Case Report

Early failure of a locked titanium plate in a proximal humeral fracture: Case report and metallurgic analysis

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ABSTRACT

Angular stability locking plates are commonly used in proximal humeral fractures, especially in old patients with osteoporotic bones. These implants show good results in short and midterm follow-up, but complications are not uncommon. Here we present a case report to describe a case of early failure of a proximal angular stability plate implanted in a 72 years old female with a highly unstable two part proximal humeral fracture. An optical and metallurgic analysis was also conducted to study the modalities of failure. We concluded that anatomic reduction and restoration of the medial cortical support are crucial in order to minimize the mechanical load on the bone-metal interface and to prevent mechanical failure, in particular when the fracture rim drop in the weak point of the plate that was found in the proximal two symmetric holes (Holes E).

Introduction

Angular stability locking plates are commonly used in proximal humeral fractures. These plates are specifically designed with the aim to reduce hardware complications and to obtain a more stable fixation. These implants show very good results at mid-term follow-up, in term of stability and rate of union [1], even if this procedure is technically demanding and many complications can occur intra- and peri-operatively [2]. Few descriptions have been reported about early failure of these implants. We describe the case of mechanical failure with hardware optical and metallurgic analysis.

Case report

A 72 years old female reported a highly dislocated two part proximal humeral fracture below the surgical neck: 1.1.A.3 fracture according to AO classification or two part fracture according to Neer classification (Fig. 1).

The fracture was treated by open reduction-internal fixation (ORIF) with a Philos Plate (Synthes® Gmbh, Solothurn, Switzerland), which was implanted through a deltopectoral approach (Fig. 2). After surgery the patient dressed a sling for three weeks, before starting a standard rehabilitation protocol with increasing active and passive motion. The four weeks radiographic controls showed good reduction and stable fixation of the fracture. Three months after surgery the patient suffered of acute local pain and complete loss of function without any trauma. The X-ray showed a complete breakage of the plate near the fracture site, at the level of the...
The patient underwent revision surgery: the plate was removed and the fracture was reduced and stabilized with a proximal humeral nail (T2-Styker®) (Fig. 4). Demineralised bone matrix (DBM) (Allomatrix-Wright®) was used as adjuvant at the fracture site.

At 2 year follow up, excellent functional results were demonstrated by VAS (0 mm.), SF-12 (40) and RA Constant Score (81 vs 81) evaluations.

At the time of the surgical revision, plate failure and bone non-union were observed. The two parts of the plate were collected for metallurgic analysis.

Instrumental examination of the plate breakage surface had been carried out using a Wild stereomicroscope (Heidelberg, Germany) and then were analysed by FEG-SEM (LEO 1530, Oberkochen, Germany) equipped with a backscatter CENTAURUS detector.

The plate breakage took place in the section characterized by the presence of two threaded holes located at the same level (Holes E). The analysis was focused on the breakage surface of the two bridges marked A and B (Fig. 5).

The low magnification image of the fracture surface of the central bridge A was characterized by a globular waved structure, characteristic of the fatigue failure (Fig. 5A). The SEM analysis of the fracture surface A B shows a wavy pattern (Fig. 5B) and evidence the springing out point at the left high corner of the bridge section (Fig. 5C). The striation remarked in the intragranular fracture surfaces is typical of fatigue rupture.

No metallurgical or tooling defects, inclusions or porosities were observed in both the fracture initiation sites. The stereomicroscopic inspection of the other bridges of the plate evidenced another crack already developed in a third site, between the surgical humeral neck (Fig. 3).

Fig. 1. Dislocated two-part proximal humeral fracture in a 72 years old female. Antero-posterior X-ray and coronal view at CT-Scan.

Fig. 2. Postperative X-Ray showing ORIF with a Philos plate.
anterior hole in position C and the D hole. The crack crosses the bridge side to side. Several other smaller fatigue initiation cracks were found in the rims of thinner zone of other bridges of the plate.

Discussion

Plating systems for proximal humeral fractures are strongly debated because of the many complications described in the literature. The rigid fixation allowed by locking plates has been suggested to improve mechanical stability and should result in better outcomes compared to traditional plate fixation without locking system [3].

However, plating of proximal humeral fractures is a demanding surgical procedure and even in case of correct surgical indication, technical errors may occur [4]. Other complications are related to the specific design of the implant [5], to the fracture morphology or to secondary osteonecrosis. In the few other reported failures, the humeral fracture line was oblique, from lateral to medial,
unstable with a certain degree of comminution, and the dislocation was in varus. In addition the failure was at the level of the E zone and the fracture line was at the same level, like in the case of the present work [7].

