

Minimal invasive fixation of proximal humeral fractures with an intramedullary nail: good results in elderly patients

Nico Sosef · Roderick van Leerdam · Pieter Ott ·
Sven Meylaerts · Steven Rhemrev

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Abstract

Objective To report on the results of a minimally invasive technique for the fixation of displaced proximal humeral fractures with a locked intramedullary nail.

Patients and methods All consecutive patients treated with a T2™ intramedullary nail between 2004 and 2007 were evaluated. Thirty-three patients were included [mean age 78, m:f ratio (1:4)]. Fracture characteristics were classified according to AO and Neer (eighteen 2-part, eleven 3-part, five 4-part fractures).

Results Functional outcome (Constant Score) was excellent in nine, satisfactory in eight and poor in three patients. Subjective outcome was satisfactory to good for patients with 2-part and 3-part fractures but poor for 4-part fractures. Major complications comprised four fixation failures, two cases of impingement and one deep infection.

Conclusions Minimally invasive fixation of displaced 2-part and 3-part humeral fractures in an elderly population shows satisfactory to excellent results in 80% of patients.

Keywords Humeral · Proximal · PHN · Nail · T2 · Fracture

Introduction

As the general population gets increasingly older, fractures such as proximal humeral fractures are becoming more prevalent. Patients with proximal humeral fractures are often fitter and more likely still net contributors to society compared to patients presenting with proximal femoral fractures, although these patients might well have converted to a lower degree of social independence caused by the fracture [4]. The majority of patients can be treated conservatively while an important minority requires an operative approach. A multitude of operative techniques exist and are generally categorized as open reduction and internal fixation (ORIF), minimally invasive fixation or hemiarthroplasty. Till date, there is still no consensus on which treatment is preferable for these fractures [11]. The goal of the treatment is to reduce pain and regain maximum functional outcome in a relatively short period of time. We performed the study of patients with displaced or comminuted proximal humeral fractures treated with a T2™ locked intramedullary nail to assess the use of this technique for this type of fractures.

Patients and methods

The standard approach for elderly patients with non-displaced proximal humeral fractures is conservative treatment combined with physiotherapy. If (progressive) displacement or comminution is present, the treatment of preference in our institution is fixation with a minimally invasive locked proximal humeral nail.

All consecutive patients who were treated with T2™ proximal humeral nails in our hospital over a period of two and a half years were included in this study. The charts of all patients were reviewed and data were collected including

N. Sosef · R. van Leerdam · S. Meylaerts · S. Rhemrev
Department of Surgery, Medical Center Haaglanden,
The Hague, The Netherlands

P. Ott
Department of Radiology, Medical Center Haaglanden,
The Hague, The Netherlands

N. Sosef (✉)
Zwaardstraat 35, 2584 TN The Hague, The Netherlands
e-mail: nico.sosef@gmail.com

trauma origin, treatment and complications. Patients with pathologic fractures secondary to a neoplasm were excluded for follow-up. An independent radiologist classified the fractures according to Neer and AO. All patients were invited for a visit to the outpatient clinic after full rehabilitation for a physical examination and analysis of the results. Medical Ethical Committee approval was obtained.

Follow-up included objective and subjective analysis of the shoulder using the Constant Score and the Shoulder Rating Questionnaire. The Constant Score [3] consists of four individual parameters which give a total of 100 points: pain (15 points), activities of daily living (20 points), range of motion (40 points) and strength (25 points). We normalized the Constant Score for age and gender as the strength of a normal shoulder differs by gender and deteriorates with age [4, 14]. The score was also compared with the contralateral shoulder. Similar to Rajasekhar [23], scores below 50 points were rated as poor, between 50 and 75 as satisfactory and scores above 75 points as excellent.

The Shoulder Rating Questionnaire (SRQ) [17] is a questionnaire that assesses shoulder symptoms and function in addition to the level of social participation with a possible range of 17–100 points. A Cochrane review [11] found the Shoulder Rating Questionnaire to be a validated instrument.

