



Internal fixation of proximal humerus fractures with the Polarus intramedullary nail

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The optimal treatment method for displaced proximal humeral fractures continues to be under debate. There are a variety of fixation techniques, none of which has been proven to be more effective. We retrospectively studied 24 patients with displaced proximal humerus fractures, treated with the Polarus intramedullary nail. All patients were followed radiographically and clinically for one year. Clinical outcome was assessed with the Constant score. All fractures went on to clinical and radiographic union. Mean time to union was 9.2 weeks (range: 9-16). Only one patient with a 3-part fracture had an asymptomatic malunion and one patient had iatrogenic radial nerve palsy, which spontaneously recovered. In total, 83.3% of the patients had an excellent or good clinical outcome. The Polarus nail appeared in this study as an effective device to treat proximal humeral fractures, with good overall functional results and a low complication rate.

Key words: humeral head fractures; intramedullary nail; Polarus nail.

INTRODUCTION

Proximal humerus fractures account for 4% to 5% of all fractures (5,20,23). Approximately 80% of these are undisplaced or minimally displaced, and non-operative treatment usually results in a good functional outcome (6,26,29). In the young and middle-aged patients, high-energy trauma is commonly implicated. In the aged population these fractures

are often related to osteoporosis and are considered an important source of morbidity (28).

For fractures necessitating surgical stabilization, various treatment methods have been used. No single technique has been demonstrated to be superior or without complications. Many authors reported good to excellent results using plating techniques (14,15,19,32). Some authors reported satisfactory results using percutaneous pins and/or tension band wiring in particular cases (26,30). Intramedullary nailing is a well established treatment method for closed diaphyseal humerus fractures. In the current literature there is an evolving role of intramedullary devices for proximal humeral fractures (1,2,17,28,35).

We retrospectively studied the patients treated in our unit for proximal humerus fractures with the Polarus intramedullary nail (Acumed, Inc, Beaver-

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ton, OR, USA). We report our results regarding fracture healing, functional outcome and related complications.

MATERIALS AND METHODS

After Institutional Review Board approval, all patients who sustained an acute proximal humerus fracture and were treated surgically using the Polarus intramedullary nail between January 2004 and December 2006, were identified. Patients with pathologic fractures were excluded. There were 24 patients, 15 male and 9 female. Their mean age was 60 years (range: 31-82). All patients were available for follow-up. The fractures were classified according to the Neer classification system (26). A fracture was considered to be significantly displaced if one or more fracture segments was more than 45° angulated or displaced more than 1cm. There were 13 patients (54.2%) with 3-part fractures, 7 patients (29.1%) with 4-part fractures and 4 patients had a 3-part fracture combined with a fracture of the humeral shaft (16.7%).

Device description and surgical technique

The Polarus® nail is a standard curved, cannulated and tapered stainless-steel intramedullary rod available with 150 and 200 mm in length. The Polarus Plus® is a longer device with various lengths from 200 to 280 mm and is designed for more distal humeral shaft fractures. There are five screw holes for proximal locking and two distal interlocking holes for low-profile locking screws. It is provided with a radiolucent targeting device to facilitate insertion of both proximal and distal screws. The positioning of the screw holes, added to the possibility to rotate the rod up to 20° reduce the risk of damaging anatomical structures such as the axillary nerve and the biceps tendon.

All patients were operated under general anaesthesia, in a semi beach chair position. Intra-operative fluoroscopy was available in each patient. The nail was inserted through a deltoid-splitting approach. A 3cm longitudinal incision was made in line with the greater tuberosity, and the deltoid muscle was split in line with its fibers. Fracture reduction was obtained by closed methods (traction-abduction/adduction-rotation) in 19 patients.

In 5 patients (4 four-part, 1 four-part fracture with diaphyseal extension), the reduction was not satisfactory. In these cases, the incision was extended and open anatomic reduction of the fracture fragments was performed. The axillary nerve was identified and protected during deltoid muscle splitting.

The entry hole for nail insertion was made immediately medial to the greater tuberosity and approximately 1.5 cm posterior to the bicipital groove with a cannulated drill-bit. The use of an awl was avoided to prevent the displacement of fractures involving the greater tuberosity (2). In cases where a tear of the supraspinatus tendon was noted, either traumatic or degenerative, the tendon split was used for drill entry. Otherwise, a small longitudinal tendon split was performed just proximal to its osseous insertion.

Guided multidirectional proximal locking was performed via drill sleeves with 5-mm cancellous screws into the humeral head, with a maximum of 5 screws. The targeting device was also used for guided placement of one or two 3.5 mm distal cortical screws. At the end, the rotator cuff and deltoid muscles were repaired with absorbable sutures and the skin was closed with metal clips.

Postoperatively the patient's arm was resting in a sling. Active assisted exercises of the shoulder were initiated on post-operative day 2, followed by active exercises.

