

# Proximal Humerus Fractures – Current Treatment Options

## Zlomeniny proximálního humeru – současné možnosti léčby

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### SUMMARY

Proximal humerus fractures represent an increasing challenge for the health system due to epidemiological changes. As estimated by a Finnish study group the number of fractures may triple by the year 2030. The majority of patients with these fractures are older than 60 years and in this population most of the proximal humerus fractures have been related to osteoporosis. Nondisplaced fractures and fractures with minimal displacement and adequate stability are usually successfully treated non-operatively. The main challenge in the operative treatment of displaced and unstable proximal humerus fractures is to achieve effective stabilization of an adequately reduced fracture to maximize the functional patient outcome. Especially in osteoporotic bone and comminuted fractures operative stabilization is challenging and the management of displaced and unstable fractures remains controversial. The most important factor for favourable results in the treatment of complex three-part or four-part humerus fractures is anatomic reduction. Minimal exposure, high primary stability, and load transfer through the implant are important for avoiding complications such as secondary dislocation, osteonecrosis, and stiffness. Recently invented implants with angular stability provide better biomechanical properties and enhanced anchorage especially in the osteoporotic bone. These implants therefore have a potential for achieving better results in the treatment of these complex injuries.

### INTRODUCTION

The goal of treatment for proximal humerus fractures is restoration of a painless shoulder with satisfactory patient functional outcome. Nondisplaced fractures and fractures with minimal displacement and adequate stability are usually successfully treated non-operatively (13, 28, 57). In contrast, the management of displaced and unstable fractures remains controversial. Especially in osteopenic bone and comminuted fractures internal fixation remains an unsolved problem, leading to unpredictable results. A variety of treatment techniques has been proposed including open reduction and internal fixation with proximal humerus plates, hemiarthroplasty as well as percutaneous or minimally invasive techniques such as pinning, screw osteosynthesis and intramedullary nails (27, 37, 43, 44, 48, 52, 55). However, several complications have been described using these techniques including implant failure, loss of reduction, nonunion or malunion of the fracture, impingement syndrome and avascular necrosis of the humeral head (21, 30, 35, 54). The aim of this article is to provide an overview over the epidemiology, classification, current treatment options and complications in proximal humerus fractures.

### EPIDEMIOLOGY

Proximal humerus fractures account for approximately 5% of all fractures and represent the third most fre-

quent fracture in elderly patients (16). More than 70% of patients with these fractures are older than 60 years and 75% are women (29). In the elderly population, most of these fractures are related to osteoporosis (24). 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 (20). Risk factors are considered low bone mass, personal history of fractures, low level of physical activity, poor vision, insulin-dependent diabetes and alcohol consumption. Suggested possible fall-related risk factors are seizure medication, depression, use of a hearing aid and left-handedness (8). In contrast to the more common indirect type of accident amongst older people, injuries in younger people are likely to be the consequence of a high-energy trauma.

### CLASSIFICATION

1934 Codman described four major fragments in proximal humerus fractures: the head, the lesser tuberosity, the greater tuberosity, and the shaft. A fracture of the proximal humerus can separate one, two, or three of the four major segments from the rest, therefore Codman classified proximal humerus fractures as 2-part, 3-part and 4-part fractures.

To assess the vascular status of the humeral head the Hertel radiographic criteria for perfusion of the humeral head are useful (18). In the Hertel criteria, metaphyseal extension of the humeral head of < 8 mm and medial

