

Similar outcomes for intramedullary nail versus locking plate in treating proximal humerus fractures: a retrospective study

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Abstract

Objective The aim of this study was to compare the clinical and radiographic outcomes and complications following locking plate versus intramedullary nail fixation of 2- and 3-part proximal humerus fractures.

Methods A total of 97 patients (47, nail group; 50, plate group) were included in this retrospective study. The patients were treated either with an intramedullary nail or a locking plate. The length of the surgical incision, operative time, healing time, Constant-Murley score, and postoperative complications were compared between groups.

Results The average length of the incision, operative time of intramedullary nail group were significantly less than locking plate group ($P < 0.05$). There were no significant differences in the average fracture union time, Constant-Murley functional score, postoperative neck-shaft angle and neck-shaft angle a year after surgery ($P > 0.05$). Postoperative complications in the plate group included delayed union ($n=2$), screw cutout ($n=1$), varus malunion ($n=3$), displacement of the greater tubercle ($n=1$), and subacromial impingement syndrome ($n=1$). Complications in the nail group included delayed union ($n=1$), screw cutout ($n=3$), displacement of the greater tubercle ($n=4$), and subacromial impingement syndrome ($n=3$); varus malunion was not observed.

Conclusion Both the nail and locking plate were effective and had similar outcomes in patients with 2- or 3-part proximal humerus fractures. For valgus-type fractures, the plate had an advantage over the nail; for varus-type, the nail was a better option.

Background

Proximal humerus fractures are common among the elderly.¹ In younger patients, these fractures are usually associated with polytrauma and high-energy injuries. The main goals for surgical treatment are accurate reduction, early mobilization, and excellent functional recovery.² For unstable proximal humerus fractures, a common approach is surgical fixation using a locking plate. However, the locking plate has a high rate of associated complications, including screw cutout, varus malunion of the proximal humerus, and implant failure.¹⁻³

Several published studies have shown intramedullary nails to be advantageous over locking plate fixation, including having a shorter operative time, less blood loss, and lower rates of implant failure.⁴⁻⁶ There appears to be no clear answer whether patients who sustain a Neer 2- or 3-part proximal humerus fracture have better outcomes when stabilized with a locking plate or an intramedullary nail. The purpose of this study was to compare the functional and radiographic results of the intramedullary nail and the locking plate in the treatment of 2- or 3-part proximal humerus fractures. We hypothesized that the intramedullary nail provides equal or better radiographic and functional outcomes compared with the locking plate.

Patients And Methods

After obtaining approval from our hospital review board, we conducted a retrospective study. All patients with a Neer 2- or 3-part proximal humerus fracture admitted to the hospital between June 2012 and December 2015 were evaluated. The inclusion criteria included the following: age over 55 years, acute Neer 2- or 3-part proximal humerus fracture, no contraindication to anesthesia. The exclusion criteria included the following: Neer 4-part proximal humerus fracture, serious osteoarthritis in the affected shoulder, and inability to tolerate an operation or anesthesia due to an underlying disease.

The patients treated with a locking plate included 38 women and 12 men with an average age of 63 years. These patients who had a PHILOS™ (Synthes, Oberdorf, Switzerland) proximal humerus locking plate underwent general anesthesia and were placed in the beach chair position. The surgical approach was through the intermuscular septum between the deltoid and pectoralis major muscles. After fracture reduction, the humerus was temporarily fixed with a Kirschner pin, and the fractured greater and lesser tubercles were temporarily fixed with sutures. The locking plate was placed 8 mm beneath the upper edge of the greater tubercle to support the bone and also to avoid acromial impingement. The locking plate was directed 5–10 mm dorsally to protect the anterior humeral circumflex artery. Before placing the plate, suture was introduced through the previously placed suture holes. Following screw fixation, C-arm fluoroscopy was performed to determine whether the fracture was properly reduced and to confirm that internal fixation was positioned properly. The wounds were cleaned, a negative pressure drainage tube was placed at the surgical site, and the incision was sutured closed in a layered fashion to complete the procedure (Fig. S1).