The patients were followed-up on 1st, 3rd, 6th and 12th month after surgery radiographically and clinically. Radiological control included AP, lateral and axillary views to evaluate union, neck/shaft angle, implant-related complications and signs of avascular necrosis (AVN). In the absence of x-ray findings suspicious for AVN, no MRI evaluation was performed. Bone healing was considered to be achieved when sclerosis and obliteration of fracture lines was noted in association with pain free shoulder motion.

Shoulder function was assessed with the Constant score (9). Functional assessment includes clinical criteria for pain (15 points), range of movement (40 points), power (20 points) and daily living activities (20 points). The Constant score is graded as poor (0-55 points), moderate (56-70 points), good (71-85 points), or excellent (86-100 points).

RESULTS

Twenty patients were operated within 48 hours from injury, while four patients were operated after 4-6 days. All fractures were radiologically healed in a mean time of 9.2 weeks (9-16weeks) (fig 1). One patient with fracture lines extending into the humeral shaft had 'delayed union' at 16 weeks. No evidence of malunion was found but in one patient with a 3-part fracture the neck-shaft angle was reduced to 115°. The patient was clinically asymptomatic, without signs of greater tuberosity impingement during shoulder abduction. No cases with avascular necrosis was diagnosed by clinical and radiological examination. No missed proximal or distal interlocking screws were noted. We had no superficial or deep wound infections.

Eight patients had an excellent clinical result with a mean Constant score of 90% (range : 86-100), 12 patients had a good result with a mean Constant score of 83% (range : 71-85), 3 patients had a moderate result with a Constant score of 63% (range : 56-70), and 1 patient had a poor result with a Constant score of 54%. In total, 83.3% of the patients had an excellent or good clinical outcome.

Two patients reported persistent shoulder pain postoperatively. Symptoms were attributed to prominence of the nail above the level of the humeral head, impinging on the acromion undersurface. The nail was removed and the pain was relieved in both patients. One patient had an iatrogenic traction injury of the radial nerve during reduction and insertion of the nail, which had fully recovered spontaneously at eight months.

DISCUSSION

The optimal treatment of displaced proximal humeral fractures is still debated (17,28). Neer *et al* (7) proposed tuberosity displacement > 1 cm, or angulation > 45° as criteria for operative treatment. Although these criteria are not absolute and their reliability and reproducibility are questioned, they do provide a treatment guideline (14,15,16). Non-operative treatment is suitable for non-displaced or stable minimally displaced fractures (2). Non-operative treatment for displaced proximal humerus, involving the greater tuberosity, is often associated with subacromial impingement, pain and functional limitations, thus only patients who are medically

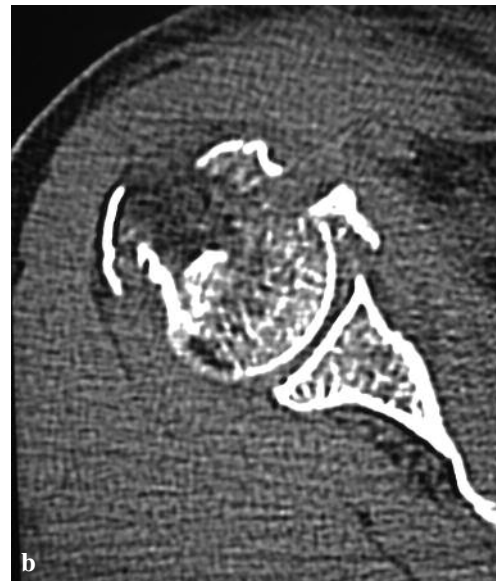


Fig. 1a & b. — A 65-year-old female sustained a displaced fracture of the surgical neck. CT scan (a : frontal, b : axial view) revealed a 4-part proximal humerus fracture with mild displacement of the tuberosities, valgus impaction and medial displacement of the humeral shaft.

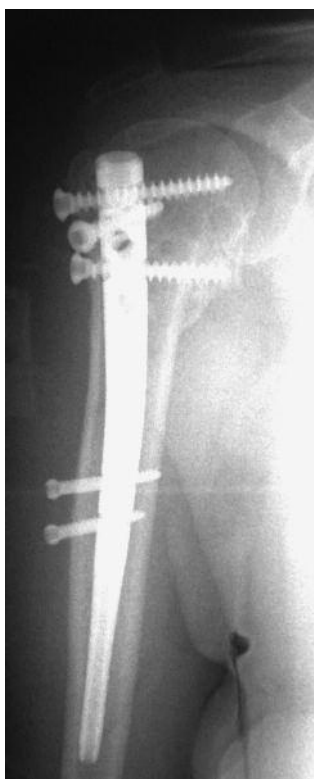


Fig. 2. — Post-operative radiograph at 6 months follow-up, showing healing of the fracture.

unable to undergo surgery or rehabilitation may be treated non operatively (1,35,39). Our surgical treatment guidelines include Neer's criteria, all displaced three-part and four part fractures and those combined with humeral shaft fractures. Fractures with dislocation of the humeral head are preferably treated with hemiarthroplasty, especially in elderly patients (10,13,24,27,30,38).