All operations were performed by one of the senior trauma surgeons. Fixation was achieved with a T2™ proximal humerus nail (Stryker); a minimally invasive cannulated titanium nail and can be used for combined neck and metaphyseal fractures. The proximal screws are fixed in an angle-stable fashion. Patients were operated under general anaesthesia without muscle relaxation and placed in a beach-chair position. A small deltoid-split incision preceded opening of the rotator cuff. The humeral head was de-rotated if necessary and fragments were reduced if possible. After introduction of the guide wire, the nail—connected to the targeting device—was introduced into the medullary cavity. Guided multidirectional proximal and distal locking was then performed. The rotator cuff was closed after nail insertion. Patients were immobilized with a sling for 1 week after the operation. Passive range of motion exercises assisted by a physiotherapist was allowed quickly after this, followed by active exercises.

Results

A total of 33 patients underwent surgery for 34 proximal humeral fractures (one of the patients sustained bilateral fractures). The male/female ratio was 1:4 with a median age of 76 years (range 38–95) at time of the injury. Most fractures (28) occurred as a result of falls from standing height while four patients fell from a height exceeding 1 m, one

Table 1 Fracture classification

| AO-classification | |
|---------------------|----|
| 11-A | 17 |
| 11-B | 15 |
| 11-C | 1 |
| 12-A | 1 |
| 12-B | 0 |
| 12-C | 0 |
| Neer-classification | |
| 2-part | 18 |
| 3-part | 11 |
| 4-part | 5 |

patient had a high-energy trauma and one fracture was sports-related. The fracture classification according to Neer [18] and the AO is listed in Table 1. Primary surgery was indicated due to significant displacements in 24 cases. Surgery was performed after an average of 8 days following the trauma (range 1–20). The fractures of the remaining ten patients were treated conservatively at first. However, nine of these patients showed progressive displacement during follow-up and required intramedullary nailing after a mean of 21 days. One patient developed a delayed-union during the intended non-operative management and had to be treated with an intramedullary nail after 84 days.

Follow-up

Twenty-three of the 33 patients were eligible for follow-up. Six patients died as a result of non-trauma-related causes and four patients could not be traced or lived abroad. Twenty patients completed the follow-up at an average of 19 months (range 9–32). Two patients could not participate due to mental deterioration and two refused to participate. The mean age at the time of follow-up was 78 years (range 40–94). The functional outcome as calculated by the Constant Score is shown in Tables 2, 3 and the subjective outcome evaluated by the SRQ can be found in Table 4.

The functional outcome (compared to the contralateral side) was excellent in nine patients (score > 75 points), satisfactory in eight patients (score between 50 and 75) and poor in three patients (score < 50 points). The Constant

Table 2 Constant Score (CS)

| (Number fractures) | Median CS normalized for age and gender (range) |
|--------------------|---|
| All fractures (20) | 62 (21–100) |
| 2-part (7) | 72 (46–100) |
| 3-part (10) | 62 (47–89) |
| 4-part (3) | 23 (21–25) |

Table 3 Constant Score (CS)

| (Number fractures) | Median CS compared to contralateral shoulder (range) |
|--------------------|--|
| All fractures (20) | 72 (26–97) |
| 2-part (7) | 81 (52–97) |
| 3-part (10) | 71 (50–100) |
| 4-part (3) | 26 (24–53) |

Table 4 Shoulder Rating Questionnaire (SRQ)

| (Number fractures) | Median SRQ (range) |
|--------------------|--------------------|
| All fractures (20) | 37 (35–99) |
| 2-part (7) | 74 (52–99) |
| 3-part (10) | 68 (35–92) |
| 4-part (3) | 41 (35–52) |

Score normalized for age and gender showed seven patients to have excellent results, eight patients had satisfactory results and five patients (one bilateral fracture) had poor results. Examples of patients with poor and excellent results are shown in Figs. 1a, b, and 2a, b.

Complications

The following complications were scored for all 34 fractures. The nail dislodged from the humeral head in four