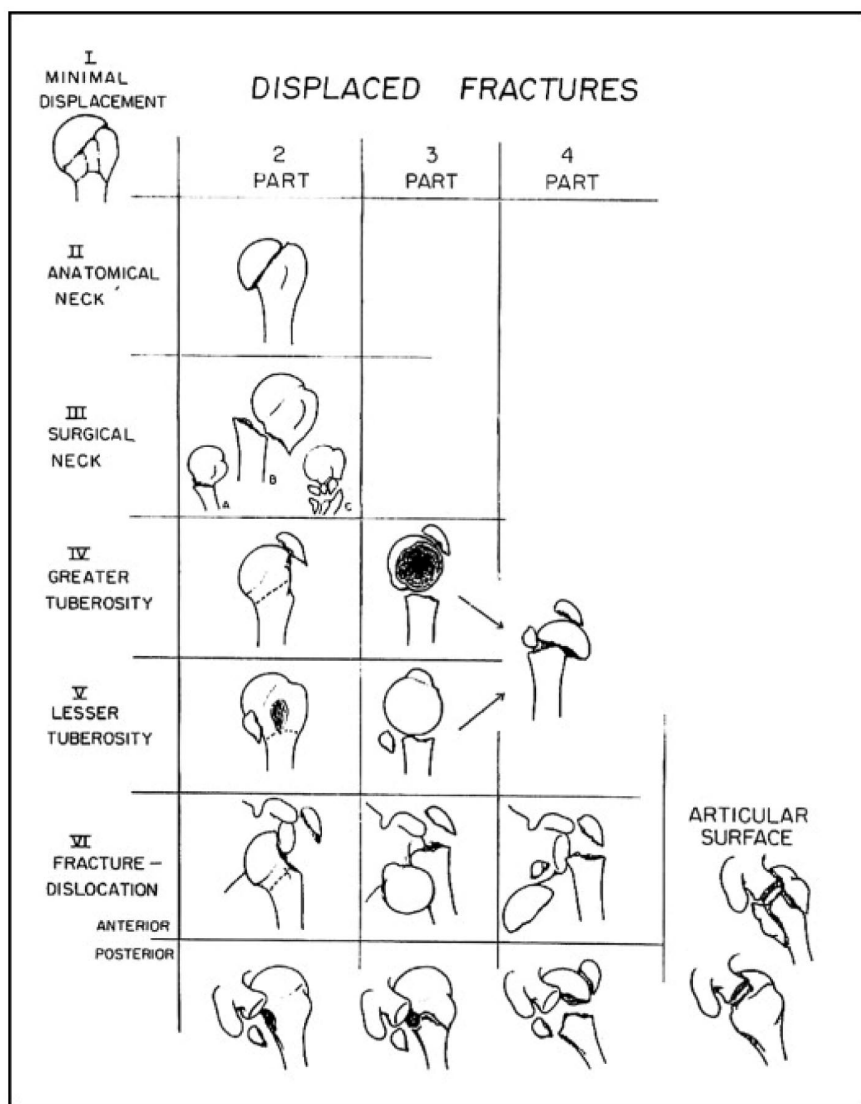


Figure 1. Neer classification of proximal humerus fractures.

hinge disruption of > 2 mm were determined to be good predictors of ischemia. The combination of metaphyseal extension of the humeral head, medial hinge disruption of > 2 mm, and an anatomic neck fracture pattern had a 97% positive predictive value for humeral head ischemia.

Nowadays commonly used classifications are the Neer classification and the AO/ASIF classification (38). Neer's classification-system is based on Codman's four fragment classification and is divided into 6 groups. All fractures with a displacement <1 cm and an angulation below 45° are classified together in group I. The other groups are determined by the number of fracture fragments, involvement of the articular surface and the direction of dislocation (Fig. 1). The AO/ASIF classification system for proximal humerus fractures classifies fractures based on the degree of articular involvement and probability of vascular injury according to the general ABC-System of fracture classification (Fig. 2).

Both the Neer and the AO/ASIF classification systems suffer from a poor interobserver reliability and inadequate

predictability of clinical outcome. Furthermore they are not user-friendly for everyday use and often do not correspond to reality at surgery (3). The low reliability of these classifications may cause difficulties in clinical comparative studies. However, training may improve agreement among doctors using the Neer system (6). We still consider Codman's classification to be the most practical since it is not based on the dislocation of the individual fragments, which is sometimes difficult to assess, but focuses on the instability of the affected fragments.

### CONSERVATIVE TREATMENT

Non-operative treatment is a well established management in minimally displaced fractures and two-part fractures, which comprise up to 85% of all proximal humerus fractures. Gaebler et al. (13) analyzed 507 consecutive minimally displaced proximal humerus fractures. 376 patients were followed for one year and 88% achieved excellent or good results with non-operative

