The proximal femoral nail (PFN)—a minimal invasive treatment of unstable proximal femoral fractures

A prospective study of 55 patients with a follow-up of 15 months

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ABSTRACT – In 1996, the AO/ASIF developed the proximal femoral nail (PFN) as an intramedullary device for the treatment of unstable per-, intra- and subtrochanteric femoral fractures. In a prospective study, we treated 55 patients having proximal femoral fractures with the PFN from 1997 to 2000. In 34 patients, we achieved what was close to anatomic reduction of the main fracture fragments. Immediate full weight bearing was permitted in 49 patients. During the follow-up period of 15 months, complications occurred in 12 patients. 2 patients had a cut-out of the implant because we used too short proximal gliding screws. In 5 patients, closed fracture reduction could not be done and open fracture reduction with use of cerclage became necessary. Careful surgical technique and modification of the PFN can reduce the high complication rate. In conclusion, the PFN is a good minimal invasive implant of unstable proximal femoral fractures, if closed reduction is possible. If open reduction of the fracture becomes necessary and several fragments are found (especially of the greater trochanter), we prefer to use a dynamic hip screw (DHS) with the trochanter stablizing plate.

The variety of implants for treatment of unstable trochanteric and subtrochanteric femoral fractures continues to increase. From the biomechanical point of view, 2 main alternatives are available. The first type of implant consists of a sliding neck screw or bolt connected to a plate in the lateral femoral cortex; this is inserted after closed or limited open reduction. In unstable trochanteric fractures, an additional "antirotational" screw is recommended and in cases with several fragments and/or impaired bone quality, a trochanter stabilizing plate should also be used (Regazzoni 1992, Babst et al. 1998, Madsen et al. 1998).

The other alternative for stabilization is to use a sliding neck screw that stabilizes the head-neck fragment by means of an intramedullary nail. This is implanted after closed reduction using a minimal invasive technique. This nail combined with a sliding neck screw may be a more appropriate technique (Rosenblum et al. 1992, Prinz et al. 1996), but many papers about the Gamma nail and similar methods have reported numerous complications (Bridle et al. 1991, Guyer et al. 1991, Halder 1992, Leung et al. 1992, Radford et al. 1993, Friedl et al. 1994, Albareda et al. 1996, Madsen et al. 1998, Valverde et al. 1998). Therefore, the Arbeitsgemeinschaft für Osteosynthesefragen (AO/ASIF) in 1996 designed a new intramedullary device—the proximal femoral nail (PFN). In a prospective study, we tried to find out whether the PFN is an appropriate method for minimal invasive treatment of proximal femoral fractures.

Patients and methods

From 1997 to 2000, we treated 55 patients with unstable proximal femoral fractures with the AO/ASIF proximal femoral nail (PFN). In four fifths of the cases the fall occurred at home. Their mean age was 73 (18–95) years, and 39 were female.

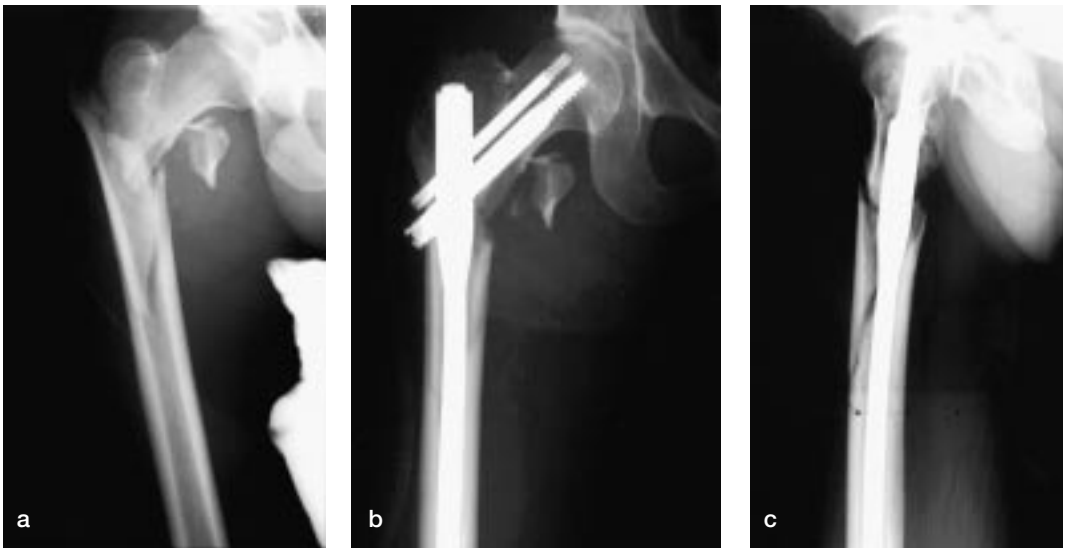

Figure 1. a. Preoperative 31-A3.3 fracture. b, c. Anatomic fracture reduction of the main fragments with dislocation of the minor trochanter.

