Locking Plates in Proximal Humerus Fractures

Zamykací dlahy u zlomenin proximálního humeru

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SUMMARY

It is well known that proximal humerus fractures are among the three most frequent fracture types. Epidemiological invetsigations show that in people elder than 60 years the fracture of the proximal humerus is more frequent than fractures of the hip region (17).

Over the last decades several techniques have been applied for treatment of proximal humerus fractures. Widely accepted is the initiation of a conservative treatment regimen for undisplaced fractures, however, the standard treatment for displaced fractures, especially three and four part fractures, is still the center of scientific debate. Many different implants have been tested and investigated, thus demonstrating lack of sufficient results. Over the last years the development of angle stable, locking implants started and clinical studies demonstrated encouraging results.

In our clinic the locking proximal humerus plate and the PHILOS plate advanced to the implant of choice for treatment of displaced proximal humerus fractures. There are still cases of implant failure and humerus head necrosis, but most of these complications were caused by the fracture type and not an implant specific problem. However the overall results with these new implants are encouraging.

Key words: locking plates, proximal humerus fracture, humerus, humerus fracture, PHILOS, PHP.

INTRODUCTION

Apart from the distal fracture of the radius and fractures adjacent to the hip joint the proximal humerus fracture is the most common fracture in elderly people. Fracture of the proximal humerus, representing 5 % of all extremity fractures, is a common fracture in everyday clinical life. According to data in the literature the incidence in the total population is 70/100,000 per annum, but this rises in women over 70 years to 400/100,000 per annum (14). In contrast to the more common indirect type of accident amongst older people, injury in younger people is likely to be the consequence of high-energy trauma.

Operative stabilization of fractures of the humeral head is still a surgical challenge and remains the subject of many clinical and experimental investigations. The large number of implants currently available on the market, and the different recommendations for operative stabilization procedures reflect the problems involved with this injury and its treatment. From the point of view of evidence-based medicine it is still not possible to define the "gold standard" for stabilization of fractures of the humeral head (11, 29).

New findings about the biomechanics and pathophysiology of bones and soft tissue have in recent years influenced and pointed the way in the design and function of new forms of osteosynthesis. In particular, the development of locking implants has strongly influenced modern surgical techniques.

SPECIAL ANATOMY OF THE PROXIMAL HUMERUS

Due to the particular blood flow situation in the area of the proximal humerus it is known that the risk of a necrosis developing in the humeral head as a result of surgical manipulation is high and can result from the fractures alone. The blood supply of the proximal humerus is provided mainly by the circumflex humeral arteries, which branch off the axillary artery. The ascending branch running through the area of the bicipital groove is significant as it also flows through a substantial part of the calvaria (4, 9). More recently, using more refined preparation and drainage techniques, additional periosteal irradiating vessels were identified in the area of the lesser tubercle in the humeral head. This periosteal blood flow is only disturbed when the humeral head suffers gross dislocation and usually continues to ensure residual blood flow to the calvaria. Studies also show that the periosteal blood flow plays an important role in the area of the calcarine spur and that the size of the fracture fragment and the extent of the dislocation permits conclusions to be drawn about the risk of necrosis developing in and around the humeral head (13). Manipulation during surgery can also slightly upset or even destroy the blood flow. Blood flow is usually further reduced by the pressure of conventional plates/screws on the periosteum. This problem is eliminated by the use of locking implants.

FRACTURE TYPES AND CLASSIFICATIONS, DIAGNOSTICS

Codman drew up a classification in 1934, which was for the first time based on classification of the four segments, i.e. the greater tubercle, the lesser tubercle, calvaria and shaft. The classification now most widely used was compiled by Neer, based on this 4 fragment classification and is divided into 6 groups. According to the Neer Classification there is an indication for surgery where there is an involvement of all 4 fragments with a dislocation of the fragments of at least 0.5–1 cm or with more than 45° tilt (24, 25). Various studies have however shown that there are difficulties with the practical application of this classification (1, 3, 18, 28).

It has not been possible to generally implement the AO Classification according to Müller et al. (16, 23, 28).

The low reliability of these classifications causes difficulties in the numerous clinical comparative studies. According to accident records, which often lack technical details, but which have to be used as a main basis for classification, the question arises whether it is possible at all to make a precise assessment of the degree of dislocation of the individual segments using these initial records. However, taking conventional X-rays in 1 to 3 planes is still the standard diagnostic procedure for the proximal humerus. If the extent of the fracture cannot be assessed a computed tomography scan is indicated (3). This is especially helpful if there is a possibility of a comminuted fracture of the calvaria and of so-called "Head-Split Fractures", which the classifications do not describe adequately. We still consider Codman's classification to be practical, as it is not based on the dislocation of the individual fragments, which is difficult to assess, but focuses on the instability of the fragments affected.

TREATMENTS FOR FRACTURES OF THE PROXIMAL HUMERUS

Although Neer intended his classification to be an aid for determining the indications for conservative or surgical treatment of proximal humerus fractures (24, 25), it has not, in the end, according to the criteria of evidence-based-medicine, resulted in a final "gold standard" for the treatment of proximal humerus fractures (11, 29). The advantages and disadvantages of both conservative and surgical procedures are still discussed controversially and both very good and also poor outcomes for both procedures are described (6, 26). However, there are still not many prospective or even randomized studies with locking implants. Our own prospective trial is still currently in progress.

In our clinic we tend to advocate a surgical procedure, as we are seeing good results with locking implants even where the bone quality is bad and in our opinion shoulder function profits from the possibility of early functional rehabilitation.

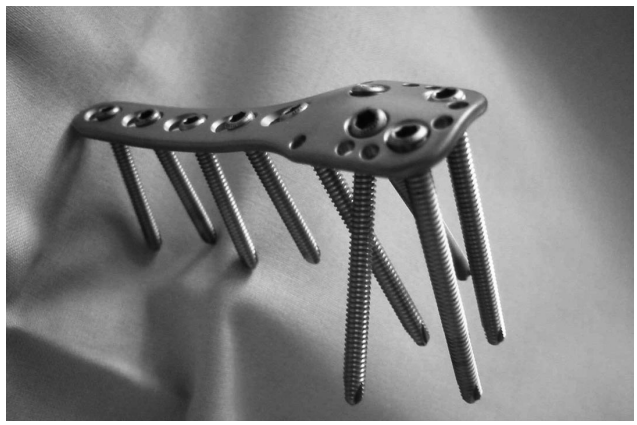

Fig. 1. Locking Proximal Humerus Plate (LPHP).

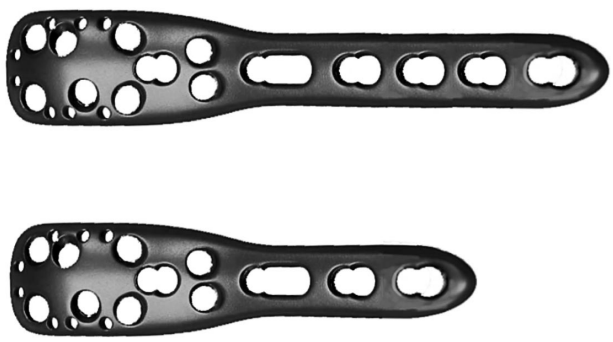

Fig. 2. Proximal Humerus Internal Locking System (PHILOS Plate), standard with 3 and 5 wholes for the shaft. In the region of the humeral head there are more different possibilities for placing screws.

THE ADVANTAGES OF THE LOCKING PLATE AT THE PROXIMAL HUMERUS

The new locking plates, designed especially for fixation procedures on the proximal humerus, have been developed giving special consideration to the specific characteristics of this anatomical region. The plates have a low profile and are not therefore very bulky. This means that, on the one hand, the soft tissue is only compromised a little during the procedure and, in addition, the danger of a post-operative impingement syndrome by the plate is lower.