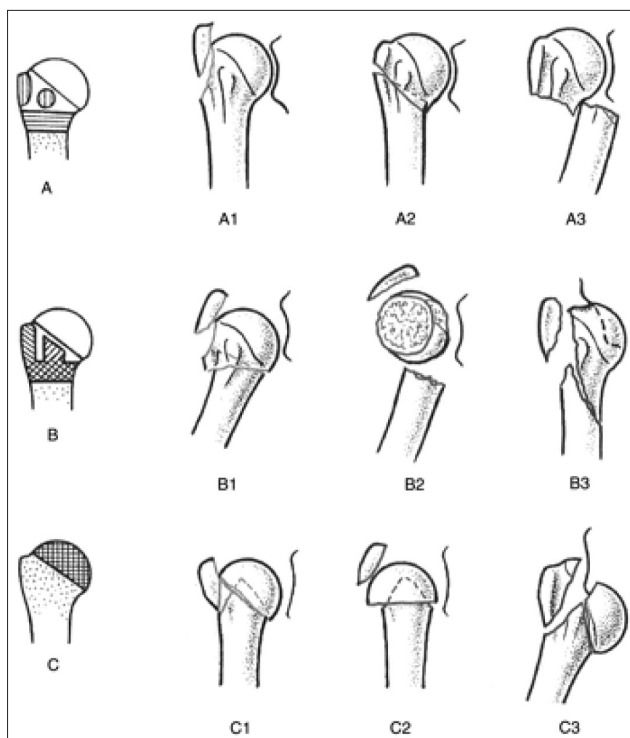


Figure 2. AO classification of proximal humerus fractures.

management. Age was the main determinant of outcome, according to the Neer score. Subjectively, older patients felt that the results of treatment were better than the objective measurement of glenohumeral function would indicate. Many patients with fair or poor results had comorbidities that prevented a good result. The length of the physiotherapy course affected the outcome at the one year follow-up. A study by Koval and colleagues showed excellent or good results in 77%, having used an independent and more detailed evaluation system. Previous studies showed excellent and good outcomes in 93–97% (9, 56).

Immobilisation of the shoulder using a sling for 2 weeks followed by physical therapy is a widely accepted procedure; however the time frame when to begin physiotherapy remains controversial. Lungberg et al. found no advantage of physiotherapy compared with independent exercises, but Koval et al. (28) showed that the percentage of good and excellent results was significantly greater for the patients who had started supervised physical therapy less than fourteen days after the injury. In another study, increasing the duration of physiotherapy did significantly improve the results in patients of similar age.

Conservative treatment of impacted varus and valgus fractures (Type A2.2 and B1.1 according to the AO-System) has been investigated by Court-Brown et al. (10, 11). At one year, 81% of the patients with valgus impacted fractures had a good or excellent result, depended on the age of the patient and the degree of displacement of the fracture. After non-operative management of impacted varus fractures the outcome one year after frac-

ture was also good or excellent in the majority of patients, regardless of the degree of varus. In this study physiotherapy could not improve the outcome. After a comparison with data from other studies the authors suggested that operative fixation of these fractures is not necessary.

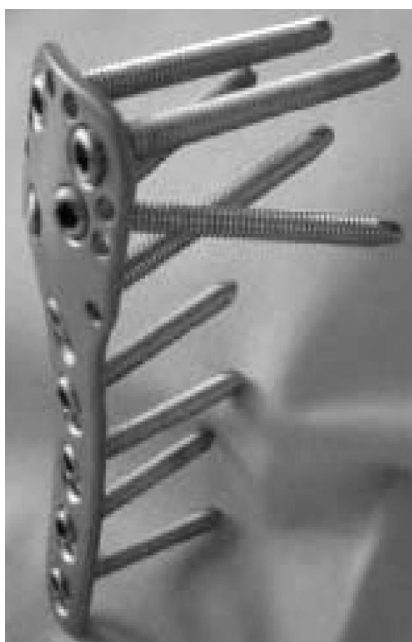
There are a few studies, in which displaced three and four part humerus fractures were investigated. Zyto (57) described in a 10 year follow-up study that, despite low functional scoring, patient contentment is good and therefore non-operative treatment should be considered. There was no clear correlation between radiographic and clinical outcome. A later study by Lill et al. (31) considered a conservative therapy in two- and three-part fractures as a good option, since 2/3 of the patients had a good and excellent result according to the Constant score. However, four-part fractures had a poor outcome with a low Constant score, mostly due to necrosis of the humeral head.

Non-operative treatment of complex fractures often results in malunion and stiffness of the shoulder (39). Although the outcome may be satisfactory in elderly patients with a sedentary lifestyle (57), in younger or active elderly patients, operative treatment should be considered when displacement of the tuberosities or the joint surface may compromise long-term shoulder function substantially.

