown.

It was the purpose of this study to analyze and group all complications seen in our institution after angular stable fracture treatment of the proximal humerus. Furthermore, we report our treatment strategies and their proper outcome.

Materials and methods

Between January 2003 and September 2010, 121 patients (119 referred patients and 2 patients initially treated at our institution) with complications after open reduction and locking plate fixation of a fracture of the proximal humerus were consecutively collected. There were 67 women and 54 men. The mean age was 59 years (range, 24-85 years) at the time of the fracture.

Of the 121 patients, 114 had complete radiographic follow-up including radiographs of the initial fracture. In 7 patients, the initial fracture radiographs were missing but the remaining films were completely available including the immediate postoperative radiographs after open reduction–internal fixation (ORIF). Therefore, the fractures could be classified in 114 patients (96%). The 114 fractures were classified according to Neer[17] and further analyzed according to Hertel et al.[13] In all 121 patients the PHILOS (proximal humerus interlocking system) plate (Synthes, Paoli, PA, USA) was used. All patients had restricted function because of pain or loss of passive and active shoulder mobility (or both).

Malreduction was considered present when either 1 or both tuberosities or the head fragment were not surgically reduced within 1-cm linear or 45° angular displacement from the normal anatomy. Malunion was considered present when the tuberosities or the head fragment did not heal within 1-cm linear or 45° angular displacement from the normal anatomy. Nonunion was considered established when the fracture line was still visible 8 months after ORIF. AVN was assessed radiographically and considered present when the humeral head had collapsed and had lost its spherical contour. A primary screw perforation was diagnosed when the tips of screws were seen above the cortical level of the head on the postoperative radiograph. The secondary screw cutout was assessed on subsequent radiographs. Furthermore, erosion or destruction on the glenoid side was assessed on radiography and confirmed on computed tomography scans. An infection was defined when cultures from tissue samples at first revision were positive.

The different treatment modalities and number of revisions per patient were assessed.

Clinically, the preoperative Constant and Murley score[5] (CS) and Subjective Shoulder Value (SSV) were determined in all patients who were operated on. In the case of arthroplasty, these scores were repeated after 1, 2, and 5 years or before revision surgery. Patients who were treated conservatively or by joint-preserving procedures were examined without scoring in the outpatient clinic. Clinical data (forward flexion) from these patients were taken from the outpatient charts.

At presentation in our unit, imaging consisted of standard radiographs (including true anteroposterior, in internal rotation, as well as axial and outlet views) and computed tomography scans. After revision surgery, patients were radiographically followed up with standard radiographs.

Statistical analysis

The Mann-Whitney test, the Wilcoxon test and, for normally distributed data, the *t*-test were used. The level of significance was set at $P < .05$.

Results

The different fracture patterns are listed in Table I. The 121 patients were first seen after a mean of 15 months (range, 1-63 months) after the index operation (ORIF). One hundred sixteen patients complained of pain, whereas elevation was restricted to less than 90° in 101 patients.

The shoulders in our cohort had a mean of 3.1 (range, 1-6) of the previously defined complications; their classification is listed in Table II.

Non–implant-related complications

Malreduction (67 patients, 55%)

Initially, 7 two-part fractures and 60 three- or four-part fractures were seen (Fig. 1). In 1 case, a posterior dislocation was missed before, during, and after initial ORIF. Ten of the eleven fractures with head splitting and nine of the thirteen fracture-dislocations had a malreduction.

Primary screw cutout (14 patients, 12%)

Primary screw cutout (14 patients, 12%) was seen frequently together with malreduction (9 patients).

Malunion (76 patients, 63%)

Malunion (76 patients, 63%) was observed in 57 patients after primary malreduction and in 19 patients after secondary displacement. Initially, there were mainly complex fractures (64 patients with 3- or 4-part fractures, 7 with fracture-dislocations, and 10 with head splitting).