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Mid-term results of internal fixation of proximal humeral fractures with the Philos plate

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ABSTRACT

Objective: To report our experience from the use of the Philos® plate for the treatment of three- and four-part proximal humeral fractures and to investigate factors influencing the final outcome.
Materials and methods: Between April 2005 and September 2007, 29 Philos plates were implanted in 17 women and 12 men, with a mean age of 62.3 years (range: 28–80 years). Positioning of the plate was performed under fluoroscopic control, through a deltopectoral approach and with the patient in the beach chair position. 27 patients were available for follow-up (mean: 17.9 months; range: 12–39). Follow-up included plain shoulder radiographs and functional assessment with Constant–Murley score.
Results: Healing of the fracture occurred uneventfully within 6 months. In three patients, humeral head collapsed due to aseptic necrosis after fracture healing and the plate had to be removed in two cases. In one patient, fracture healing occurred in >10° varus displacement. The clinical result according to the Constant–Murley score was 86 points (range: 58–112).
Conclusions: Internal fixation with the Philos plate seems to be a reliable option in the operative treatment of upper end humeral fractures, especially in osteoporotic bone. It allows secure fracture fixation and quick shoulder mobilisation, while quick and uneventful fracture healing and very satisfactory clinical results are achieved.

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The proximal humeral fractures account for 5–9% of all fractures and mostly affect elderly osteoporotic patients with highest incidence among women in the ninth decade.[6,18,32,41,43] Displaced or unstable proximal humeral fractures should be treated operatively with surgical options, including prosthetic replacement or fracture fixation. A great variety of surgical fixation options has been proposed. However, all of them suffer from persistent rate of mechanical failure and increased complication rate. Therefore, the treatment of choice remains a matter of controversy.[24,45]

Locking plates have been recently introduced in proximal humeral fracture fixation in an effort to successfully address these issues. These new implants provide greater angular stability, better screw anchorage in osteoporotic bone and function as a locked internal fixator. In theory this results in enhanced osteosynthesis stability and lower rates of implant failure and subsequent loss of reduction, allowing earlier mobilisation and possibly leading to improved clinical results.[27,28]

Complications following fixation of proximal humeral fractures are partly due to the poor bone quality of the osteoporotic humeral head, leading to reduced grip strength of the implant.[17,21,25] Moreover, the neurovascular anatomy around the humeral head precludes plate fixation as a buttress on the medial cortex,[4,7,15,29] while traditional lateral plate osteosynthesis appears to be rather insufficient to withstand varus-deforming forces, especially in an osteoporotic environment.

The purpose of this study is to analyse our experience from the use of the Philos® plate (Synthes, Paoli, PA, USA), for the treatment of three- and four-part proximal humeral fractures. In addition, we aim to investigate the exact indications and contraindications of this implant and recognise the effect various patient factors, fracture patterns and specific technical details have on the final clinical outcome.

Patients and methods

Between April 2005 and September 2007, 29 unstable, displaced proximal humeral fractures in 29 patients (12 males, 17 females), including four polytrauma patients, were treated with open reduction and internal fixation with the Philos® locking plate. Inclusion criteria consisted of age ≥18 years and a closed

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three- or four-part displaced, unstable proximal humeral fracture that was less than 4 weeks old. Patients with fracture-dislocations, as well as those with fractures older than 4 weeks or a history of primary or metastatic tumours were excluded from our initial cohort.

Twenty-two patients had a three-part fracture (75.9%) and seven a four-part one (24.1%) according to the Neer's classification, while according to the AO classification, 15 fractures (51.8%) were B-type (six B1 and nine B2 type) and 14 fractures (48.2%) were C-type (seven each of C1 and C2 type).

The mean patient age was 62.3 years (range: 28–80 years); 18 patients (62.1%) were older than 60 years and 11 (37.9%) were younger. In all but two patients older than 60 years the fracture was the result of a low-energy fall on the ground, while in those younger than 60 years the cause was a high-energy trauma, mainly road traffic accident in nine cases and a fall in two cases.