cases. The nail in one 75-year-old patient with a 2-part fracture had to be replaced with an angle-stable plate. Another patient, 88-year-old with Alzheimer's disease and a 2-part fracture had a nail dislodgement after repeated falls and the nail had to be removed. Both these patients were not available for follow-up. The postoperative radiograph of a 66-year-old patient with a 2-part fracture showed malposition of the humeral head but physiotherapy still resulted in functional improvement and the nail was not removed at first. This patient's Constant Score 7 months after surgery was 46 with a subjective score of 60 points. The patient's nail was removed 10 months after surgery at which time the Constant Score improved from 46 to 72 points and the subjective score from 60 to 74 points. A 94-year-old patient with a 4-part fracture showed a very poor functional result with a Constant Score of 26 and a subjective score of 41 points. The patient was advised to have the nail removed for its inadequate position, but further surgery was refused and the poor result accepted. The nail extruded in two cases with complaints of impingement and required removal after consolidation of the fracture. One of these two patients died and was therefore not available for follow-up; the other had a Constant Score of 64 but with a pre-existing moderate shoulder function due to Parkinson's disease. One or more proximal screws had to be removed in six cases. Two minor and one major complications of infection occurred: a superficial infection without any clinical consequences and one case of pneumonia. One mentally incapacitated alcoholic patient acquired a deep infection, for which the nail had to

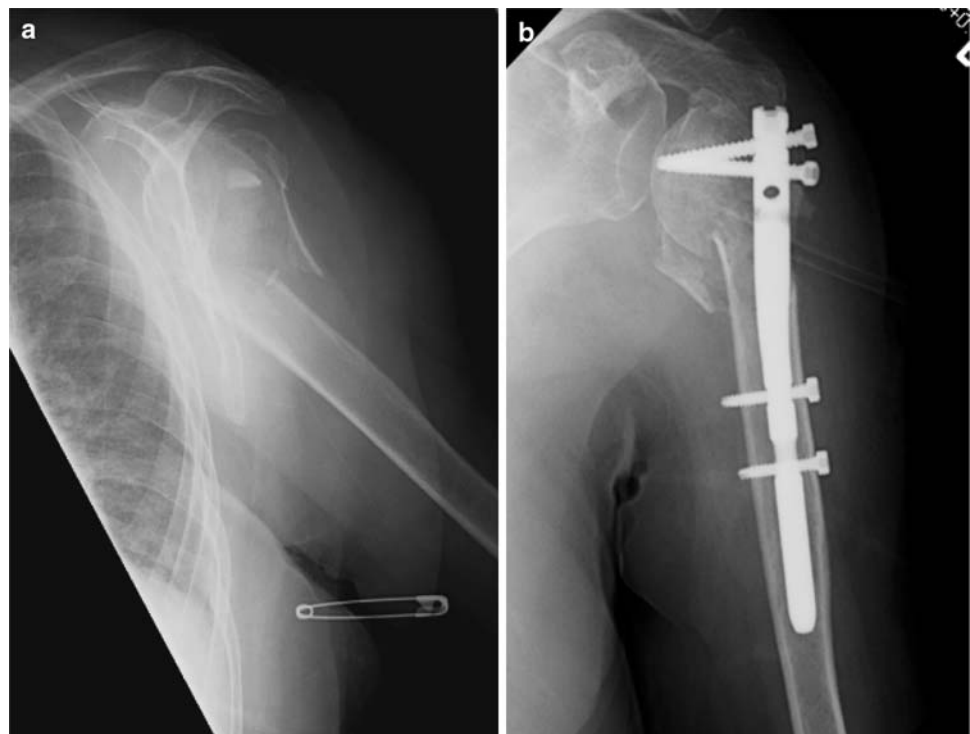
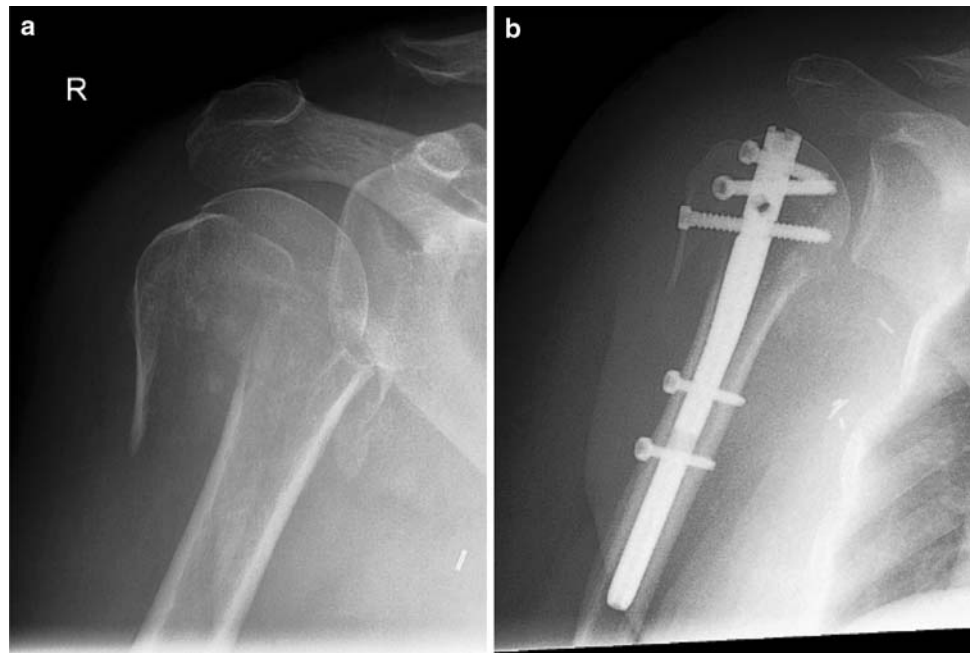
Fig. 1 Patient with a poor result

