The Polarus intramedullary nail for proximal humeral fractures

Outcome in 28 patients followed for 1 year

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Background **One of the new treatment options for proximal humeral fractures is the minimally invasive intramedullary nail. In this study, we reviewed the early clinical results after 1 year.**

Patients and methods **35 patients with proximal humeral fractures were treated using the Polarus nail. In 14 cases the initial treatment was operative; the other 21 patients were initially treated nonoperatively. 19 patients had a 2-part fracture, 5 had a 3-part fracture and 2 had a 4-part fracture. In 9 patients the fracture extended metaphyseally. The functional outcome was assessed by the Constant score.**

Results **28 patients were available for 1-year follow-up. 17 patients showed excellent functional outcome (with an average Constant score of 81%). 6 patients required revision surgery, 1 because of nonunion and 1 because of an avascular necrosis. 4 others were reoperated because of inadequate position of the osteosynthesis or migration of the screws.**

Interpretation **The Polarus nail is of value for (displaced) 2-, 3-, and even 4-part proximal humeral fractures and enables early postoperative mobilization with a limited amount of pain.**

Up to 80% of patients with proximal humeral fractures respond satisfactorily to nonoperative treatment (Young and Wallace 1985, Hodgson et al. 2003). In some patients, displaced fractures require surgery. Unfortunately, the results of the standard fixation devices have been inconsistent (Robinson and Christie 1993, Adedapo and Ikpeme 2001, Resch 2003). One more advanced appliance is the locking proximal humerus plate with angular stability. Hente et al. (2004) described good to very good results and Plecko and Kraus (2005) reported satisfactory results with this plate for 2-, 3-, and 4-part fractures.

The third option is hemiarthroplasty. Because of disappointing results and the complexity of this operation, hemiarthroplasty is reserved for selected patients such as those with clinical avascular necrosis or massive comminuted fractures (Wijgman et al. 2002, Diercks 2003).

Optimal treatment for displaced proximal humeral fractures should allow early mobilization with little pain, maximal range of motion, and a minimal risk of complications. These criteria may be obtained by a minimally invasive intramedullary device such as the Polarus nail. We have reviewed our early clinical results with this nail.

Patients and methods

This survey was performed at the Departments of Surgery of three Dutch trauma centers. All 35 patients with non-pathological proximal humeral fractures who were treated surgically with the

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Polarus nail between September 2002 and September 2004 were included. All operations were performed by 1 of the 4 senior trauma surgeons at each department.

The fractures were classified according to Neer (1970) as (displaced) 2-, 3-, or 4-part fractures. A fracture is considered to be significantly displaced if one or more of the fracture segments is more than 45° angulated or displaced by more than 10 mm. Functional and radiographic outcome was measured at mean 12 (1–27) months of follow-up. Patients' shoulder function was assessed with the Constant score (Constant and Murley 1987). Strength in the shoulder was measured with an isometric tensiometer. As it was not possible to obtain the strength score for all of the patients, as the measurement device was not always readily available, we excluded the strength score (25 points) and recalculated the Constant score as a percentage. This means that if a patient had no pain (15 points), no limitations in daily living (20 points), and a maximum range of motion (40 points), a score of 75/75 was possible and gave a Constant score of 100%. Like Rajasekhar et al. (2001), we considered scores below 50% to be a poor result, between 50% and 75% a satisfactory result, and scores above 75% to be an excellent result. Postoperative complications were recorded.

Operative technique

The Polarus nail is a minimally invasive cannulated 150-mm titanium nail (Acumed Inc., Hillsboro, OR), used for combined neck and metaphyseal fractures. There is a longer nail (200–260 mm) for more distal humeral shaft fractures.

The patient is operated under general anesthesia (without muscle relaxation) and placed in a beach-chair position. After closed fracture reduction, a small deltoid-splitting and rotator cuff incision is made. Under image-intensifier control, the medullary canal is opened with an awl just medial to the greater tuberosity. After introduction of the guide wire the humeral canal is reamed with a hand reamer. The nail connected to a targeting device is inserted over the guide wire into the medullary cavity. If reduction is unsatisfactory, a cannulated joystick inserted into the humeral head can be used. Another aid for reduction can be to rotate the already inserted Polarus nail (a maximum of 20°) to align the fracture fragments. In 3 cases, all with a 2-part fracture, open reduction was necessary by an extended incision.