Sufficient length of the plate should prevent implant failure due to stress fracture [6]. All screw holes should be filled in order to

Fig. 5. The breakage surface: metallurgic analysis (A/B/C).
minimize the bending moments on the locking plates [8].

The increased number of screws in the humeral head may affect the fracture healing and the perfusion of the humeral head, even if it would increase the fixation strength. The optimal rigidity of the implants for the fixation of proximal humerus fractures is controversial in literature [9]. Rigid implants allow for early and more aggressive rehabilitation in young patients with good bone quality. In the elderly, however, they may fail due to an insufficiency of the bone–metal interface during cyclic loading, while more elastic implants may reduce the strain on the interface by absorbing part of the energy. Hertel states that an optimal reduction is the key issue to improve the longevity of fixation [10]. In our opinion, anatomic reduction and restoration of the medial cortical support might be more important than hardware characteristics. In our case the fixation stability, the anatomic reduction and the restoration of the medial cortical support were explored intraoperatively under fluoroscopic dynamic amplification and confirmed on post-operative X-ray. In this case the forces acting on the proximal fragment have caused bending moments on the plate at the fracture level. Cyclic loading above the fatigue limit of titanium alloy determined the fracture of the plate. Tolat described a fatigue failure with no manufacture defect [7]. Our study confirmed these results and found a fatigue rupture characterized by a globular waved structure; mainly the combination of two factors has led to the failure of the plate: the type of fracture and the positioning of the E holes of the plate at the same level of the fracture line.

The plate design with two holes for the screws at the same level determine a low strength section in the device. When the fracture line is opposed to this section fatigue fracture may occur, especially in unstable humeral fractures. The anatomic reduction and restoration of the medial cortical support are crucial in order to minimize the mechanical load on the bone–metal interface.

To improve the implant resistance it may be appropriate to avoid the positioning of the two screw holes at the same level of the fracture. It is clear that a lack of medial support will leave the lateral plate exposed to large bending effects.

**Conclusion**

Surgeons should be aware of the risk of fixation failure in elderly patients with low BMD and in oblique unstable neck fracture of the humerus. To prevent a possible plate breakage, the surgeon should place the weak section of the plate (E zone) slightly above or below the line of the fracture. If this is not possible, we suggest the use of a different method of fixation.

**Disclosure**

There are no identified conflicts of interest identified by any authors involved in this research. There was no financial or grant support of this case report.

**References**

[1] F. Brunner, C. Sommer, C. Bahrs, et al., Open reduction and internal fixation of proximal humerus fractures using a proximal humeral locked plate: a prospective multicenter analysis, J. Orthop. Trauma 23 (2009) 16372.

[2] N. Sudkamp, J. Bayer, P. Hepp, et al., Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study, J. Bone Joint Surg. Am. 91 (2009) 1326–1328.

[3] K. Seide, J. Triebe, M. Faschingbauer, et al., Locked vs. unlocked plate osteosynthesis of the proximal humerus—a biomechanical study, Clin. Biomech. (Bristol, Avon) 22 (2007) 176–182.

[4] J. Agudelo, M. Schurmam, P. Stahel, P. Helwig, S. Morgan, W. Zechel, et al., Analysis of efficacy and failure in proximal humerus fractures treated with locking plates, J. Orthop. Trauma 21 (2007) 676–681.

[5] H. Lilli, P. Hepp, J. Komer, J. Kassi, A. Verheyden, C. Josten, et al., Proximal humeral fractures: how stiff should an implant be? A comparative mechanical study with new implants in human specimens, Arch. Orthop. Trauma Surg. 123 (2004) 74–81.

[6] M.J. Gardner, J.E. Voos, T. Wanich, D.L. Helfet, D.G. Loric, Vascular implications of minimally invasive plating of proximal humerus fractures, J. Orthop. Trauma 20 (2006) 602–607.

[7] A.R. Tolat, A. Amis, S. Crofton, J. Sinha, Failure of humeral fracture fixation plate in a young patient using the Philos system: case report, J. Shoulder Elb. Surg. 15 (6) (2006 Nov-Dec) e44–e47 (Epub 2006 Sep 28).

[8] D.S. Drosdowech, K.J. Faber, G.S. Athwal, Open reduction and internal fixation of proximal humerus fractures, Orthop. Clin. North Am. 39 (2008) 429–439.

[9] P.C. Siffri, R.D. Peindl, E.R. Coley, et al., Biomechanical analysis of blade plate versus locking plate fixation for a proximal humerus fracture: comparison using cadaveric and synthetic humeri, J. Orthop. Trauma 20 (2006) 547–554.

[10] R. Hertel, A. Hempfling, M. Stichler, M. Leunig, Predictors of humeral head ischemia after intracapsular fractures of the proximal humerus, J. Shoulder Elb. Surg. 13 (2004) 132–136.