Surgical technique and postoperative treatment

All patients were operated upon under general anaesthesia, in 'beach chair' position and under C-arm control. All procedures were carried out by a consultant orthopaedic surgeon with interest in shoulder surgery (PP or DK). The arm was draped separately to allow abduction and rotation in order to facilitate fracture reduction. A standard deltopectoral approach was used, the cephalic vein was routinely retracted medially and the subdeltoid space was developed. Throughout fracture-site preparation, care was taken to avoid damage of the ascending branch of the anterior circumflex humeral artery located laterally in the bicipital groove, since this provides the primary blood supply to the head fragment. After adequate exposure of the fracture site with the least possible soft-tissue dissection, the fragments were reduced and provisionally stabilised with the use of Kirschner wires (K-wires). The tubercles were additionally secured with 1-2 No-2 Ethibond sutures (Ethicon, Somerville, NJ, USA) passing through the bone–tendon junction and inserted in the appropriate plate holes. Correct plate positioning in both the medio-lateral and cephalo-caudal direction was controlled with the image intensifier. Positioning the first screw in the centre of the slotted gliding hole found in the distal part of the plate, facilitates accurate plate placement by allowing for minor adjustments. A minimum of five equally distributed, divergent locking screws (range: 5–9) were placed in the humeral head through the proximal part of the plate. During and after completion of the osteosynthesis, fracture reduction and accurate screw placement in the humeral head was confirmed fluoroscopically in both anteroposterior (AP) and lateral planes. The wound was closed in layers over a drain and the arm was placed in a shoulder sling.

Intravenous antibiotics were administered for 24 h postoperatively and the drain was removed during the first postoperative day. Elbow and wrist range of motion exercises were commenced on the first postoperative day, while passive motion and pendulum exercises of the shoulder were encouraged as soon as pain had subsided. Active-assisted range of motion activities were initiated about 4–6 weeks postoperatively, while unassisted active motion was allowed at 8–10 weeks postoperatively.

Radiological and clinical evaluation

Fracture healing and maintenance of reduction were evaluated in AP shoulder radiographs taken immediately postoperatively, at 6 weeks, 3 months, 6 months and 1 year after surgery (Fig. 1a–c). The appearance of callus in radiographs and/or the disappearance of fracture lines were considered evidence of fracture healing. Radiographs were further assessed for identifying signs of humeral head osteonecrosis and implant 'cut-through' or 'cut-out'.