The nail must be properly countersunk to avoid impingement. Guided multidirectional proximal locking is performed via drill sleeves with 5-mm cancellous screws into the humeral head, with a maximum of 5 screws. Angle-stable screws are not available with this implant. An end-cap with a polyethylene base can be used to hold the most proximal screw in position, by advancing the cap into the nail until the polyethylene base fully engages the threads of the screw. By using the targeting device, damage to the surrounding structures is prevented. The targeting device is also used for guided placement of one or two 3.5-mm distal cortical screws (Figures 1 and 2). The rotator cuff incision is closed after nail insertion. Postoperatively, patients are immobilized with a sling for 1 week. Thereafter, passive range-of-motion exercises are allowed, followed as soon as possible by active assisted motion.

Results

Of the 35 operated patients 1 patient died and 6 could not be traced, which left 28 patients (20 females) for assessment. The median age was 66 (34–90) years. In 14 cases the initial treatment was operative; the other 21 patients were initially treated nonoperatively. Indications for primary surgery were severe displacement (12 patients) and massive comminution (2 patients). The indications for secondary surgery were progressive displacement (17 patients) and nonunion (4 patients). Median delay until primary surgery was 4 (0–13) days and the median delay before secondary surgery was 21 (8–208) days.

There were 19 patients with a Neer 2-part fracture, 5 with a 3-part fracture, and 2 with a 4-part fracture. In 9 cases, the fracture extended metaphyseally. The standard nail was used in 26 patients; the other 9 patients with metaphyseal extension required the longer nail.

Functional outcome

The median overall Constant score was 89% (39–100) with a mean of 81% (without strength,

Figure 1. A 3-part proximal humeral fracture in a 63-year-old man.

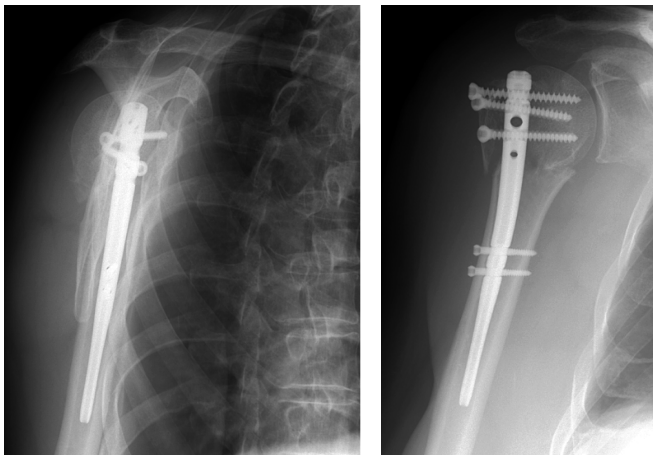

Figure 2. Position of the Polarus nail 1 week postoperatively, with an excellent outcome.

Table 1. Functional outcome after a mean of 1 year

Constant score (% of maximum [a])	No. of patients
> 75%, excellent	17
50–75%, satisfactory	8
< 50%, poor	3

[a] without strength, maximum 75 points.

Table 2. Median Constant score according to type of fracture

Type of fracture	No. of patients	Constant score (% of maximum [a]) median (range)
2-part	16	83 (47–100)
3-part	4	96 (65–100)
4-part	2	96 (92–100)
Extension to metaphyseal	6	72 (39–99)

[a] without strength, maximum 75 points.

maximum 75 points) (Tables 1 and 2). 20 patients reported no pain or mild pain of the shoulder. 16 patients achieved 75% or more of the possible maximum score of 40 points in the section concerning movement, as calculated in the Constant score. The daily activities of 2 patients were severely impaired; one had had a fracture that extended into the proximal humeral shaft and the other had had a 2-part humeral fracture with inadequate positioning of a screw into the glenohumeral joint. Both were treated nonoperatively at first, but osteosynthesis was necessary because of further displacement.