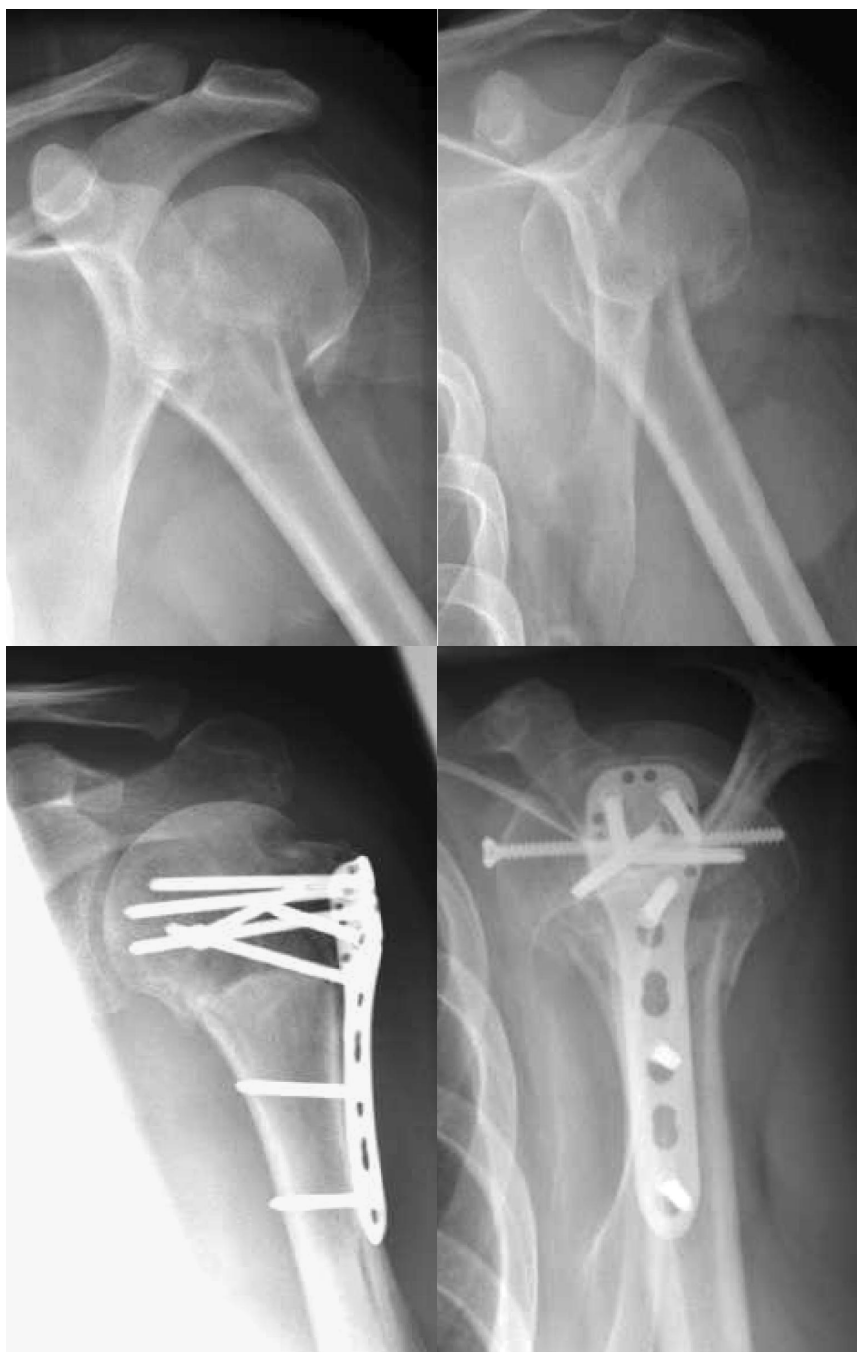
## PLATE OSTEOSYNTHESIS

Successful outcomes after buttress plate fixation of displaced and unstable proximal humerus fractures have been reported (19, 54, 55). Since the stability of the osteosynthesis with non-locking plates and screws relies upon the friction between the plate and bone the effectiveness of the traditional plate and screw fixation decreases with bone quality. ORIF of proximal humerus fractures with non-locking plates and screws has been shown to provide the strongest fixation in non-osteoporotic bone (55). In that study the average age of the population at the time of injury was 48 years. In osteoporotic bone complications such as screw loosening from the insufficient purchase of screws lead to high failure rates, especially in three- and four-part fractures. Kristiansen and Christensen (30) reported satisfactory or excellent results in only nine of twenty patients who had fixation of proximal humerus fractures with a T-buttress plate. There was a high occurrence of fixation failure (30). In another study 74% of patients had excellent to satisfactory results after treatment of proximal humerus fractures with the use of a T-buttress plate. It was stated that the results in all four-part fractures were poor and primary treatment with prosthesis was recommended (40).