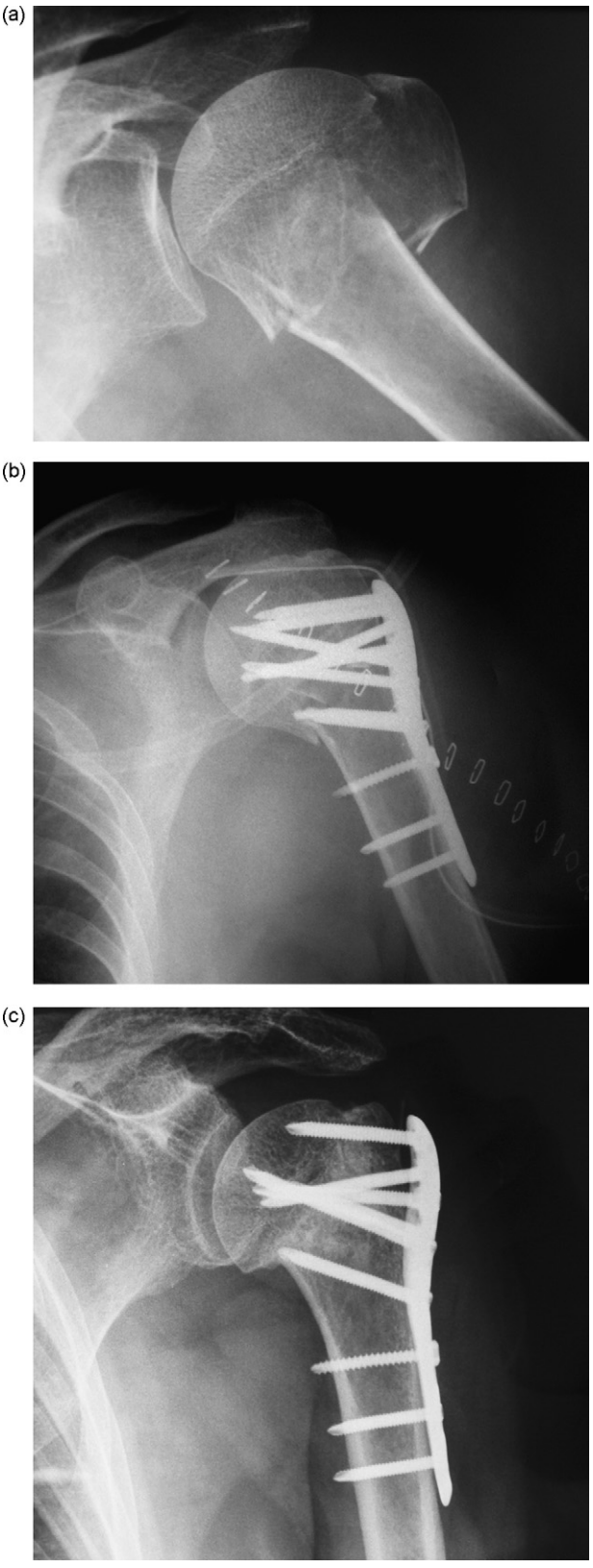

Fig. 1. (a) Preoperative X-ray of a three-part proximal humeral fracture. (b) Immediate postoperative X-ray showing satisfactory fracture reduction. (c) Eighteen months postoperatively X-ray demonstrates fracture healing without fragment displacement.

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In order to assess shoulder function the Constant–Murlay score as normalised by Katolik[5,19] was used at the final follow-up visit.

Results

From the 29 patients operated upon, 27 were available for final follow-up, since two polytrauma patients had died within the first month after surgery from causes unrelated to the humeral fracture. All patients were followed for a minimum of 12 months (mean follow-up time: 17.9 months, range: 12–39 months).

The average duration of hospitalisation was 5.7 days, ranging from 2 to 14 days. Hospitalisation ranged from 10 to 14 days for the four polytrauma patients and from 2 to 8 days for the rest of our patients.

In the early postoperative period no superficial or deep wound infections, nerve or vascular injuries were observed. In all cases fracture healing occurred uneventfully within 3–6 months. No implant failure and no delayed union or nonunion was noted. The mean Constant–Murley score, as normalised by Katolik, was 86 points (range: 58–112) on final review.

Complications

In three patients (11.1%) humeral head collapse due to aseptic necrosis occurred after fracture healing (Fig. 2). In two patients (7.4%) the head collapse led to severe limitation of shoulder range of motion and pain due to head screw perforation into the glenohumeral joint. The patients were re-operated upon and the implants were removed, leading to symptom subsidence and clinical improvement, (Constant–Murlay score: 63 and 65 before implant removal, 81 and 82, respectively, after implant removal). The third patient had minimal pain and satisfactory range of motion and the clinical result 'did not correlate well' with the radiological picture of aseptic necrosis of the humeral head, therefore no hardware removal was required. In one other patient (3.7%) $>10^{\circ}$ varus displacement was noted 6 weeks postoperatively following 'medial hinge' collapse and screw 'cut-through'. Strictly passive mobilisation was continued for a further 6 weeks, by which time signs of fracture healing without further displacement were noted. The functional end-result of this patient was very satisfactory on final follow-up 14 months postoperatively. No other cases of either early or delayed loss of reduction were recorded.

Discussion

Although proximal humeral fractures are among the commonest fractures in the human body with peak incidence in the elderly population, their surgical treatment still remains a matter of controversy.[24,25,45] Various implants and surgical techniques have been proposed in an effort to overcome the above limitations. These include bone sutures, tension band, cerclage wires, K-wires, T-plates, intramedullary devices, double tubular plates, and the PlantTan Humerus Fixator Plate.[34,36,38–40,44] Most fixation methods though, suffer from unacceptably high complication rates, including 'cut-through', 'cut-out' or 'back-out' of the screws, implant failure, avascular necrosis, nonunion, malunion, nail migration, rotator cuff impairment and impingement syndrome. The rate of these complications can be rather high, especially in elderly patients with poor bone quality.[14,15,38] The use of locking plates has been recently introduced in the treatment of these fractures in an effort to successfully address the problems encountered with previously used fixation methods.

