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COMPLICATIONS OF LOCKING PLATE FIXATION OF PROXIMAL HUMERUS FRACTURES: A RETROSPECTIVE SERIES OF 16 CASES AND REVIEW OF THE LITERATURE

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ABSTRACT

Introduction: Locking plate fixation is widely used for displaced proximal humerus fractures. It offers stable fixation and allows early mobilisation, but complications remain frequent. The aim of this study was to describe the complications observed after locking plate fixation in our department and to discuss their mechanisms and prevention.

Materials and Methods: We conducted a retrospective study in the Department of Traumatology and Orthopaedics A, Hassan II University Hospital, Fez, from December 2016 to January 2024. Among all patients treated with a locking plate for a proximal humerus fracture, those who presented a complication were included and analysed.

Results: Of 78 patients treated with a locking plate during the study period, 16 (20.5%) presented at least one complication, with a total of 19 complications. Varus collapse of the humeral head was the most frequent (n = 6), followed by adhesive capsulitis (n = 4), intra-articular screw penetration (n = 3), avascular necrosis of the humeral head (n = 3), nonunion (n = 2) and infection (n = 1). In the cases of mechanical failure, the absence of an inferomedial calcar screw was the main technical error identified.

Conclusion: Most complications of locking plate fixation are mechanical and related to a loss of medial support. Correct plate height, restoration of the medial calcar and a well-placed calcar screw are key to prevention. In young patients with complex fractures, augmentation techniques may help; in elderly patients, arthroplasty should be considered.

Keywords: Proximal humerus fracture; Locking plate; Complications; Varus collapse; Medial support; Avascular necrosis.

1 INTRODUCTION

Proximal humerus fractures are common. They mainly affect elderly patients with osteoporotic bone, often after a simple fall from standing height [1]. Most of these fractures are minimally displaced and heal well with non-operative treatment [2,3]. Surgery is discussed for displaced and unstable fractures, especially in active patients.

Locking plates have become one of the most widely used implants for these fractures. The angular stability of the screw-plate construct improves fixation in osteoporotic bone. It allows early mobilisation of the shoulder, which is important for functional recovery [4,5].

However, locking plates have not solved every problem. Large series and systematic reviews report high rates of complications and reoperations [4–7]. Varus collapse, screw cut-out, avascular necrosis and shoulder stiffness remain frequent, and they are still a topic of debate.

The aim of this study was to describe the complications observed after locking plate fixation of proximal humerus fractures in our department, to analyse their mechanisms, and to discuss the technical points that may help to prevent them.

2 MATERIALS AND METHODS

2.1 Study design and setting

We conducted a retrospective, descriptive study in the Department of Traumatology and Orthopaedics A, Hassan II University Hospital, Fez, Morocco. The study period ran from December 2016 to January 2024. During this period, 78 patients were treated with a locking plate for a proximal humerus fracture in our department.

2.2 Patients

We included all patients treated with a locking plate for a proximal humerus fracture who presented at least one complication during follow-up. Patients with incomplete records or lost to follow-up before the diagnosis of a complication were excluded. Fractures were classified according to Neer [8].

2.3 Surgical technique and follow-up

All patients were operated under general anaesthesia, in the beach-chair position, through a deltopectoral approach. Fixation was performed with a proximal humerus locking plate. Postoperatively, the arm was immobilised in a sling for 3 to 4 weeks, depending on the patient, with early passive mobilisation.

Patients were followed clinically and radiologically with standard anteroposterior and lateral (Y) views. Data were collected from medical records, operative reports and radiographs. We recorded age, sex, side, mechanism of injury, fracture type, type of complication, time to diagnosis and management. No standardised functional score was used; function was assessed clinically by shoulder range of motion.

3 RESULTS

3.1 Population

Of the 78 patients operated, 16 presented at least one complication, giving a complication rate of 20.5%. The mean age of these patients was 61 years (range 18–75). The dominant side was involved in 10 cases (62.5%). The mechanism of injury was a simple fall from standing height in 11 cases (68.8%) and a road traffic accident in 5 cases (31.3%). According to Neer, there were 3 two-part fractures, 5 three-part fractures, 5 four-part fractures and 3 head-split fractures. Follow-up ranged from 2 to 6 years.

3.2 Complications

A total of 19 complications were recorded in 16 patients, as three patients had two complications. Varus collapse of the humeral head was the most frequent complication (n = 6), followed by adhesive capsulitis (n = 4). Intra-articular screw penetration and avascular necrosis of the humeral head were each found in three patients. Two patients developed a nonunion and one patient developed an infection (Table 1).

Table 1: Distribution of complications after locking plate fixation (n = 16 patients)

Complication	Number of patients	% of patients (n = 16)
Varus collapse of the humeral head	6	37.5
Adhesive capsulitis (shoulder stiffness)	4	25.0
Intra-articular screw penetration	3	18.8
Avascular necrosis of the humeral head	3	18.8
Nonunion	2	12.5
Infection	1	6.3
Total complications	19*	—

* Three patients had two complications: avascular necrosis of the humeral head associated with intra-articular screw penetration.

All three cases of intra-articular screw penetration occurred in the patients with avascular necrosis: the screws became prominent secondarily, after collapse of the necrotic humeral head. Management depended on the type of complication and on the patient's choice: some patients underwent revision surgery, while others declined further surgery.

3.3 Illustrative cases

Case 1. Fixation was performed with a locking plate without an inferomedial calcar screw. Follow-up radiographs showed progressive loss of reduction, then a nonunion with hardware failure (Figure 1). The patient underwent revision surgery with a long plate and bone grafting.