New techniques like plates and screws with angular stability have been introduced in order to avoid these complications. These implants are precontoured to the anatomy of the lateral proximal humeral metaphysis and functions as an internal fixateur by securing an anatomical reduction using angular stability (Fig. 3). Advantages of these implants include gentle fracture reducti-



*Figure 3. Locking Proximal Humerus Plate. The implant is precontoured to the anatomy of the lateral proximal humeral metaphysis and functions as an internal fixateur by securing an anatomical reduction using angular stability.*

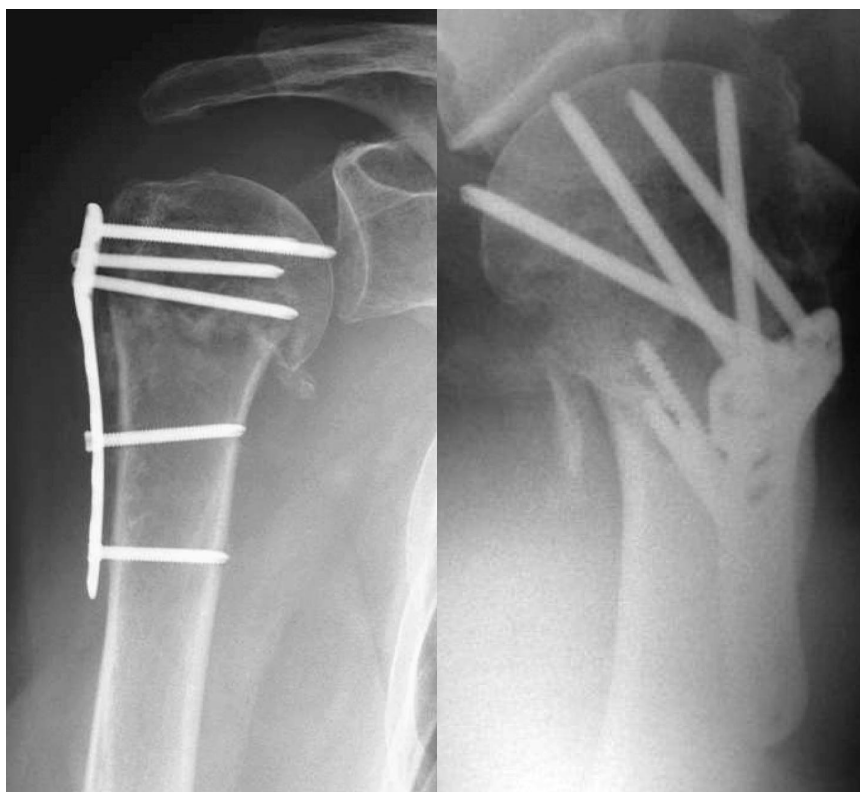


*Figure 4. A 61 year old woman sustained a four-part displaced proximal humerus fracture after a casual fall. After open reduction and internal fixation using a Locking Proximal Humerus Plate the fracture healed uneventfully after 3 months. The patient achieved a relative Constant score of 94%.*

on using indirect maneuvers, no surgical damage to the rotator cuff, high resistance to avulsion even in poor bone stock due to the combination of fixed-angle screw-plate locking and three-dimensional placement of screws in the humeral head (Fig. 4), and possibility of early exercise and short period of immobilization because of the high initial stability (25).

In a recent biomechanical study with simulated humerus neck fractures subjected to cyclic loading locking-

plate constructs demonstrated significantly greater torsional stiffness and similar bending stability to blade plates in a cadaveric specimen model, therefore indicating potential advantages for the locking plate (49). Lill and coauthors (32) determined the in vitro characteristics of five clinically used and newly developed implants for the stabilization of proximal humerus fractures under static and cyclic loading. Compared to the stiff implants (Humerus-T-plate, unreamed proximal humerus nail)



*Figure 5. Complications after ORIF using a Locking Proximal Humerus Plate. A primary screw perforation of the humeral head was seen on the postoperative AP and axial radiograph. The screws were exchanged to shorter screws in a second operation.*

the more elastic Locking Compression Plate Proximal Humerus showed a low load decrease with a low load level and a steady curve, which is promising for long-term stability (32).