Fig. 2 Patient with an excellent result



be removed. The pseudo-arthritis that developed afterwards was treated conservatively. Regrettably, this patient was not able to attend the follow-up in this study. Avascular necrosis of the humeral head did not occur.

Discussion

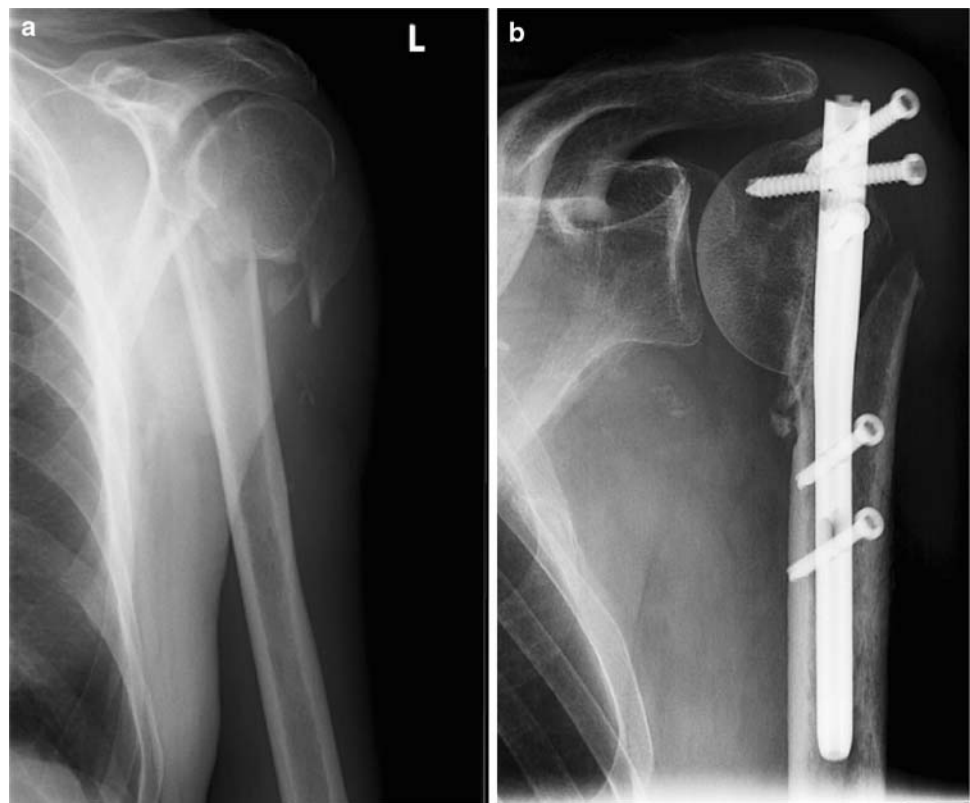
Proximal humeral fractures often occur in a difficult patient population. Most patients are old and have osteoporotic fractures. Particularly, this group is hard to follow. The younger patient with a low-energy trauma proximal humeral fracture has often co-morbidity as alcohol abuse, diabetes or psychical disturbances. One can imagine these patients are not prone to visit the outpatient department. Nevertheless, in this study, we demonstrated that functional and subjective results after intramedullary fixation of proximal humerus fractures were satisfactory to excellent in 80% of patients. Our policy to treat the elderly aggressively for this displaced fracture implies that to our opinion early motion and by early fixation of the fracture adequate pain relief can be expected in the majority of cases. We believe that these benefits outweigh the risks of surgery and contribute to higher rates of regained independence in the first weeks after treatment.

