ABSTRACT

Purpose. To report the outcomes of Polarus nail fixation for displaced proximal humeral fractures.

Methods. Medical records of 19 men and 27 women aged 26 to 84 (mean, 63) years who underwent fixation using a standard Polarus nail (n=34) or Polarus plus nail with shaft extension (n=12) for proximal humeral fractures of 2 and 3 parts (n=34) and 2-part with extension to the shaft (n=12) were reviewed. Fracture union, neck shaft angle, and hardware complications were evaluated using radiographs. Outcomes were assessed using the Constant score, the visual analogue scale for pain, and subjective satisfaction. The range of motion, grip strength, and ability to return to work were also recorded.

Results. The mean follow-up was 20 (range, 15–28) months. The mean humeral neck shaft angle was 137.2º. 44 (96%) patients achieved fracture union after a mean of 14 (range, 11–16) weeks. Two patients with 3-part fractures did not unite; one of them underwent hemiarthroplasty and the other consented for nail removal only. Complications included temporary radial nerve palsy (n=2), impingement symptoms caused by the prominent metal work (n=10), and missing of the proximal screws in the nail (n=4). Respectively in patients aged <60 (n=15) and ≥60 years (n=31), the mean Constant scores were 79 and 67 (p=0.04). The mean pain score improved from 93 to 15.5 at 12 months. 16 patients were very satisfied, 22 were satisfied, and 8 were not satisfied with the outcome. Of the latter, 3 were aged <60 years and 5 were aged ≥60 years.

Conclusion. Polarus nail fixation for displaced proximal humeral fractures achieved good fracture union and satisfactory functional outcome, particularly in younger patients and those in active employment, but elderly dependent patients tended to have poor functional results. The rates of minor hardware problems and non-union in 3-part fractures were relatively high.

Key words: bone nails; humeral fractures

INTRODUCTION

Proximal humeral fractures account for 4% to 5%
of all fractures,\(^1\) and they usually can be treated satisfactorily with conservative methods.\(^2\) Complex, displaced, unstable fractures are difficult to treat, particularly those in the elderly and extending into the shaft with multiple fragments. Operative treatments include Kirschner wire fixation, external fixation, tension band fixation, Rush pin fixation, intramedullary nailing, and plating.\(^3,4\) There is no gold standard technique. Proximal humeral nailing is minimally invasive, involves less soft-tissue dissection, and preserves fracture biology. This study reports the outcomes of Polarus nail fixation for displaced proximal humeral fractures.

MATERIALS AND METHODS

Medical records of 19 men and 27 women aged 26 to 84 (mean, 63) years who underwent fixation between January 2007 and December 2010 using a standard Polarus nail (n=34) or Polarus plus nail with shaft extension (n=12) for proximal humeral fractures in 2 parts (n=30), 3 parts (n=4), and 2-part with extension to the shaft (n=12) were reviewed. Those with pathological fractures or head split fractures were excluded. Fractures were evaluated using standardised anteroposterior, scapular lateral, and axillary radiographs, and were classified according to the Neer classification. The injury mechanism included simple falls (n=38), road traffic accidents (n=7), and snowboarding (n=1).

The standard Polarus nail (Acumed, Hillsboro [OR], USA) was a 150 mm long cannulated intramedullary nail. It had a 9º lateral bend proximally to facilitate insertion. Its tapered tip reduced stress concentration. The proximal screw holes were in a spiral array, which provided fixation in multiple planes and thus increased stability. A radiolucent targeting device was used for insertion of proximal and distal locking screws for the standard nail. Both 5.3-mm locking and 5.0-mm non-locking proximal cancellous screws were used. The distal screws were 3.5 mm in diameter. The Polarus plus nail is available from 200 to 280 mm in length for fixing combined proximal humeral and shaft fractures.

Patients were placed in a beach chair position under general anaesthesia. Prophylactic antibiotics were administered. A small deltoid splitting incision was made, and the rotator cuff was cut along the incision. A pilot hole was made under an image intensifier, and closed reduction by gentle traction was performed with minimal soft-tissue disruption. Four patients required mini-open reduction through the deltoid split. The Polarus nail is a curved nail and necessitates a more lateral entry portal, near the supraspinatus tendon insertion. In 3-part fractures, the entry portal may be located between the greater tubercle and humeral head fragment. Insertion of the nail may push the fracture fragments apart and cause fragment displacement. Caution is needed. The reduced fracture fragments were held temporarily with Kirschner wires (n=6) or ethibond sutures (n=4) through the small deltoid incision. The proximal and distal nail ends were locked with a mean of 3.2 screws, with at least 2 proximal screws in 2-part fractures. Locking proximal screws were used in 16 patients with poor bone quality, whereas non-locking proximal screws were used in the remaining 30 patients. The rotator cuff was then repaired carefully and the wound closed in layers. The arm was supported in a sling, and the shoulder was mobilised within limits of comfort under the supervision of a physiotherapist.

Patients were followed up at weeks 2 and 6 and thereafter at 3-month intervals. Fracture union, neck shaft angle, and hardware complications were evaluated using radiographs. Outcomes were assessed by a physiotherapist using the Constant score,\(^5\) the visual analogue scale for pain, and subjective satisfaction. The shoulder range of motion was measured using a goniometer, and grip strength was measured using a dynamometer. The ability of the patient to return to work was also recorded.