There is only a limited number of clinical studies investigating the results after ORIF of proximal humerus fractures using locking plates and most of the studies included a rather small number of patients (12, 25, 27). In a recent study Koukakis et al. reported a mean Constant score of 76 using a proximal humerus internal locking system (PHILOS) in 20 patients with one occurrence of hardware failure and one avascular necrosis. The authors concluded that the plate design provides stable fixation with a good clinical outcome. In another prospective study Fankhauser et al. (12) reported 28 patients with 29 proximal humerus fractures treated with a locking proximal humerus plate (LPHP) using an deltoid splitting approach. After one year, the average Constant score for all fractures was 75. Complications included breakage of the plate in one patient and loss of reduction in four patients. Partial osteonecrosis was seen in two patients. They concluded that the LPHP is a reliable method of fixation. In a retrospective study Bjorkenheim et al. (4) reported a mean Constant score of 72 using the PHILOS plate in 72 patients. They report two non-unions, three patients with avascular necrosis, and two failures caused by technical error. The authors recommend the PHILOS plate for the treatment of proximal humerus fractures in patients with poor bone quality.

Several important points need to be considered when using angular plates to stabilize proximal humerus frac-

tures. Since the screws are inserted three-dimensional in the humeral head it is necessary to check the correct proximal position of every single screw separately by rotating the arm using an image intensifier. Primary screw perforations of the humeral head should be avoided (Fig. 5). Care has also to be taken not to insert the plate too far cranially to avoid impingement. If an adequate reduction is not achieved and medial buttressing is insufficient, especially in varus malreduction, secondary loss of reduction and subsequent screw perforation or plate breakage is possible. The locking of the screws onto the plate prevents their backing out. Therefore, if the fracture collapses, the screws may penetrate the articular surface. This may be more likely if the screws are placed very close to the articular surface or if the articular surface is penetrated during drilling (7).

When these points are considered a locking plate fixation leads to excellent or good results in the majority of cases. Therefore, in our hospital the PHILOS plate is the treatment of choice for dislocated multifragmentary fractures of the proximal humerus.

#### **ANTEGRADE INTRAMEDULLARY NAILING**

Stedtfeld et al. (51) introduced the treatment of displaced proximal humerus fractures with an angular and sliding stable antegrade nail (Targon-PH). The technique aims to achieve maximum primary stability by three-dimensional screw interlocking at the humeral head level with minimal dissection on the surrounding soft tissue. In a prospective study, 112 consecutive patients with displaced proximal humerus fractures were treated with the



Figure 6. 76-years old woman sustained a 4-part fracture of the proximal humerus. The fracture was treated with primary arthroplasty using an EPOCA C.O.S. shoulder prosthesis. The patient was followed-up for 11 months and achieved a Constant score of 73.

Targon-PH (15). The treatment led to good functional results, especially in 2- and 3-part fractures. In 4-part fractures a substantial risk for postoperative complications and bad function exists. In another study 64 patients with a displaced proximal humerus fracture and an intact head fragment were treated with antegrade interlocking nailing and followed up twelve months after surgery (37). The mean Constant score on the injured side was 75 points, but patients with 4-part fractures had a tendency to have a poorer functional outcome. The authors concluded that intramedullary stabilization of proximal humerus fractures with an angular and sliding stable antegrade locking nail represents a minimally invasive procedure that provides a high degree of primary stability even in osteoporotic bone and allows for immediate postoperative mobilization. In the study of Rajasekhar et al. (42) 30 proximal humerus fractures, mostly 2-part fractures, were treated with the Polar nail; 3% of the patients developed a non-union, and 80% had satisfactory to excellent results.

Intramedullary techniques preserve periosteal blood supply and retain surrounding soft tissue attachments. The short operating time, the limited exposure and soft tissue dissection, the short duration of hospitalization, and the rapid functional recovery are the advantages of the procedure, which can be used with good results in 2- and 3-part fractures.

#### MINIMAL INVASIVE OSTEOSYNTHESIS

Because extensive exposure and insertion of large metal implants may increase the risk of osteonecrosis, limited exposure and dissection of the soft tissue with a minimal amount of hardware has been recommended (17, 21). Although these techniques minimize the risk of osteonecrosis, the low postoperative stability may compromise early rehabilitation especially in patients with a poor bone stock.

In a series of 34 consecutive patients with proximal humerus fractures very good results have been achieved using K-wires and/or osteosutures (14). Although the rate of avascular necrosis was rather high (35%), patients had functionally satisfactory results as long as anatomic reduction was achieved. Another reason for these good results and good restoration of the anatomy might be because of the relative youth of the patients (mean age 45 years). Anatomic reduction and subsequent fixation could be done in a good bone stock. However, Hertel (17) advocates that also in osteoporotic bone osteosutures, K-wire fixation, and minimal additional plating should be used. Due to his study reduction and stabilization of the tuberosities against each other would be sufficient to achieve a stable positioning of the humeral head, whereas other implants seem too stiff and do not allow any load sharing in osteoporotic bone. On the other hand, some authors stated that transcutaneous pinning has numerous complications such as unstable fixation, pin track infection, skin irritation, a high incidence of pin migration, and massive X-ray exposure; furthermore the surgical technique is also quite demanding (23, 26).