Probably the most serious concern in proximal humeral fracture fixation has been the high rate of avascular necrosis of the humeral head, with reported rates as high as 45% when

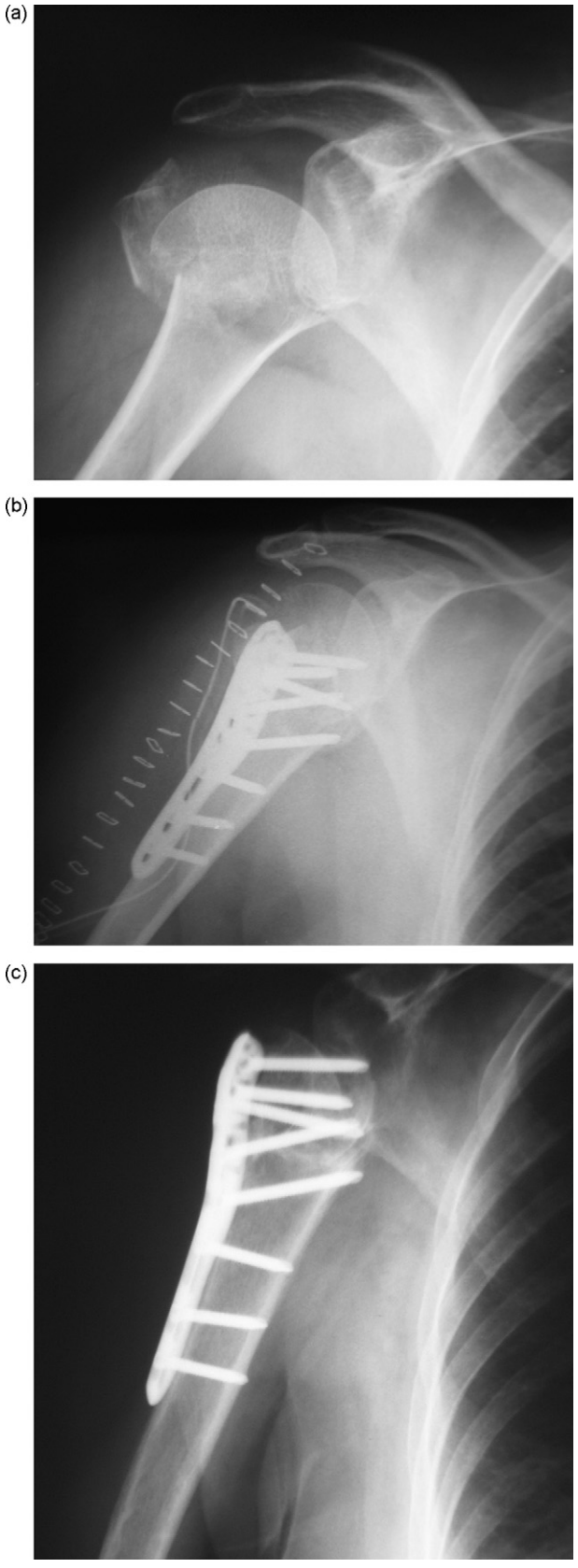

Fig. 2. (a) Preoperative X-ray of a three-part proximal humeral fracture. Note the head fracture line located in the humeral anatomical neck. (b) Immediate postoperative X-ray shows satisfactory fracture reduction. (c) Fourteen months postoperatively humeral head avascular necrosis is evident, leading to subsequent head collapse.

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traditional plating was used.[12,23,45] In our study avascular necrosis was noted in only three patients (11.1%), a rate consistent with the low incidence reported in other studies where locking plates were used (range: 4.5–16%).[3,7,9,20,33,35] Avascular head necrosis is initiated by the fracture pattern itself that almost unavoidably damages the delicate blood supply of the humeral head.[11] However, humeral head vascular supply may be further compromised by the rather extensive soft tissue dissection required in order to achieve adequate reduction and fracture fixation with conventional plates.[45] In that respect the use of locking plates, which act as a locked internal fixator, requires considerably less soft tissue and periosteal stripping, thus minimising further iatrogenic damage to the already compromised blood supply of the humeral head.[1,27,28]

Our results suggest that if avascular necrosis (AVN) leading to humeral head collapse occurs, the screws of the locking screw construct 'cut-through' and eventually 'cut-out' through the collapsing humeral head. This led to perforation of the head screws into the glenohumeral joint, necessitating implant removal in two cases. It is possible that the exceptional fixation strength of the device that is responsible for lower implant failure rates, is also a substantial contributing factor to this particular complication.[8,9] However, neither implant failure nor loss of fixation occurred in our AVN cases, indicating that, if reduction of the necrotic humeral head is preserved, fracture healing can be achieved leading to an acceptable clinical result that does not necessarily correlate with radiological findings of severe humeral head damage.[45] It has been proposed that even re-vascularisation of the humeral head is possible when a stable fixation is provided.[2] Moreover, one should note that even in the case of post-fixation segmental collapse of the humeral head, the functional results can be as good as those of primary hemiarthroplasty.[37,45]