Surgical options for stabilization of proximal humeral fractures include Kirschner wires (KW), Ender nails, transosseous tension band sutures, plate fixation and intramedullary nails. Kirschner wires are associated with a number of complications ; namely loss of fracture reduction, loosening and migration of pins and pin track infection. When compared with percutaneous pins (PP), the Polarus nail provided a stronger, more stable and durable fixation option than did PP fixation for large-fragment multipart proximal humeral fractures with minimal comminution (36). However, If there is

extensive comminution, the intramedullary device may be inadequate and PP may be effective (36).

Ruch *et al* (32) in a cadaveric study demonstrated that plate/screws fixation and IM nailing provide greater torsional and bending stiffness than does fixation with tension band wires /Ender nails.

Plates have been extensively used in the past to treat these fractures. New plates with locked screws allow for anatomic fracture reduction and provide great stability, especially in fractures with bone loss or severe osteoporosis. However, we should keep in mind that open reduction with extensive soft tissue stripping may impair the head blood supply even further, thus increasing the risk of osteonecrosis (34).

Malster *et al* (25) compared the Polarus nail with the Russel-Taylor nail and an experimental nail. The Polarus nail had the highest bending as well as torsional stiffness and lower angular displacement.

Usually, healing of a proximal humeral fracture occurs within 8-10 weeks (6). If the fracture has not achieved union by 3-4 months, it can be considered as delayed union, and as nonunion if union has not occurred by 6-8 months (6). In the study of Rajasekhar *et al* (28), 30 proximal humeral fractures were treated ; only one fracture developed a nonunion (3%), and 80% had satisfactory to excellent results. Sosef *et al* (36) in a series of 35 patients treated with the Polarus nail, reported one patient who developed avascular necrosis and one who developed nonunion. In the study by Kazakos *et al* (17), bony union was achieved in all patients in 5-11 weeks (mean : 6 weeks). In our series all fractures were healed within 9.2 weeks median time, with no case of clinical or radiological nonunion.

Although union of the fracture lines, with restoration of the mechanical axis, is important for successful clinical outcome, not all patients with good anatomical restoration report an excellent result. We should keep in mind that these injuries may be associated with severe intra-articular trauma also affecting the surrounding soft-tissue envelope. In our study an excellent or good clinical outcome was obtained in 79 % of the patients according to the Constant score. This functional restoration is comparable with that reported in the literature, ranging from 75-90% (17,28,37). Kazakos *et al* (17)

had satisfactory to excellent results in 78% of the patients using the Neer functional score, while Koike *et al* (18) reported satisfactory to excellent results in 79% of the patients.

Avascular necrosis of the humeral head is a well known complication, related to the specific pattern of its blood supply. Although traumatic necrosis often is not progressive and will not cause significant pain or functional deficit, it sometimes causes a disabling problem. An incidence between 3-14% (21) has been reported for 3-part fractures, rising to 21-75% in 4-part fractures (21,22). No case of AVN at latest radiological follow-up at one year was noted in our patients. However further follow-up is necessary to estimate the true incidence of AVN as it can develop radiologically even 2-3 years later. Adedapo and Ikpeme reported avascular necrosis of the humeral head in 4% of their patients (1). Kazakos *et al* (17) found that one of 27 patients had avascular necrosis, whereas Agel *et al* (2) and Koike *et al* (18) had no evidence of avascular necrosis in their study.

Impingement from high-riding tuberosities or subacromial scarring may limit motion. We noted two patients with symptomatic impingement caused by nail protrusion over the greater tuberosity. In other studies, the authors reported subacromial irritation as a complication of proud placement of the nail (2,28,35). Adedapo and Ikpeme (1) noted in their series proximal screw loosening and extrusion causing pain in three patients (13%). After removing these loosened screws, all symptoms were completely relieved.

It remains difficult to decide on the best treatment option for each different fracture pattern of the proximal humerus. The plethora of treatment options suggests that the ideal method is not yet established. The Polarus nail offers specific advantages especially for multi-fragment or displaced fractures where open reduction would require an extensive surgical approach. Preservation of the periosteal blood supply and biomechanical stability of the fracture site encourage uneventful healing. Immediate shoulder mobilization can be undertaken, resulting in rapid postoperative functional recovery. The Polarus nail appeared in this study as an effective device for proximal humeral fractures

especially in young active patients, allowing for early return to their previous activities of daily living.

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