Figure 1: Case 1. Preoperative radiograph, postoperative control, and follow-up radiographs showing loss of reduction and progression to nonunion with hardware failure. No inferomedial calcar screw was placed

Case 2. The plate was fixed without a supporting calcar screw. The humeral head progressively collapsed into varus, with screws migrating towards the joint (Figure 2). Revision surgery was proposed, but the patient declined it.



Figure 2: Case 2. Anteroposterior radiograph showing varus collapse of the humeral head after locking plate fixation, in the absence of medial calcar support

Case 3. The patient had a head-split fracture of the proximal humerus treated with a locking plate. The fracture healed in a good position, but the patient kept a limited range of motion of the shoulder (Figure 3). At two years, the shoulder remained stiff, and the patient continued physiotherapy.



Figure 3: Case 3. Preoperative anteroposterior and lateral views of a head-split fracture (top), and postoperative radiographs showing healing in a satisfactory position (bottom). Shoulder range of motion remained limited

4 DISCUSSION

Locking plate fixation of proximal humerus fractures carries a high complication rate. Most published series report rates between 17% and 35%, and reoperation rates may reach 25% in some studies [4–7]. In a systematic review of 514

patients, Sproul et al. found an overall complication rate of 49% and a reoperation rate of 14% [6]. Our complication rate of 20.5% falls within this range, and our series confirms that these complications are mainly mechanical.

4.1 Varus collapse and the role of medial support

Varus collapse was the leading complication in our series. Gardner et al. showed that medial support was the only factor that significantly influenced loss of reduction [9]. Patients without medial support lost on average 5.8 mm of head height, compared with 1.2 mm when medial support was present. Screw penetration was also more frequent in the group without medial support [9].

Medial support can be obtained by an anatomic or slightly impacted reduction of the medial calcar, and by an inferomedial oblique locking screw [9,10]. This screw should be placed as close as possible to the calcar, in the inferior part of the humeral head, with its tip in the subchondral bone. Krappinger et al. also identified the lack of medial support and a non-anatomic reduction as predictors of failure [11]. In our two cases of mechanical failure (cases 1 and 2), no calcar screw had been placed, which in our view explains the failure of fixation.

4.2 Avascular necrosis and intra-articular screws

Avascular necrosis of the humeral head is mainly related to the fracture pattern itself. Hertel et al. showed that a short posteromedial metaphyseal extension and a disrupted medial hinge are strong predictors of head ischaemia [12]. Surgical dissection may add to this risk. When the head collapses, the screws become prominent and may penetrate the joint, as seen in our series.

Primary screw perforation during surgery is also frequent and can be avoided by careful fluoroscopic control in several planes [5,13]. Secondary perforation, as in our patients, usually reflects loss of head height. It should be looked for on every follow-up radiograph, because it can quickly damage the glenoid cartilage.

4.3 Plate position and subacromial impingement

Plate position is a key technical point. A plate placed too high can cause subacromial impingement and limit abduction. A plate placed too low gives a poor angle for the calcar screw and reduces medial support. The surgeon should therefore check plate height on the anteroposterior view before locking the screws [4,13].

4.4 Augmentation techniques

When medial support cannot be restored, several augmentation options have been described. Calcium phosphate cement in the metaphyseal void reduced screw penetration and loss of reduction in the series of Egol et al. [14]. An intramedullary fibular strut allograft also improved medial support and reduced complications in the study of Neviasser et al. [15]. Dual plating has been proposed for highly comminuted fractures. These techniques may be most useful in younger patients with complex fractures, where preserving the humeral head is the goal.

4.5 Long-term results

At longer follow-up, a recent study from 2026 with six years of follow-up reported a complication rate of about 25% [16]. The most frequent complications were avascular necrosis and intra-articular screws, often secondary to head collapse, with no nonunion. Range of motion and the Constant score were generally satisfactory. However, patients kept a loss of strength in forward elevation and external rotation [16]. A 2026 meta-analysis of long-term studies also found acceptable but variable function, with a considerable burden of late complications and secondary procedures [17].

4.6 Fix or replace?

The choice of treatment depends largely on the patient's age and bone quality. Most proximal humerus fractures can be treated non-operatively, and the PROFHER trial found no benefit of surgery for most displaced fractures in adults [2]. In elderly patients with complex fractures, reverse shoulder arthroplasty is increasingly preferred [18]. The most difficult decisions concern younger patients with comminuted three- or four-part fractures. In these patients, the quality of the stability obtained at surgery is the key to success.

4.7 Limitations

This study has several limitations. It is retrospective and includes a small number of patients. Only patients with complications were analysed in detail, so risk factors could not be compared with patients who had an uneventful course. Functional outcomes were not assessed with a standardised score. Larger prospective studies are needed.

5 CONCLUSION

Locking plates remain an effective option for displaced proximal humerus fractures, but their complications are frequent and often mechanical. Most of them are linked to a loss of medial support. A correct plate height, a restored medial calcar and a well-placed inferomedial calcar screw are the main ways to prevent them. Augmentation with cement, bone graft or a second plate may help in difficult cases. In the end, the patient's age and bone quality guide the key decision: fix or replace.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

Statement of ethical approval

This retrospective study was conducted in accordance with the Declaration of Helsinki. The study was approved by the local ethics committee. Patient data were anonymised.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study, including consent for the publication of anonymised radiographs.

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