The plates are also bio-mechanically not as stiff as other implants designed for this region, which has a positive effect on load capacity and is also better suited to osteoporotic bones; furthermore, the plates sit very firmly in the bone due to the (converging/diverging) screw orientation and the locked screw anchorage (19). The locking head screws ensure that the periosteal blood flow is not too severely impaired which stimulates the healing of the fracture and counteracts the danger of a necrosis of the humeral head. In addition, functional physiotherapy can be started directly after the operation due to the locked fixation of the fragments, without the risk of the screws becoming loose and/or secondary loss of reduction.

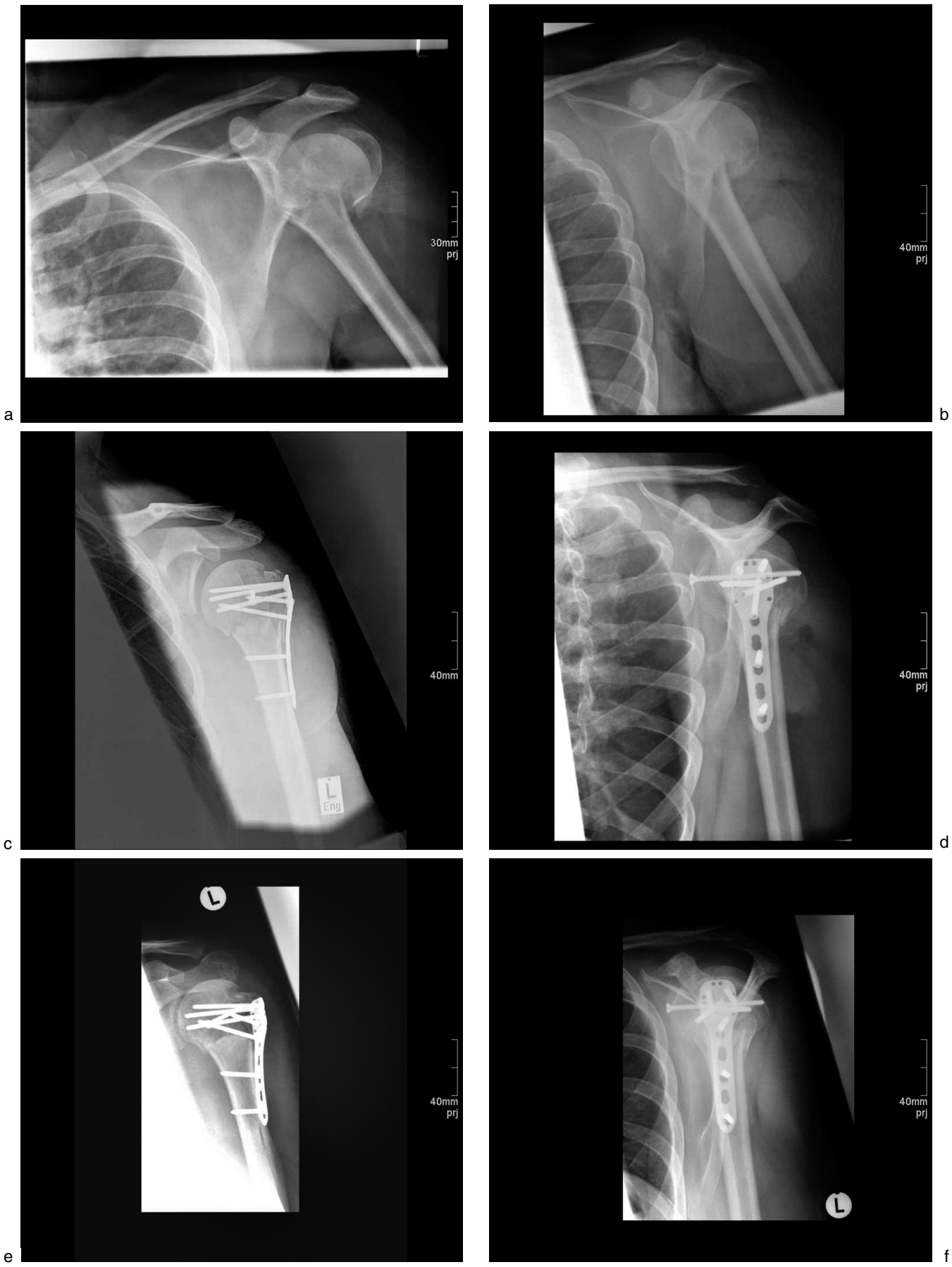

Fig. 3a–f. Four part fracture according to the Codman classification (a, b). Radiographs after stabilization with a LPHP (c, d). Follow-up after 12 weeks (e, f).

Fig. 4a–f. Four part fracture according to the Codman classification (a, b). Radiographs after stabilization with a PHILOS plate (c, d). Follow-up after 14 weeks (e, f).

THE LOCKING PLATES

In our department we used in formertimes the LPHP (Locking Proximal Humerus Plate, Fig. 1) and nowadays the PHILOS (Proximal Humerus Internal Locking System, Fig. 2) as the standard implant for the stabilization of proximal humerus fractures. There are only slight differences between both plates. The PHILOS plate is preferred for long fractures because the plate is available in longer sizes and may possibly provide greater stability as it has a greater number of screws in the head area and greater variability and perhaps higher stability for certain fractures.

The form of both plate systems is anatomical and shaped to accommodate the junction of the humeral head and the shaft. In the area of the humeral head the plate has, in addition to the holes for the locking head screws, small holes in order to fix the rotator cuff with sutures or cerclage wires. The screw holes of the plates in the area of the humeral head have been designed exclusively for the insertion of locking head screws for safer fragment fixation. The holes are drilled either with an aiming device, or through the LCP drill sleeves and, after length measurement, the locking head screws are inserted. The special arrangement of the locking head screws ensures a high level of stability. This does not result from the angular stability alone but also from the partly converging (and