The patients treated with a humeral intramedullary nail included 34 women and 13 men with an average age of 65 years. We used a Trigen™ humeral intramedullary nail (Smith & Nephew, Tennessee, USA), and these patients also underwent general anesthesia and were placed in the beach chair position. A longitudinal incision was made over the anterolateral aspect of the acromial process to allow an approach via the intermuscular septum of the deltoid muscle. We reduced the humeral head and shaft fractures and achieved temporary fixation using a Kirschner pin. The pin entry point was located at the apex of the humeral head on anteroposterior radiographic images and at the mid-point of the humeral head on lateral images. An incision was then made to insert the intramedullary nail 1–2 mm beneath the cartilage. After reducing the greater and lesser tubercle fractures, screws or sutures were used for further fixation. The proximal and distal ends of the humerus fracture were fixed with locking screws. The wound was cleaned, and the incision was sutured in a layered fashion to complete the procedure (Fig. S2).

An intravenous drip of cefuroxime was begun 30 min before surgery and continued for 24 hours after surgery to prevent infection. Postoperatively, the injured limb was suspended using a triangular bandage for mobilization. On the second postoperative day, passive external and internal rotation mobilization of the shoulder joint (without pain) was initiated, along with active functional training of the elbow joint, wrist, and fingers. Four weeks later, patients began active functional exercises of the shoulder joint.

Outpatient follow-ups were performed at 1, 3, 6, and 12 months after surgery. X-rays of the injured shoulder were obtained to assess fracture union and the location of the internal fixation. When bridging callus or blurring of the fracture gap was observed on imaging, and the patient was without pain on clinical examination, the fracture was considered united. Nonunion was defined as persistent pain and the absence of radiographic signs of union 6 months after the operation. Any postoperative complications such as implant displacement, malunion, or fracture were recorded. Twelve months after surgery, the same group of surgeons measured the following parameters using the same criteria: a) comprehensive shoulder joint function was assessed using the Constant-Murley shoulder outcome score; b) neck-shaft angle was measured postoperatively and 1 year after surgery.

The results were compared between the 2 groups using SPSS 16.0 software (SPSS Inc., Chicago, IL, USA). Differences between groups were evaluated with a Student's t-test. Dichotomous variables were analyzed using a chi-square test. A P-value less than 0.05 was considered significant.

Results

Ninety-seven patients that met the selection criteria were included in this study. Among these patients, 25 were male and 72 were female. Thirty-eight patients had Neer 2-part fractures, while 59 had Neer 3-part fractures. Fifty-nine of the fractures were in valgus alignment, and 38 were in varus. There were no differences in sex, age, fracture type, or cause of injury between the groups. There were 47 patients who were treated with an intramedullary nail (nail group), and they were compared with 50 patients who were treated with a locking plate (plate group) (Table S1).

Among the patients, follow-up periods ranged from 13 to 36 months (mean: 17.8 months). The average surgical duration was 92.6 ± 13.1 min in the plate group, which was significantly longer than 71.4 ± 11.8 min in the nail group ($P < 0.001$). The average length of incision was 11.4 ± 1.6 cm in the plate group, which was also significantly greater than 6.2 ± 1.4 cm in the nail group ($P < 0.001$) (Table S2).

The average time to achieve fracture union was 12.3 ± 4.2 weeks in the plate group, which was not significantly different from 12.1 ± 4.9 weeks in the nail group ($P = 0.829$). The average Constant-Murley functional score was 80.6 ± 8.3 in the plate group, which was not significantly different from 81.9 ± 5.6 in the nail group ($P = 0.371$). The average neck-shaft angle in the plate group was $139.2^\circ \pm 6.40^\circ$ and $134.7^\circ \pm 8.0^\circ$ immediately postoperatively and 1 year after surgery, respectively, which was a decrease of 4.5° . The average neck-shaft angle was $137.9^\circ \pm 7.04^\circ$ and $133.3^\circ \pm 6.42^\circ$ in the nail group, immediately postoperatively and 1 year postoperatively, respectively, which was a decrease of 4.6° . There was no significant difference between the two groups ($P = 0.343$, immediately postoperatively; 0.346 , 1 year after surgery) (Table S2).