#### PRIMARY ARTHROPLASTY

The use of primary arthroplasty in complex proximal humerus fractures was first propagated by Neer 1970 and is now used for treatment of fractures that are impossible to reconstruct with internal fixation techniques, e.g. displaced four-part fractures and fractures involving more than 40% of the articular surface. Advanced age and poor bone quality favours a treatment regimen involving the performance of a shoulder hemiarthroplasty (53). Primary arthroplasty in the treatment of humeral head fracture is generally considered as a procedure with a low complication rate and a satisfying clinical outcome (45). One of the most important parameters in res-

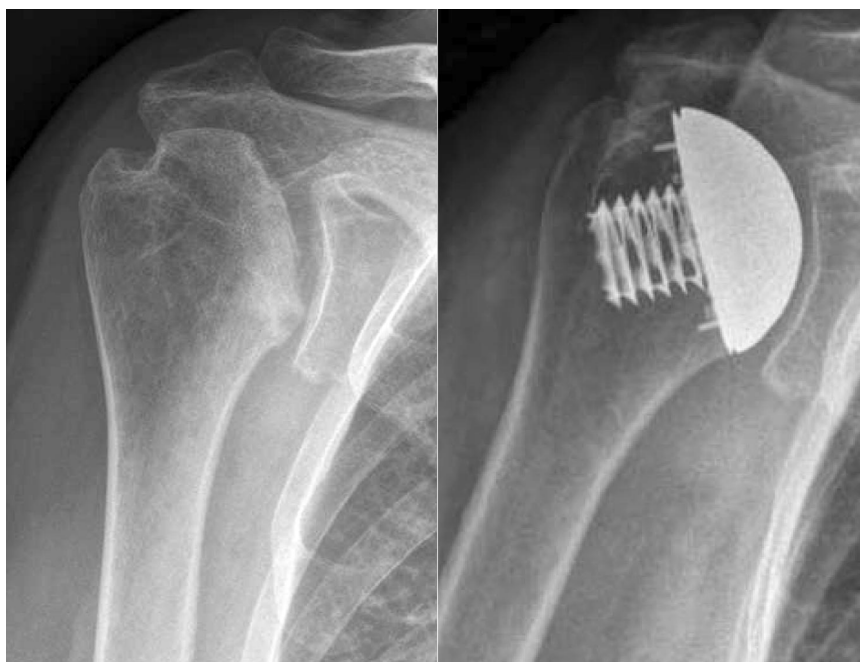


Figure 7. A 65-years old woman suffering from a post-traumatic humeral head necrosis was treated with an ECLIPSE™ humeral head prosthesis.

toring shoulder function by alloplasty is humeral head retroversion. If this is not correct, ventral or dorsal instability of the shoulder may result. Another important factor is the correct reconstruction of anatomic position of the greater and the lesser tubercle in relation to the insertion of rotator cuff muscles into the humeral head (22).

In our own patients collective we followed up 26 elderly patients (age > 65 yrs) suffering from a four-part-humeral head fracture after implantation of a shoulder hemiarthroplasty (Fig. 6). After a mean follow-up of 17 months the patients achieved an average Constant Score of 52 including poor shoulder mobility and good pain relief (34). Similar results were obtained in other studies which show that two thirds of the patients are free of pain a few weeks after implantation of the prosthesis, but achieve only a moderate functional outcome (41, 47). The insufficient bony healing of displaced tuberosities after intraoperative fixation at the stem of the prosthesis is considered one reason for the poor outcome in shoulder mobility. Therefore, some authors favour a primary reconstruction and fixation of the displaced humeral head to get a stable bony healing of the tuberosities at the humeral diaphysis. In case of a post-operative avascular necrosis or omarthrosis the plate is removed and shoulder hemiarthroplasty is performed in a second operation (Fig. 7).