also diverging) angulation of the screws. Due to its flat profile the plate can also be fixed in a very proximal position, without causing impingement later when the range of motion is good. With the locking system there is also in principle the possibility of inserting the plate via a minimally invasive approach in the manner of a biological ostesynthesis. In our experience however this technique is still reserved for more simple types of fractures, although good results have also been reported for more severe fracture patterns (7, 8, 20).

In the shaft area different plate fixation techniques are possible due to the combination holes provided by the LCP, permitting insertion of different types of screw. Conventional small fragment screws can also be introduced, on the one hand as compression screws, on the other hand, as lag screws or to hold individual fragments.

Longer versions of the plate can stabilize complex fractures long-term, or fractures where shorter implants have pulled out.

Even good results are described with other locking plates at the proximal humerus, but we do not have our own experience of these implants (15, 21, 22, 30).

SURGICAL TECHNIQUE

Our patients are positioned with the injured shoulder on a side table in normal supine position. The procedure is performed in general anaesthesia. According to our experience the intraoperative flouroscopy is better possible in supine position than in beach chair position. After analysing the shoulder images revealed by flouroscopy the operative field was draped and prepaired in sterile fashion. The deltopectoral approach is used and the cephalic vein is visualized and retracted laterally. Minimal invasive meticulous soft tissue dissection is performed until the fracture site is visualized. The humeral head is reduced carefully by the insertion of a rasparatorium. Temporary retention is performed by two or three K-wires. Then, the plate is positioned lateral of the intertubercular sulcus. To avoid an impingement it is important to place the plate not to far cranially. The plate is then fixed with angle stable screws on the humeral head and shaft. Position of plate and screws are checked by flouroscopy, even to see the length of the screws and to give the possibility to change them intra-operatively. The tendons of the rotator cuff and the tubercula are fixed to the plate with PS-sutures if necessary. In some cases it is indicated to stabilize the greater tubercle with a single screw (Fig. 3).

As already mentioned above as an alternative to the standard approach a minimally invasive approach can also be chosen, in which case the longitudinal incision is in the direction of the fibers above the deltoid muscle while taking care not to injure the axillary nerve (7, 8, 20). Reduction can be supported by the use of percutaneous K-wires and a bone rasp (10).

CONCLUSION

The first published results for locking plates at the proximal humerus as well as our own experiences are very promising (2, 5, 7, 12, 27). Where there is a relevant indication we currently see stabilization with a locking plate fixation procedure as the treatment of choice for dislocated multifragmentary fractures of the proximal humerus, especially in less mineralized bone for example osteoporotic bone. In our own clinic we are currently running a prospective study with the LPHP for cases of fresh multifragmentary fracture of the humeral head.

Operative stabilization of this injury, especially in view of its frequency, will certainly remain a topical subject in future. At the moment, however, the LPHP and the PHILOS plates are the standard implants for injuries of the proximal humerus in our clinics and in many others. In our opinion, locking implants will also gain acceptance primarily for use in this anatomical region.

References

1. BERNSTEIN, J., ADLER, L. M., BLANK, J. E., DALSEY, R. M., WILLIAMS, G. R., IANNOTTI, J. P.: Evaluation of the Neer system of classification of proximal humeral fractures with computerized tomographic scans and plain radiographs. J. Bone Jt Surg., 78-A: 1371–1375, 1996.
2. BJORKENHEIM, J. M., PAJARINEN, J., SAVOLAINEN, V.: Internal fixation of proximal humeral fractures with a locking compression plate: a retrospective evaluation of 72 patients followed for a minimum of 1 year. Acta orthop. scand., 75: 741–745, 2004.