Postoperative complications in the plate group included delayed union ($n = 2$), screw cutout ($n = 1$) (Fig. S3), varus malunion of the proximal humerus ($n = 3$), displacement of the greater tubercle ($n = 1$), and subacromial impingement syndrome ($n = 1$). In contrast, postoperative complications in the nail group included delayed union ($n = 1$), screw cutout ($n = 3$), displacement of the greater tubercle ($n = 4$) (Fig.S4),

and subacromial impingement syndrome (n = 3); varus malunion of the proximal humerus was not observed. In the comparison of the postoperative complications based on the Neer fracture classification, there was no significant difference between the two groups (P = 0.255, Neer 2-part; 0.786, Neer 3-part). In valgus fractures, the incidence of complications in the plate group was lower than in nail group (P = 0.002), while in varus fractures, the complication rate was higher than in the nail group (P = 0.028) (Table S3, S4).

Discussion

For unstable 2- and 3-part proximal humerus fractures, both locking plates and intramedullary nails can be used. Gonc et al. assessed the clinical outcomes of proximal humerus fractures treated with locking plates at a 1-year follow-up. The average Constant scores for normal and fractured shoulders were 84.8 ± 5.1 and 73.2 ± 10.9 , respectively. He concluded that the locking plate is a safe and effective internal fixation method for proximal humerus fractures.⁷ Dilisio et al. found that the major disadvantages of the earlier intramedullary nails were the inability to secure unstable fracture fragments, lack of rotational control, and inadequate security of the proximal interlocking screws.⁸ The third-generation nails have been successful in leading to improved shoulder function. However, few studies have compared the two techniques. Foruria et al. reported that locking plates showed superior biomechanical properties compared with intramedullary nails under rotational loads in a cadaveric proximal humerus fracture model. He concluded that locking plates would likely provide better clinical outcomes.⁹ Tamimi et al. reported the clinical results of 113 patients after an average 12-month follow-up after surgery. He found that shoulder function in the nail group was superior to the plate group.¹⁰ Lekic et al. enrolled 24 patients, among whom 12 were treated with a locking plate and 12 with an interlocking intramedullary nail. During the 6-month follow-up, shoulder joint mobility was not significantly different between the two groups.¹¹ Konrad et al. reported the use of a locking plate or intramedullary nail to treat 3-part proximal humerus fractures and found no significant difference between the groups regarding postoperative shoulder joint function.¹² We also found no significant difference in shoulder function between the groups in the current study.

Displaced proximal humerus fractures are commonly classified into varus- and valgus-type fractures based on radiographic appearance.¹³ Valgus-type fractures are defined as having an impaction of the humeral head into the lateral metaphysis of the shaft. In our study, for valgus-type fractures, a higher complication rate occurred in the nail group. The postoperative follow-up showed that four patients with valgus-type fractures in the nail group experienced displacement of the greater tubercle. Three of these patients suffered subacromial impingement syndrome, which led to shoulder pain that seriously affected shoulder function. In valgus-type proximal humerus fractures, the integrity of the greater tubercle is often undermined, which can easily result in posterior-superior displacement of the greater tubercle. Because of traction of the rotator cuff, the reduction of the greater tubercle is usually difficult.^{14,15} Moreover, it is also difficult to fix the greater tubercle with intramedullary nail. Recent advances in interlocking intramedullary nail technology now permit fixation of the greater tubercle by locking of the proximal humerus; however,

these nails do not provide firm fixation of the proximal humerus.⁶ A locking plate can avoid these problems by providing good fracture reduction and proper placement of implant. Therefore, we believe that a locking plate may be superior to an intramedullary nail for valgus-type fractures.