Complications

9 patients had minor to severe complications. 1 patient developed avascular necrosis of the humeral head after a displaced 2-part fracture, with a delay until placement of a standard nail of 4 days. A hemiarthroplasty was performed. Nonunion occurred in one other patient, a man with a proximal fracture with metaphyseal extension who was initially treated nonoperatively. After 16 days, a nail was inserted because of progressive displacement. Nonunion developed and surgical revision was required after 10 months. The intramedullary nail was removed and fixation was performed with screw-and-plate osteosynthesis. The patient had an alcohol addiction and was lost to follow-up.

4 patients required removal of all or parts of the osteosynthesis under general anesthesia. 1 patient was initially treated nonoperatively, but after 2 months secondary surgical treatment with a nail was performed because of delayed union with progressive displacement. After consolidation, the patient had pain. The most proximal screw was first removed, but with no effect, and 11 months after primary surgery the entire osteosynthesis was taken out but the pain persisted. Another patient also suf-

fered from persistent pain, thought to be caused by impingement of the proximal part of the nail. The nail was removed after consolidation, but with no effect. 1 patient required removal of the proximal screw, as it extended into the glenohumeral joint. After this intervention, the Constant score progressed from 11% to 47% but still remained poor. A second patient also required removal of the proximal screw because of outward migration, and this patient recovered completely. 3 other patients had a minor complication: migration of a proximal screw, and removal under local anesthesia was necessary. Wound infections were not seen.

Discussion

Up to 80% of all patients with proximal humeral fractures respond satisfactorily to nonoperative treatment (Young and Wallace 1985, Hodgson et al. 2003). Gaebler et al. (2003) studied a group of 507 patients with an average age of 63 years, all with minimally displaced fractures, and found good to excellent results in 87% after 1 year of nonoperative treatment. Koval et al. (1997) also showed good to excellent results in 77% of 104 patients with minimally displaced fractures, all of whom were treated nonoperatively.

The various treatment options for displaced proximal humeral fractures can be divided into three categories: nonoperative, osteosynthesis, and hemiarthroplasty. There is, however, still inadequate data for evidence-based decision making for the treatment of displaced proximal humeral fractures (Cochrane review, Handoll et al. 2003). Because of the disadvantages associated with other osteosynthesis techniques, we decided to study the outcome of the intramedullary Polarus nail.

Long-term results after nonoperative treatment of displaced fractures were reported by Rasmussen et al. (1992) in 16 displaced proximal 2-part fractures, 17 displaced 3-part fractures, and 9 displaced 4-part fractures. 26 of the 42 patients assessed the result as being excellent or satisfactory. Zyto (1998) also found a high degree of patient satisfaction at a minimum follow-up period of 10 years after nonoperative treatment of 9 displaced 3-part fractures and 5 displaced 4-part fractures. The mean Constant score was 59 (SD 13) in patients with a 3-part fracture and 47 (SD 8) in the 4-part fracture group. In this study as well as in the study of Rasmussen et al. (1992), the level of patient satisfaction was remarkably higher than the functional scoring. Zyto (1998) suggested that nonoperative treatment of displaced 3-part fractures in elderly patients should be considered.

In another study, Zyto et al. (1997) again suggested nonoperative treatment for displaced 3-part fractures in elderly patients. In this study with 40 elderly patients, he compared the functional outcome of nonoperative treatment with that of tension-band wiring of displaced multifragment fractures. The Constant score was 65 (SD 15) for the nonoperative group vs. 60 (SD10) for the intervention group. As only 3 patients had a 4-part fracture, no conclusions could be drawn for this group.

Plate osteosynthesis can effectively reduce the fracture but may cause devascularization of the humeral head, scarring, and stiffness due to damage to the soft tissue (Wijgman et al. 2002, Agel et al. 2004). After an average of 10 years, Wijgman et al. (2002) assessed the results of 60 patients with a 3- or 4-part fracture who had undergone fixation with cerclage wires or a T-plate. The Constant scores were poor in only 13 patients. Hessmann et al. (1999) reviewed the results of plating in a rather young population of 98 patients (22 of whom were less than 50 years of age) with 2-, 3-, and 4-part fractures. Good to excellent results were obtained according to the Constant and Neer scores in 68 and 58 of the fractures, respectively. It has been recommended that AO plating be used in younger patients only, as fixation failure is common in elderly, osteoporotic patients (Robinson and Christie 1993).