3. BRIEN, H., NOFTALL, F., MACMASTER, S., CUMMINGS, T., LANDELLS, C., ROCKWOOD, P.: Neer's classification system: a critical appraisal. J. Trauma, 38: 257–260, 1995.
4. DUPARC, F., MULLER, J. M., FREGER, P.: Arterial blood supply of the proximal humeral epiphysis. Surg. Radiol. Anat., 23: 185–190, 2001.
5. FANKHAUSER, F., BOLDIN, C., SCHIPPINGER, G., HAUNSCHMID, C., SZYSZKOWITZ, R.: A new locking plate for unstable fractures of the proximal humerus. Clin. orthop., 176–181, 2005.
6. FJALESTAD, T., STROMSOE, K., BLUCHER, J., TENNOE, B.: Fractures in the proximal humerus: functional outcome and evaluation of 70 patients treated in hospital. Arch. Orthop. Trauma Surg., 125: 310–316, 2005.
7. GALLO, R. A., ZEIDERS, G. J., ALTMAN, G. T.: Two-incision technique for treatment of complex proximal humerus fractures. J. Orthop. Trauma, 19: 734–740, 2005.
8. GARDNER, M. J., GRIFFITH, M. H., DINES, J. S., LORICH, D. G.: A minimally invasive approach for plate fixation of the proximal humerus. Bull. Hosp. Jt Dis., 62: 18–23, 2004.
9. GERBER, C., SCHNEEBERGER, A. G., VINH, T. S.: The arterial vascularization of the humeral head. An anatomical study. J. Bone Jt Surg., 72-A: 1486–1494, 1990.
10. GERBER, C., WERNER, C. M., VIENNE, P.: Internal fixation of complex fractures of the proximal humerus. J. Bone Jt Surg., 86-B: 848–855, 2004.
11. GIBSON, J. N., HANDOLL, H. H., MADHOK, R.: Interventions for treating proximal humeral fractures in adults. Cochrane Database Syst. Rev., CD000434, 2002.
12. HENTE, R., KAMPSHOFF, J., KINNER, B., FUCHTMEIER, B., NERLICH, M.: Treatment of displaced 3- and 4-part fractures of the proximal humerus with fixator plate comprising angular stability. Unfallchirurg, 107: 769–782, 2004.
13. HERTEL, R., HEMPFING, A., STIEHLER, M., LEUNIG, M.: Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J. Shoulder Elbow Surg., 13: 427–433, 2004.
14. HESSMANN, M., GEHLING, H., GOTZEN, L.: Proximal humerus fracture in advanced age. Langenbecks Arch. Chir. Suppl. Kongressbd., 113: 907–909, 1996.
15. KINZL, L., GEBHARD, F.: Winkelstabile Plattenosteosynthesen – Die NCB-PH winkelstabile Humerusplatte. In: Lill, H. ed.: Die proximale Humerusfraktur. Stuttgart, New York, Thieme 2006, 108–112.
16. KOSTLER, W., STROHM, P. C., SUDKAMP, N. P.: New techniques for bone synthesis on the humerus. Chirurg., 73: 969–977, 2002.
17. KOSTLER, W., STROHM, P. C., SUDKAMP, N. P.: Proximal humerus fracture in advanced age. Treatment with fixed angle plate osteosynthesis. Chirurg, 74: 985–989, 2003.
18. KRISTIANSEN, B., ANDERSEN, U. L., OLSEN, C. A., VARMARKEN, J. E.: The Neer classification of fractures of the proximal humerus. An assessment of interobserver variation. Skeletal Radiol., 17: 420–422, 1988.
19. LILL, H., HEPP, P., KORNER, J. 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: 74–81, 2003.
20. LILL, H., HEPP, P., ROSE, T., KONIG, K., JOSTEN, C.: The angle stable locking-proximal-humerus-plate (LPHP) for proximal humeral fractures using a small anterior-lateral-deltoid-splitting-approach – technique and first results. Zbl. Chir., 129: 43–48, 2004.
21. LUNGERSHAUSEN, W., BACH, O., LORENZ, C. O.: Locking plate osteosynthesis for fractures of the proximal humerus. Zbl. Chir., 128: 28–33, 2003.
22. MÜCKTER, H., HERZOG, L., BECKER, M., VOGEL, W., MEEDER, P., BUCHHOLZ, J.: Die winkel- und rotationsstabile Osteosythese proximaler Humerusfrakturen mit der Humerus-Fixateurplatte. Chirurg., 72: 1327–1335, 2001.
23. MÜLLER, M., NAZARIAN, S., KOCH, P., SCHATZKER, J.: The comprehensive classification of fractures of the long bones. Berlin, Heidelberg, New York, Springer 1990.
24. NEER, C. S.: Displaced proximal humeral fractures. I. Classification and evaluation. J. Bone Jt Surg., 52-A: 1077–1089, 1970.
25. NEER, C. S.: Displaced proximal humeral fractures. II. Treatment of three-part and four-part displacement. J. Bone Jt Surg., 52-A: 1090–1103, 1970.
26. OLSSON, C., NORDQUIST, A., PETERSSON, C. J.: Long-term outcome of a proximal humerus fracture predicted after 1 year: a 13-year prospective population-based follow-up study of 47 patients. Acta Orthop., 76: 397–402, 2005.
27. PLECKO, M., KRAUS, A.: Internal fixation of proximal humerus fractures using the locking proximal humerus plate. Oper. Orthop. Traumatol., 17: 25–50, 2005.
28. SIEBENROCK, K. A., GERBER, C.: The reproducibility of classification of fractures of the proximal end of the humerus. J. Bone Jt Surg., 75-A: 1751–1755, 1993.
29. TINGART, M., BÄTHIS, H., BOUILLON, B., TILING, T.: Die dislozierte proximale Humerusfraktur: Gibt es gesicherte Therapiekonzepte? Chirurg, 72: 1284–1291, 2001.
30. WIEDEMANN, E., ZEILER, C.: Winkelstabile Plattenosteosynthesen – Die Humeral Suture Plate. In: Lill, H. ed.: Die proximale Humerusfraktur. Stuttgart, New York. Thieme 2006: 112–117.

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