Varus-type fractures are characterized by the impaction of the humeral head on the medial side. For varus-type proximal humerus fractures, if the inner edge of the humeral neck is comminuted and cannot be satisfactorily reduced, inversion and traction of the rotator cuff can lead to varus deformity of the humeral head, which is a common complication following treatment of proximal humerus fractures with plating.^{3,5,7,11} Screw cutout and even plate fracture can occur later, which are the main causes of treatment failure. The intramedullary nail is particularly suitable for varus proximal humerus fractures. In our study, the postoperative complication rate in the plate group was higher than in the nail group. Three patients undergoing surgery for varus-type fractures in the plate group developed varus deformity of the humeral head, with one patient also experiencing screw cutout that resulted in varying degrees of shoulder joint dysfunction (Fig. S3). Compared with a locking plate, a nail is a load-sharing device for internal fixation, so the biomechanics are more stable than a locking plate.^{16,17} Thus, intramedullary nailing is a more reliable technique for treating varus-type proximal humerus fractures.

Gonc et al. reported that fixation of proximal humerus fractures using a plate had a postoperative complication rate of 22.6%. Popescu et al. found that the incidence of postoperative complications was higher after fracture fixation with a nail than with a locking plate.¹⁸ Improper intramedullary nailing can result in more complications. To reduce the incidence of postoperative complications, surgical skill and technique must be maximized.

During intramedullary nailing, exposure of the nail entry point at the humeral head is relatively challenging in varus-type fractures. The suture can be introduced above the supraspinatus muscle to pull the humeral head and correct the varus deformity. If tension is high, a Kirschner pin can be inserted via the humeral head to facilitate reduction to restore the neck-shaft angle at the proximal end of the humerus as much as possible. The correct nail entry point can be chosen after reduction, and it is the apex of the humeral head on anteroposterior radiographs and the mid-point of the humeral head on lateral images.

Loosening of the interlocking nails and displacement of the greater tubercles often occur after internal fixation using an intramedullary nail in proximal humerus fractures with a broken greater tubercle (Fig. S4). Displacement of a fractured greater tubercle by > 3 mm can cause impingement. Therefore, in patients with fractures of the greater tubercle of the humerus, straight nails are even more advantageous because they allow the nail entry point to move inwards, which avoids nail destabilization of the greater tubercle. For patients with a relatively intact greater tubercle, cannulated screws fixation can be performed; alternatively, binding and suturing may be applied.

The limitations of this study were that it was a non-randomized controlled study that only included a small number of cases and a short follow-up time. These limitations reduce the generalizability and the

strength of the conclusions. In the comparison of the postoperative complications based on the Neer fracture classification, there was no significant difference between the intramedullary nail group and the locking plate group. This may be related to the limitations described above. Additional studies that include larger cohorts and longer follow-ups are necessary to better compare the clinical outcomes of these treatment methods.

Conclusions

In conclusion, for Neer 2- and 3-part proximal humerus fractures, both intramedullary nailing and proximal humeral plating can be reliably used for internal fixation with similar outcomes. However, for valgus-type fractures, locking plate fixation may be preferred, while intramedullary nailing may be a more reliable technique for varus-type fractures.

Declarations

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Authors' contributions

All authors participated in every revision and improvement of the manuscript. Absolutely, we declare all authors have read and approved the manuscript.

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Availability of data and materials

Corresponding author Ming-hui Wang can be contacted to request the raw data.

Ethics approval and consent to participate

We have obtained verbal consent from the patient's legal guardian for his data to be used in our study. And this procedure has been approved by Medical Ethics Committee, Shanghai University of Medicine & Health Sciences Affiliated Zhoupu Hospital; the reference number is 2012-C-008-E01.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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