Patient selection seems crucial for treatment of these cases. We have shown that 4-part fractures are difficult to treat with intramedullary fixation and that results were disappointing. Reduction of the greater and lesser tubercles through the spilt incision is technically more demanding and perhaps not feasible in common practice. An anterior approach with angle-stable plate fixation might be the

better option. Hessler showed good results using fixed-angle plates of 46 unstable proximal humeral fractures. Collapse of the humeral head occurred twice and avascular necrosis once [13]. Hente et al. also found good to very good results in 20 out of 31 patients. This study showed that the dislocated 4-part fractures had a higher risk of developing avascular necrosis than other fractures [12]. Plecko and Kraus [21] showed satisfactory results in three quarters of the 36 patients and partial or complete avascular necrosis in 3 patients. A recent study in elderly patients showed a clear correlation between the final score and the quality of reposition of the tuberosities and/or plate position but stated that the currently celebrated angle-stabilizing plates did not lead to significant improvements in functional outcome, compared with other established osteosynthesis procedures [7].

Other technical aspects of the procedure may have contributed to success or failure of the treatment. Precise introduction of the nail into the lateral aspect of the articular surface is advocated but not exercised in all patients. This can result in secondary loss of nail position. If the nail entry point is not placed adequately, the positions of the fixation screws in the humeral head are altered and this generally causes reduced fixation strength and an increased risk of secondary dislocation [26]. Furthermore, reduction of the greater tubercle seems mandatory for a stable construct and allows the humeral head to be tight between the shaft and tubercle after fixation of the tubercle to one of the screws. Omission of this technical aspect can also contribute to secondary loss of fixation (Fig. 3a, b). In the treatment of proximal humeral fractures with locking plates, it is postulated that anatomical or slightly impacted reduction and

Fig. 3 Secondary loss of fixation



stabilization of the medial hinge is important for maintenance of reduction and that mechanical complications are related to varus malalignment [9]. Finally, derotation of the humeral head also plays an important role in the operation. If not performed adequately, subsequent parts of the reduction, such as the head (varus or valgus position) and greater tubercle will not be anatomic. We think that an omission of one of the above-mentioned surgical aspects could prevent successful operations. In this study, dislodgment of the nail from the humeral head took place three times in 2-part fractures and once in a 4-part fracture. Although numbers are too small to draw definitive conclusions, all patients with a poor result had a varus malalignment and not adequately reduced medial hinge, of those with satisfactory results half of them had a varus malalignment (twice in combination with a not adequately reduced medial hinge) and of the nine patients with an excellent result two of them had a varus malalignment (once in combination with a not adequately reduced medial hinge).

The majority of all patients with proximal humeral fractures can be treated to satisfaction without surgery [14, 29]. Conservative treatment can be appropriate for (minimally) displaced or displaced fractures. A study of 507 patients with minimally displaced fractures treated non-operatively showed that 87% had good to excellent results after 1 year [8]. Koval [16] found similar results in a group of 104 patients with 77% of patients attaining good to excellent

results. Some authors also suggest non-operative treatment for displaced fractures in elderly patients, as this has high patient satisfaction at long-term follow-up [24, 30].

Operative treatment options can be divided roughly into open reduction and internal fixation, hemiarthroplasty or minimally-invasive fixation. Open reduction and internal fixation can be performed using a wide array of methods such as tension-band wiring, screw fixation and conventional or locked-plate osteosynthesis. The latter is the most advanced type of plate fixation. In a recently published review article concerning the treatment of proximal humerus fractures, Vallier stated that locked plating is of benefit in those cases where adequate fixation via other methods is not possible. However, specific indications, limitations and cost-effectiveness warrant further study [27]. Disadvantages of open reduction and internal fixation could be devascularization of the humeral head, scarring and stiffness due to soft-tissue damage. Hemiarthroplasty has been shown to provide good pain relief, while the achievement of excellent range of motion using this method has been less predictable [19]. Medium-term results of hemiarthroplasty by Grönhagen [10] demonstrated moderate function and poor strength with a mean Constant Score of 42. Wiggman [28] and Diercks [5] suggest that this intervention be reserved for selected cases such as massively comminuted fractures, avascular necrosis or after previous procedures. Pavlopoulos [20] and Bufquin [2] recently presented