One relatively new implant is the locking proximal humerus plate with angular stability. Hente et al. (2004) found good to very good results in 20 of 31 patients, but 5 had partial avascular necrosis of the humeral head. Plecko and Kraus (2005) reported satisfactory results in 3/4 patients with a mean Constant score of 63.

Because of disappointing results and the complexity of hemiarthroplasty, this intervention is reserved for selected cases such as massive comminuted fractures or avascular necrosis—or after previous procedures (Wijgman et al. 2002, Diercks 2003). Hemiarthroplasty gives adequate pain relief

but has a poor functional outcome, and age is a main predictor of outcome.

In our, and others, opinion nonoperative treatment of displaced proximal humeral fractures often fail, resulting in pain and thus limiting activities of daily living (Adedapo and Ikpeme 2001). We believe that during the first few months of nonoperative treatment after a displaced proximal humeral fracture, there is excessive pain and disturbance in daily living and sleep. We found that the shoulder function 1 year after treatment with the Polarus nail was more than satisfactory with a median Constant score (expressed as percentage of the maximum without strength, i.e. of 75 points) of 89% (range 39–100). These results are comparable to those of 2 other published studies concerning the Polarus nail. Rajasekhar et al. (2001) measured a median Constant score of 75 (25–88) points for patients aged over 60 years, and 70 (34–100) points for those younger than 60 years, in 25 patients treated with the Polarus nail. Adedapo and Ikpeme (2001) reviewed 23 patients with displaced 2-, 3- or 4-part shaft fractures. They found a mean Constant score of 88 (40–100), 67 (50-91), and 69 (40–94) points, respectively, at 1-year follow-up.

Unfortunately, the use of the Constant score is rather confusing; it is used in a different way in almost every paper. Also, in our study it was not always possible to obtain the strength score for all patients, so we had to exclude it and recalculate the Constant score as a percentage. Often the Constant score is recommended for use without strength score, especially in elderly and rheumatoid shoulders. We also believe that, for the elderly, strength is not the most important issue in shoulder function; few limitations in daily activity and absence of pain are of greater importance. The patients in our study for whom the measurement of strength was not possible actually had a maximum score for the other parameters.

One of the advantages of this minimally invasive intramedullary device is the possibility of early postoperative mobilization with minor pain. There were major complications in 6 of the 23 patients, requiring revision surgery. Most complications were related to the position of the osteosynthesis. Furthermore, we encountered 1 nonunion and 1 avascular necrosis of the humeral head. There is controversy concerning functional impairment of the shoulder due to local rotator cuff damage at insertion of the nail (Robinson et al. 1992). We consider that this is unlikely, because only a small incision is made in the rotator cuff and this incision is carefully reconstructed after implantation of the nail (Kelsch et al. 1997, Gaullier et al. 1999, Kropfl et al. 2000). The only impingement we noted postoperatively was caused by inadequate positioning of the osteosynthesis.

The functional scores of the 3- and 4-part group in our series were as satisfactory as the 2-part group, suggesting that this method of treatment is also suitable for displaced multifragmentary fractures of the proximal humerus. However, one should consider the low number of patients (n = 7) reviewed with a 3- and 4-part fracture. Adedapo and Ikpeme (2001) reported 23 patients treated with the Polarus nail. In that study, the median Constant score in the 3-part group was 92 (40–100) points, and 67 (50–91) points in the 4-part group.

It still remains difficult to decide what the best treatment is for each different fracture of the proximal humerus. Until "hard" evidence is provided, this decision will still be based on the experience and expertise of the treating surgeon, regarding the type of patient and the type of fracture. We believe that minimally invasive intramedullary fixation of displaced 2-, 3-, and even 4-part proximal humeral fractures is of value.

Contributions of authors

NS, IS and LM: surgical residents who collected the data of all the patients at the three different hospitals. NS and IS: the main authors of the paper. MH, JV, MvdE and SR: trauma surgeons who performed the surgical intervention, evaluated the patients at the outpatient department, and supervised the study and writing of this paper.

No competing interests declared.

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