As recommended by the AO/ASIF, the fractures were classified on the basis of the preoperative radiographs as 0 31-A1 (stable pertrochanteric), 4 -A2 (unstable pertrochanteric), 34 -A3 (unstable intertrochanteric) and 17 subtrochanteric fractures. The operations were performed within 3 days of the accident on a fracture table thus achieving closed adequate reduction in 50 cases. The standard PFN (with a length of 240 mm) or other lengths (320–420 mm) were implanted by using a 5-cm skin incision which extended from the cranial part to the tip of the greater trochanter. After penetrating the fascia and muscles, a 2.8 mm K-wire was inserted at the tip of the greater trochanter under fluoroscopic control in both planes. The proximal part of the femoral shaft was reamed with a 17-mm reamer. The nail was then introduced manually into the femoral shaft. Using C-arm control the first guide wire for the neck screw was placed in the femoral neck so that the screw could be placed in the lower half of the neck on the anteroposterior view and centrally/or slightly posterior on the lateral view. Then the guide wire for the antirotational hip pin was introduced. The hip pin should be introduced no further than to a horizontal line through the tip of the greater trochanter. The neck screw should be introduced afterwards. Depending on the type of fracture, distal static or dynamic interlock was obtained afterwards, using the same aiming device.

50 fractures were reduced by closed means. In 5 patients with 31-A3 fractures, open reduction was necessary with supplementary use of a cerclage wire. The mean duration of surgery was 68 (22–205) min. Depending on the type of fracture, the surgeon checked the stability obtained, the quality of bone, and the postoperative radiographs, to determine whether the patient would be allowed full or partial weight bearing. Full weight bearing was allowed in 49 patients and partial weight bearing in 6. During a mean of 15 (7–30) months, the results, intraoperative and postoperative complications were followed prospectively. All patients were evaluated by regular physical and radiographical examinations.

Results

Postoperative radiographs showed near anatomic fracture reduction in 34 patients (Figure 1). The fracture healed in all 55 patients. The longest consolidation time was 5 months. 1 patient suffered a medial femoral neck fracture after partial implant removal (the hip screw and hip pin were removed because of irritation to the fascia lata).

Complications were divided into intraoperative and postoperative ones: we found an intraoperative fracture displacement of the pertrochanteric fracture in 2/4 patients with 31-A2 fractures. During

Figure 2. Movement of the hip pin into the joint (z-effect) and poor reduction of the fracture.

Figure 3. 3 months after surgery, the hip pin moved out of the femoral neck (reversed z-effect).

manual introduction of the nail, we saw the femoral neck and head move towards the medial side and the shaft fragment with the greater trochanter towards the lateral side. The entry point of the PFN was placed directly in the region of the fracture at the tip of the greater trochanter causing intraoperative fracture displacement. Open reduction was threfore necessary, results were good. No fractures of the femoral shaft occurred.

10 patients had postoperative complications. 3 died within 4 days of surgery because of causes, unrelated to the implant. In 3 cases, a so-called Z-effect was seen (Figure 2). This means a movement of the hip pin towards the medial side into the hip joint with destruction of the cartilage in the joint. Since 1999, we have used a lateral ring on the hip pin to prevent this. In 2 patients, the so-called reversed-Z-effect occurred with movement of the hip pin towards the lateral side, which required early removal of the pin (Figure 3). 2 patients had cut-out of implant because we used too short hip screw and these were allowed full weightbearing (Figure 4). No relation to the type of fracture or adequacy of fracture reduction could be found.