Early loss of fixation has been another serious concern in the surgical treatment of proximal humeral fractures, with reported rates ranging from <4% to >25%.[26,33,42] It appears that the overall rate of loss of fixation has significantly decreased after the introduction of locking plates instead of traditional plates in the treatment of these fractures.[13,22] This is supported by our findings, as loss of reduction was recorded in only one patient (3.7%) in this series. In a multicentre study with a relatively large cohort of patients treated with locking plates, it was found that varus malreduction (<120°) was significantly associated with early loss of fixation.[1]

The low rate of early loss of fixation achieved, when locking plates are used, can be partly attributed to the 'different mode of failure' of these plates. Traditional non-locking screws and plates rely on friction between the plate and bone for stability. In osteoporotic bone, this construct is more prone to failure because of bone resorption underneath the plate and high rotational forces. Additionally, the screws may not obtain sufficient purchase in the cancellous and osteoporotic humeral head, leading to high failure rates. Since locking plates rely on an angular-stable interface between the screw head and plate, the 'classic' failure of screw back-out or screw-breakage at the screw head/plate interface is far less common.[1,26–28] Locking plates usually fail as a complete 'monoblock' by pulling out of the humeral head or shaft.[1]

Our results compare well with those reported in most recently published series, in terms of complication rates and postoperative functional scores [2,9,13,16,20,31] and do not support recently raised concerns.[33] It should also be pointed out that all four of our complications, the three AVN cases and the one where substantial varus collapse occurred, were observed in fractures with a disrupted medial hinge and with the humeral head fracture-line located in the anatomical neck (AO/ASIF types 1.1 C1 and C2). This observation could indicate that such fracture types bear a higher risk for AVN, humeral head collapse and screw perforation and may not be suitable for internal fixation with the Philos plate, especially in elderly osteoporotic patients.

It seems that satisfactory fracture reduction, accurate plate placement, as well as an adequate number of head screws and their topography play an important role in avoiding implant failure.[8,10,16] It is recommended that at least five equally distributed divergent fixed-angle plate screws are used in the humeral head in order to maintain reduction until the bone heals.[16] We currently aim to insert as many divergent screws as possible in the head fragment, make every effort to provide adequate mechanical support in the inferomedial area of the humeral head with adequately placed oblique locked screws and leave the screws at least 5–10 mm below the subcortical bone. We believe that all the above increase the construct stability and decrease the probability of screw 'cut-through' and eventual 'cut-out', should some degree of head collapse occur.

At the present time, none of the available surgical fixation options is based on solid, comparative and randomised evidence.[30] Therefore, the actual choice of best treatment can only be based on case series, personal and institutional experience. The fact that all procedures were carried out by the same two shoulder surgeons in the same clinical setting, with a uniform surgical technique and a common postoperative protocol, together with prospective data collection constitute the strengths of this study. However, we appreciate that the present case study is faced with a number of limitations including a relatively small study population with considerable heterogeneity as regards age and fracture types and lack of a control group. Furthermore, we recognise that with a minimum follow-up of 1 year the reported rate of AVN may be lower than the pragmatic one, since late osteonecrosis with humeral head collapse has been recently recognised to be more common than previously thought.[2] Therefore, conclusions should be reviewed in light of the aforementioned limitations.

The critical arguments for the choice of a specific method will inevitably be its ability to preserve or improve bone perfusion and to eventually help achieve healing in the desired position, while minimising the likelihood of complications.[14] In this respect the Philos® locking plate represents a very satisfactory option in the operative treatment of proximal humeral fractures; it facilitates fracture reduction and offers adequate fixation stability even in an osteoporotic environment, thus leading to high union rates and allowing early shoulder mobilisation. Our results also indicate that certain fracture types bear higher complication risks and certain technical details during Philos® locking plate application should be closely adhered to. However, further experimental and long-term clinical studies are required in order to evaluate in more depth the role of humeral head vascularity at the time of surgery and recognise the technical details during implant insertion together with the exact fracture parameters and patient factors that may positively or negatively affect the final outcome. These will help us clarify the exact indications for the use Philos® locking plate in proximal humeral fracture fixation.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of the article.

Conflict of interest

The authors state that there are no conflicts of interest.

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