hemiarthroplasty results that showed acceptable function and levels of pain, but a high complication rate. Results of retrospective studies with minimally invasive fixation by an intra-medullary nail (Polarus™) show satisfactory to good results [1, 23, 25]. The only other available study in English literature regarding the T2-proximal humeral nail showed this type of fixation to be safe and reliable for 2- and 3-part fractures [22]. The wide diversity of types of fractures described as proximal humeral fractures makes it difficult to compare the end-results of various studies. But as is commonly stated in keynote lectures and courses: anatomic reduction rather than the choice of implant is the cornerstone in the successful treatment.

The Constant Score normalized for age and gender showed three cases with a poor functional result at follow-up. One patient, who was the patient with the bilateral fractures (AO fracture type 11-B2), suffered from complaints of frozen shoulder prior to the trauma. No other causes were found for the poor results. A 94-year-old patient (AO fracture type 11-B2) with an inadequate position of the nail refused further surgery and accepted the poor result. All of these patients also had a low subjective outcome with results ranging from 35 to 41 points.

Two different scores were used to analyse shoulder function and to compare results to other studies. We believe that the strength score component of the standard Constant Score makes it an inconsistent measure. Strength was measured differently in several studies and the use of the Constant Score was recommended without the strength score component [25]. Furthermore, if used as described by Constant initially [3], the weight considered to be achievable for groups of elderly patients is too heavy. We normalized the Constant Score beforehand for age and gender-related differences in the same way as suggested by Katolik [15]. A decrease in absolute value of the Constant Score due to these factors was thereby reduced. Finally, we compared the Constant Score of the injured shoulder to the contralateral side. These modifications allowed us to minimise scoring restrictions in this study.

The SRQ is a validated subjective scoring method but it is not widely used yet. Only 5 out of the 20 elderly patients in this study were still employed. The employment-related questions were omitted for retired patients, without recalculating the total score for these patients. This means that the SRQ score in this series was always 2–10 points lower compared to an employed population.

A study in an elderly population with a median age of 78 inevitably has a high dropout rate. This could well influence the outcome. One-fourth of the patients could not participate in this study due to the patients' deaths or mental incapacity to participate. During this study period all patients treated with a different intramedullary nail (Polarus™ nail Acumed) were also excluded to create uniformity in this

study group. After 2006, this type of nail was no longer available in our hospital. Fourteen patients underwent surgery with this type of nail during the study period and were excluded. These low-volume studies have methodologic limitations and are difficult to compare. Therefore, several questions still remain unanswered. We believe that our own results preclude the use of intramedullary nails for the treatment of 4-part fractures, as reduction is too demanding technically and secondary loss of reduction cannot be avoided. The nail has been proven to provide less biomechanical strength [6]. Angle-stable plate fixation or hemiarthroplasty is possibly a better option. The studies mentioned in this paper will not enable us to determine which implant to use for what fracture. Most institutions do not treat sufficient patients to enable specialization with various specific implants for all types of fractures. They must skill themselves in using only one or two implants for all fractures. A number of speakers also made similar comments at Eurotrauma 2007. In a medium volume institution such as ours, it is probably the best to further broaden our experience of proximal humerus nails for displaced 2- and 3-part fractures but consider plate osteosynthesis, hemiarthroplasty or conservative treatment for 4-part fractures.

Conclusions

Based on the experiences described in this study, we find minimally invasive fixation with intramedullary nails suitable for displaced 2- and 3-part fractures of the proximal humerus. The limited number of 4-part fractures in this study showed poor results. Minimally invasive intramedullary fixation seems to be difficult for these complex fractures in particular and plate osteosynthesis, hemiarthroplasty or conservative treatment should be considered instead. Proximal humerus fractures are diverse with a wide array of fixation methods lacking a definitive guideline, making it necessary and important to provide patients with customized surgery.

Conflict of interest statement There is no conflict of interest in this study.

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