Discussion

The discussion about the ideal implant for treatment of proximal femoral fractures continues. From the mechanical point of view, a combined intramedullary device inserted by means of a minimally invasive procedure seems to be better in elderly patients (Rosenblum et al. 1992, Prinz et al. 1996). Closed reduction of the fracture preserves the fracture hematoma, an essential element in the consolidation process (McKibbin 1978). Intramedullary fixation allows the surgeon to minimize soft tissue dissection thereby reducing surgical trauma, blood loss, infection, and wound complications (Leung et al. 1992, Radford et al. 1993). The currently used Gamma nail as an intramedullary device also has a high learning curve with technical and mechanical failure rates of about 10% (col-

Figure 4. a, b. Poor reduction of a 31-A3.2 fracture and too short screw. c, d. 5 days after the primary operation, cut-out of the hip screw and hip pin were noted.

lapse of the fracture area, cut-out of the implant, fracture of the femur shaft) (Guyer et al. 1991, Albareda et al. 1996, Friedl 1996, Valverde et al. 1998). The Arbeitsgemeinschaft für Osteosynthesefragen (AO/ASIF) therefore developed the proximal femoral nail with an antirotational hip pin together with a smaller distal shaft diameter to avoid these failures.

In an experimental study, Götze et al. (1998) compared the loadability of osteosynthesis of unstable per- and subtrochanteric fractures and found that the PFN could bear the highest loads of all devices.

Simmermacher et al. (1999), in a clinical multicenter study, reported technical failures of the PFN after poor reduction, malrotation or wrong choice of screws in 5% of the cases. A cut-out of the neck screw occurred in 0.6%. The distribution of the fracture types showed a large number of 31-A2 fractures (67%). Anatomical fracture reduction was found in 86% of the patients and full weight bearing stability was achieved in 94%. Our study showed a higher rate of complications, perhaps because 34/55 of the proximal femoral fractures were 31-A3 fractures. We achieved postoperative anatomical fracture reduction in only 34/55 patients, and immediate full weight bearing was allowed in nine tenths of them. A cut-out of the neck screws was seen in 2 patients because we used neck screws that were too short. In the literature, cut-out frequencies in proximal femoral fractures have been reported in up to 10% (Friedl et al. 1994, Lustenberger and Ganz 1995). An intraoperative fracture displacement during manual introduction of the nail into the femoral shaft has not been reported with

the Gamma nail (Bridle et al. 1991, Guyer et al. 1991, Halder 1992, Leung et al. 1992, Radford et al. 1993, Friedl et al. 1994, Albareda et al. 1996, Madsen et al. 1998, Valverde et al. 1998), but this has been a problem with the PFN. One reason may be that the entry point of the PFN at the tip of the greater trochanter is located directly in the fracture region of 31-A2 fractures which can cause an intraoperative fracture displacement. However, Simmermacher et al. (1999) had no cases of intraoperative fracture displacement using the PFN mainly in 31-A2 fractures. In comparison to the Gamma nail, we found no fracture of the femoral shaft and no break in the implant (Bridle et al. 1991, Halder 1992, Leung et al. 1992, Radford et al. 1993, Madsen et al. 1998, Valverde et al. 1998). Since 1999, the Z-effect with migration of the hip pin into the joint has been avoided by using a ring on the lateral side of the hip pin.

In 5 patients with 31-A3 fractures, closed fracture reduction was not successful and open reduction with use of a cerclage wire was necessary. The latter procedure must, of course, be performed in some unstable proximal femoral fractures although this is not the purpose of minimally invasive devices. Friedl et al. (1994) reported open reduction in 8% of the 31-A1, 13% of the -A2, and 52% of the -A3 fractures.

The most widely used method for proximal femoral fractures is probably still the Dynamic Hip Screw (DHS). A search in the Cochrane Database for a comparison of intramedullary and extramedullary implants for proximal femoral fractures reveshowed led a lower complication rate with the DHS. For more distal and uncommon trochanteric fractures, the intraoperative and fracture fixation results while the PFN were better than with sliding hip screws (Parker and Handoll 2002). Several prospective randomized comparisons of the DHS and the Gamma nail have been reported. Some authors have preferred the Gamma nail for treatment of unstable pertrochanteric fractures because of its higher loadability (Guyer et al. 1991, Leung et al. 1992, Prinz et al. 1996). Bridle et al. (1991) while Radford et al. (1993) did not recommend the use of the Gamma nail because of the high incidence of femoral shaft fractures. The PFN has been shown to prevent of femoral shaft fractures by having a smaller distal shaft diameter which reduces stress concentration at the tip (Simmermacher et al. 1999).

At present, we consider that the PFN is a good minimally invasive implant for unstable proximal femoral fractures when closed reduction is possible. The modification of the PFN and careful surgical technique should reduce the high complication rate in our study. If open reduction is needed and multiple fragments especially of the greater trochanter are present, we prefer the DHS with the trochanter stabilizing plate. This minimizes excessive secondary fracture impaction and medialization of the femoral shaft (Regazzoni 1992, Babst et al. 1998, Madsen et al. 1998).

No competing interests declared.

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