## COMPLICATIONS

Beside general complications after fracture treatment bone sintering with loss of reduction, adhesive capsulitis, avascular head necrosis, posttraumatic omarthrosis or subacromial plate or nail impingement are observed. A major complication after proximal humerus fracture – treated conservatively or with open reduction and fixation – is the osteonecrosis of the humeral head. The post-

traumatic incidence varies between 0% and 70% and is caused by the disruption of the blood supply to the humeral head, especially in complex fractures involving the medial column segment (18). We implanted a shoulder hemiarthroplasty in 11 patients suffering from posttraumatic necrosis/non-union after failed primary treatment of a four-part humeral head fracture. Seven of these patients were treated initially with a plate osteosynthesis and four were treated conservatively. The patients achieved an average Constant Score of 46 with a satisfying pain relief and a moderate shoulder function (34). Similar results were obtained by Atuna who treated patients suffering from a fracture-related non-union of the proximal humerus with shoulder arthroplasty (1).

In 176 patients treated with a locking plate after proximal humerus fracture axial deviations (>30°) were noted in 5% and malreduction (>5mm) was observed in 9%. Primary screw perforations were seen in 11% and collapses of the humeral head with secondary screw perforations in 8%. 3% cases of total and 5% of partial avascular humeral head necrosis were noted (25).

In another study 112 consecutive patients with displaced proximal humerus fractures were treated with an angular and sliding stable antegrade interlocking nail. Complications requiring surgical therapy were seen in 30% of patients included backing out of screws in nails without peak inlay (20%), protrusion of screws into the glenohumeral joint (5%), loss of reduction with malunion (9%) and major tubercle displacement (7%) (15). Gerber et al. (14) treated 34 consecutive articular fractures of the proximal humerus by open reduction and internal fixation. Complete or partial avascular necrosis occurred in 35% of the cases. These 12 patients obtained a mean Constant score of 66 points compared to patients without an avascular necrosis who reached a Constant Score of 78 points.

For complication management after osteosynthetic treated and failed proximal humerus fracture early implant removal, subacromial decompression and adhaesiolysis of the shoulder joint was performed in patients with implant impingement and reduced shoulder mobility. In patients with bone sintering, loss of reduction and cut-out of the screws an early revision with open reduction and shortening of the screws or a late revision with an implant removal and corrective osteotomies are proposed. Benegas treated a posttraumatic varus deformity with a valgus wedge osteotomy and obtained 60% excellent and 40% good results (2).

After primary shoulder hemiarthroplasty general problems of joint replacement like aseptic loosening, periprosthetic fractures, infections and heterotopic ossification are observed. In 15 to 45% of the patients undergoing shoulder arthroplasty heterotopic ossifications were seen and in patients with omarthrosis or rotator cuff tears the risk was significantly increased (5, 50). The oral administration of non-steroidal anti-inflammatory drugs seems to have no benefit in preventing heterotopic ossifications following shoulder arthroplasty (5). Therefore, some authors propose the application of preoperative low dose radiation to prevent heterotopic bone formation in shoulder arthroplasty (46).

## ZÁVĚR

Vzhledem k epidemiologickým změnám mají zlomeniny proximálního femuru stále větší dopad na systém zdravotní péče. Podle odhadu finské výzkumné skupiny se počet těchto zlomenin může do roku 2030 ztrojnásobit. Většina pacientů s těmito zlomeninami je starší než 60 let a v této populaci jsou zlomeniny ovlivněny osteoporózou. Nedislokované zlomeniny a zlomeniny s minimální dislokací a s adekvátní stabilitou jsou obvykle úspěšně léčeny konzervativně. Hlavním cílem při operační léčbě dislokovaných nestabilních zlomenin proximálního humeru je dosažení dostatečné fixace po provedení adekvátní repozice zlomeniny tak, aby byl funkční výsledek u pacienta co nejlepší. Zejména u osteoporotické kosti a u tříštvých zlomenin je operační fixace obtížná a u dislokovaných a nestabilních zlomenin zůstává kontroverzní. Nejdůležitějším faktorem pro dosažení příznivých výsledků v léčbě komplexních, tří- či čtyřúhlových zlomenin proximálního humeru je anatomická repozice. Minimální operační přístup, vysoká primární stabilita a přenos zátěže prostřednictvím implantátu jsou důležité pro prevenci komplikací, jako je sekundární dislokace, osteonekróza a ztuhlost kloubu. V nedávné době vyvinuté úhlově stabilní implantáty mají lepší biomechanické vlastnosti, což přispívá k pevnější fixaci implantátu zejména v osteoporotické kosti. Tyto implantáty mají všechny předpoklady pro dosažení lepších výsledků při léčbě těchto komplexních poranění.

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