RESULTS

The mean follow-up was 20 (range, 15–28) months. The mean humeral neck shaft angle was 137.2º (standard deviation, 12º). 44 (96%) patients achieved bone union after a mean of 14 (range, 11–16) weeks. Two patients with 3-part fractures did not unite; one of them underwent hemiarthroplasty and the other consented for nail removal only. Two patients developed temporary radial nerve palsy. Ten patients had impingement symptoms caused by the prominent metal work: one required removal of the nail, 8 underwent removal of the backing out locking (n=2) and non-locking (n=6) proximal screws, and one with the Polarus plus nail required removal of the distal anteroposterior screw owing to impingement over the triceps tendon causing clicking (Fig.). In 4 patients, one of the proximal screws missed the nail, owing to the relative rotatory movement between the nail and the guide, but this did not affect the outcome.

In patients aged <60 (n=15) and ≥60 years (n=31), the mean Constant scores were 79 (range, 36–92) and 67 (range, 24–84), respectively (p=0.04); and
the score was excellent (>75) in 10 and 12 patients, satisfactory (50–75) in 3 and 12, and poor (<50) in 2 and 7, respectively.

The mean pain score improved from 93 (range, 60–100) to 15.5 (range, 0–35) at 12 months. 24 patients had little or no pain at rest or during activity; 17 patients had pain on activity and on raising the arm over the shoulder, and 5 had pain at rest requiring intermittent analgesia.

Loss of forward flexion, abduction, and external rotation was noted at 12 months. The mean forward flexion was 85° (range, 40–130°), abduction was 75° (range, 30–120°), and external rotation averaging neutral was -7° to 15°. The stiffness was confined to the glenohumeral motion; the scapulothoracic motion was similar to that in the unaffected limb. Stiffness was common in elderly patients; its cause was multifactorial and included fracture severity, premorbid status, duration of immobilisation, patient motivation, and associated soft-tissue damage. Rehabilitation programme was standardised in all the patients. Secondary adhesive capsulitis appeared to be a contributory factor. Respectively in patients aged <60 (n=15) and ≥60 years (n=31), the mean pain-free flexion was 110° and 90° and the mean abduction was 100° and 80° at 18 months.

The grip strength decreased to a mean of 19.5 kg, compared with 22 kg in the unaffected limb. All patients had restriction in activities of daily living, particularly dressing, rising from a chair, and washing.

16 patients were very satisfied, 22 were satisfied, and 8 were not satisfied with the outcome. Of the latter, 3 were aged <60 years and 5 were aged ≥60 years.

All the 15 employed patients returned to work: 6 of them were manual workers and 5 of them changed to office jobs. In 31 patients aged ≥60 years, all the 8 patients in employment achieved excellent results, whereas those who were dependent and limited in mobility had poor outcome.

**DISCUSSION**

Patient selection and appropriate fracture configuration are keys to achieving good outcome in displaced proximal humeral fractures. Four-part fractures are most difficult to treat and may require early replacement to optimise function. Stiffness and reduced function are common in the 3- and 4-part fractures.3–9 Fracture stability is necessary to enable soft-tissue healing and restoration of function.

Outcomes are similar after tension band wiring and conservative treatment.6,7 Rush pins are a better alternative than rigid plates for 2-part fractures, but are associated with proximal migration of the pins into the joint necessitating early removal.8 The AO T-plates and cloverleaf plates are associated with poor results, particularly in patients with poor bone stock; the complication rate is around 40% and complications include poor hold of screws in osteoporotic bone, subacromial impingement, and avascular necrosis from excessive periosteal and soft-tissue stripping.4,9 Locking plates are associated with a high complication rate and increased learning curve10,11; medial support in the proximal humerus to maintain reduction is emphasised.12 Intramedullary devices are biomechanically superior to plates for treating proximal humeral fractures.13

In a study of 25 patients with 2- and 3-part fractures treated with the Polarus nail, 20 achieved satisfactory-to-excellent functional outcomes in terms of the Constant score.14 Complications included non-union (n=1), avascular necrosis (n=1), and proximal screw loosening (n=1).14 In another 23 patients with 3- and 4-part fractures treated with the Polarus nail, functional results were very good for the 3-part

**Figure**  (a) Backing out of proximal screws and (b) cutting out of the locking proximal screw penetrating the articular surface and backing out of the nail and a locking distal screw.
fractures with a mean Neer score of 89. The mean scores for 4-part and 3- and 4-part fractures with shaft involvement were 60 and 73, respectively. Complications included avascular necrosis and collapse of the humeral head that led to nail protrusion and subacromial impingement (n=1) and loosening of the proximal screws necessitating removal (n=3). In another study of 20 patients with proximal humeral fractures treated with the Polarus nail, 14 achieved bone union. Complications included proximal screw penetration to the articular surface (n=1), loosening of proximal screws (n=3), nail failure necessitating conversion to a custom blade plate (n=1), and nail failure causing varus collapse (n=1). In the latter 2 nail failure cases, the nail was inserted through the greater tuberosity fracture and lateral to the sulcus; therefore, the nail insertion site is critical in lateral metaphyseal comminution. In another study of 16 patients with 2-part and 5 patients with 3- and 4-part fractures, the union rate was 96% and complication rate was 28%; the mean constant score was 74.5; patients aged <60 years achieved better functional outcome.

Our study results were comparable with those in other studies in terms of fracture union, complications, functional outcome, and patient satisfaction, but we had higher rates of minor hardware problems and failure in 3-part fractures. One limitation of this study was its retrospective nature.

CONCLUSION

Polarus nail fixation for displaced proximal humeral fractures achieved good fracture union and satisfactory functional outcome, particularly in younger patients and those in active employment, but elderly dependent patients tended to have poor functional results. The rates of minor hardware problems and non-union in 3-part fractures were relatively high.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES