Original Article

Efficacies and complications of internal fixations with PHILOS plate and intramedullary Multiloc® nails in the surgical treatment of proximal humerus fractures

Lin Wu, Yingying Jiang, Xin Cao, Xianfeng Meng

Department of Traumatic Orthopedic, Dongying Shengli Oilfield Central Hospital, Dongying 257034, Shandong Province, China

Received February 4, 2021; Accepted June 22, 2021; Epub October 15, 2021; Published October 30, 2021

Abstract: Objective: To compare the efficacies of internal fixations with proximal humeral internal locking system (PHILOS) plate and intramedullary MultiLoc® nails in the surgical treatment of proximal humerus fractures (PHF).

Methods: A total of 115 patients with PHF admitted to our hospital were selected as the research subjects, and were randomly divided into PHILOS group (n=57) and MultiLoc group (n=58). PHILOS group was treated with internal fixation with PHILOS plate, while MultiLoc group was treated with internal fixation with intramedullary MultiLoc® nails.

Results: MultiLoc group was superior to PHILOS group in the surgical duration and amount of intraoperative hemorrhage (P < 0.05). At 1 week after surgery, the visual analogue scale (VAS) scores in MultiLoc group were lower than those in PHILOS group (P < 0.05). After surgery, MultiLoc group had a shorter time of occurrence of bony callus and disappearance of fracture line (P < 0.05) and a lower incidence of complications (0.00% vs. 3.51%) (P > 0.05) compared with PHILOS group. At 6 months after surgery, MultiLoc group had higher abduction and external rotation angles and higher scores of Constant-Murley and American Shoulder and Elbow Surgeons (ASES) than PHILOS group (P < 0.05).

Conclusion: The internal fixations with PHILOS plate and intramedullary Multiloc® nails are effective in the treatment of PHF. However, the internal fixation with intramedullary MultiLoc® nails is superior to the internal fixation with PHILOS plate in alleviating pain and expediting the postoperative restoration of joint function.

Keywords: Proximal humerus fractures, PHILOS plate, intramedullary MultiLoc® nails, internal fixation, treatment, efficacy, complications

Introduction

Proximal humerus fractures (PHF) are highly prevalent in adults. The statistics show that the incidence rate of PHF in the elderly is more than 50% [1]. Clinically, non-surgical and surgical options are available for the treatment of PHF. Fracture patients without displacement or with a displacement of less than 1 cm can be cured by conservative treatment [2].

However, conservative treatment is ineffective in the treatment fracture patients with an obvious displacement or patients with unstable fractures, yet surgical treatment is effective. The open reduction and internal fixation with plate are available in surgical treatment, and have their advantages and disadvantages in clinical practices. Therefore, there is currently no optimal surgical option for treatment of PHF [3, 4]. As in-depth studies have been widely applied, locking plate and intramedullary nail fixation have been extensively implemented for the treatment of fractures. Among them, proximal humeral internal locking system (PHILOS) plate and intramedullary MultiLoc® nails represent locking plate and intramedullary nail, respectively [5, 6]. It has been shown that PHILOS plate, leading to a high stability in fracture reduction, can be supported and fixed from multiple angles, and it can prevent the bone loss in patients with osteoporosis after fracture reduction [7]. A study reveals that intramedullary nail fixation, which is in high conformity with biomechanics, can reduce the dissection of soft tissues, effectively protect the blood supply of the fracture end, and improve the blood supply of the damaged caput humeralis [8].
It remains to be determined which of the aforementioned two internal fixations is more effective. In this study, we compared the implementation values of internal fixations with PHILOS plate and intramedullary MultiLoc® nails.

Materials and methods

General materials

A total of 115 patients with PHF admitted to our hospital from January 2018 to January 2020 were selected as the research subjects, and were randomly divided into PHILOS group (n=57) and MultiLoc group (n=58). Inclusion criteria: PHF diagnosed by imaging examinations; closed fracture; new fractures; Neer classification of PHF [9]: type II and III fractures; the fracture displacement of more than 1 cm or the angle of more than 45°; patients with ability to complete at least 6-month follow-ups after surgery; patients with complete clinical data; patients were informed of the study contents, and voluntarily signed the informed consent form; the study has been reviewed and approved by the Ethics Committee of Dongying Shengli Oilfield Central Hospital. Exclusion criteria: open fractures; without fracture displacement; stable fractures; infectious lesions in proximal fractures; pathological fractures; neglected fractures; previously irreparable rotator cuff injuries; indications that could not be treated with internal fixation.

Methods

PHILOS group: The patients received general anesthesia, and were placed in a supine position, with the upper extremities abducted. The approach site was between deltoid muscle and pectoralis major muscle, and the cephalic vein was protected during the surgery. Upon the complete exposure of the fracture end, the hematoma was completely removed. During the surgery, the dissection of periosteum was avoided, and the fractures occurred near the soft tissues. The site of the intertubercular groove was determined. The fracture end was reduced using percutaneous reduction by leverage, and Kirschner wire was selected for temporary fixation. Upon confirmation of the satisfactory reduction of the fracture end by X-ray machine, the internal fixation with PHILOS plate was performed. The distal end of the plate was placed on the lateral side of the shaft of humerus, the proximal end of the plate was placed about 5 mm behind the intertubercular groove and 5-10 mm below the apex of the greater tubercle. The two locking screws were used to fix the proximal end of the plate on the lateral side of humerus, and an ordinary bicortical screw was used to fix the distal end of the plate. The X-ray machine was used to confirm the satisfactory reduction of the fractures and the satisfactory placement of the plate. Then, 3-4 locking screws were fixed at the proximal end of the fracture, and humeral calcar screws were used if necessary. After the insertion of all screws, they were examined and confirmed by the X-ray machine. Upon confirmation of the unrestricted movement of shoulder joint in different directions by visual observation, the incision was washed with normal saline, and the incision was sutured routinely after drainage tube was retained.

MultiLoc group: The patients received general anesthesia, and were placed in a dorsal elevated position. The affected side was kept on the radiolucent side, the sandbag was put behind the shoulder for support, the anterior and posterior angles, coracoid process and clavicle of the acromion were marked, a small anterolateral incision was made towards the distal end at the anterior angle of the acromion, the deltoid muscle was split along the gap between the anterior and middle bundles of the deltoid muscle, and overextension of the distal end of the incision was avoided, so as to prevent axillary nerve injuries. The fractures were reduced using screws and Kirschner wire based on the joystick technique, and the guide pins were inserted on the posterolateral side of the long head tendon of biceps brachii muscle and the medial side of the groove between the greater tubercle and caput humeralis. Regarding patients with complete rotator cuff, a small incision of about 1 cm was made along the tendon fiber of the supraspinatus muscle. For patients with rotator cuff tear, the site for insertion of the needle was determined through the rotator cuff tear. After the insertion of the guide pin, the X-ray machine was used to determine whether the reduction was satisfactory and whether the direction and site of Kirschner wire were correct. The hollow boring bit was selected for grooving, and the assembled intramedullary MultiLoc® nails were placed. The site of intramedullary nail was determined by the
X-ray machine to ensure that the proximal end of intramedullary nail was 2-3 mm below cartilage of caput humeralis. The assembly of aiming arm was performed, and at least 4 screws with a diameter of 4.5 mm and multiple screws were selected in accordance with the fracture types. If necessary, the calcar screws could be used to support the humeral calcar, and 1-2 locking screws with a diameter of 4 mm could be used for fixation at the distal site. If necessary, the tail caps could be used to stabilize the intramedullary nail. Finally, the rotator cuff was sutured and repaired. For patients with severe rotator cuff injury, the rotator cuff tissues could be sutured using non-absorbable sutures to the MultiLoc screw hole. Postoperative hemostasis was performed on the incision. The incision was washed with a large amount of normal saline, and a drainage tube was retained. The incision was sutured routinely.

After surgery, the two groups were treated with antibiotics for one day to prevent infection, and the drainage tubes were removed within 2 days after surgery. On day 1 after surgery, rehabilitation exercises were conducted, and the contents, amount and extent of the exercises were incrementally increased.

Observational indices

Surgical conditions: The surgical duration and amount of intraoperative hemorrhage were compared between the two groups. Determination of surgical duration: the interval from the use of anesthetic medication to the completion of incision suture was recorded. The amount of intraoperative hemorrhage was measured by the gauze weighing method, the polishing gauze was weighed before surgery, the gauze was used for blood cleaning during surgery, the gauze was weighed again after surgery, and the weight difference was the amount of hemorrhage.

Degrees of postoperative pain: On day 1 after surgery and at 1, 2, 3 and 4 weeks after surgery, the pain degree at the fracture site was evaluated by Visual Analogue Scale (VAS) [10]. A scoring system of 0-10 points was used, and the score was selected by patients based on their subjective feelings, with 0 point indicating painless and 10 points indicating the most severe pain.

Fracture healing time: The time of occurrence of bony callus and the time of disappearance of fracture line were compared between the two groups.

Postoperative complications: After surgery, the two groups were followed up for 6 months, and the incidence rates of fracture nonunion, infection of incisional wound, delayed union of fracture, rotator cuff injury, axillary nerve injury, screw penetration and acromion impingement were compared between the two groups.

Range of motion (ROM) of shoulder joint: The angles of abduction, external rotation and anteflexion of shoulder joint were compared between the two groups on day 3 before surgery and at 6 months after surgery.

Shoulder joint function: The shoulder joint function was evaluated by the criteria for shoulder joint function (Constant-Murley Score) [11] and the rating scale of the American Shoulder and Elbow Surgeons (ASES) [12]. The total score of the Constant-Murley Scale is 100 points, and the scale comprises muscle strength (25 points), degrees of pain (15 points), ROM of shoulder joint (40 points) and level of daily living (20 points). Higher scores indicated higher muscle strength, degree of pain, ROM of shoulder joint or level of daily living. ASES consists of pain, stability and function. Pain and stability were scored by 0-5 points, and function was scored by 0-4 points. Higher scores indicated lower degree of pain, higher stability and better function. The aforementioned two scales were evaluated on day 3 before surgery and at 6 months after surgery.

Statistical method

SPSS23.0 was used for statistical analysis. The enumeration data were expressed using [n (%)], and detected using $X^2$ test. The measurement data were expressed using ($\bar{x}\pm s$), and detected using $t$ test. The multi-point comparison was performed using analysis of variance (ANOVA), and detected using F test. The graphs were plotted using Graphpad Prism 8. $P < 0.05$ indicated a statistical significance.

Results

General data

There was no statistical difference in the male-to-female ratio, average age, the average fracture displacement, and the ratios of fractures according to Neer classification and fracture
Effects of internal fixation with intramedullary MultiLoc® nails

Table 1. Comparison of general data between the two groups (\(\bar{X}\pm s\)/[n (%)]

<table>
<thead>
<tr>
<th>Data</th>
<th>MultiLoc group (n=58)</th>
<th>PHILOS group (n=57)</th>
<th>(t/\chi^2)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>35 (60.34)</td>
<td>37 (64.91)</td>
<td>0.256</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>23 (39.66)</td>
<td>20 (35.09)</td>
<td></td>
</tr>
<tr>
<td>Age (year)</td>
<td></td>
<td>42.15±13.26</td>
<td>43.29±12.76</td>
<td>0.470</td>
</tr>
<tr>
<td>Fracture displacement (cm)</td>
<td></td>
<td>3.12±1.16</td>
<td>3.18±1.21</td>
<td>0.271</td>
</tr>
<tr>
<td>Neer classification</td>
<td>Type II</td>
<td>37 (63.79)</td>
<td>39 (68.42)</td>
<td>0.275</td>
</tr>
<tr>
<td></td>
<td>Type III</td>
<td>21 (36.21)</td>
<td>18 (31.58)</td>
<td></td>
</tr>
<tr>
<td>Fracture cause</td>
<td>Accidents</td>
<td>23 (39.66)</td>
<td>21 (36.84)</td>
<td>0.672</td>
</tr>
<tr>
<td></td>
<td>Injury by fall from height</td>
<td>13 (22.41)</td>
<td>14 (24.56)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Injury from falling</td>
<td>15 (25.86)</td>
<td>16 (28.07)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>5 (8.62)</td>
<td>6 (10.53)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Surgical duration and amount of intraoperative hemorrhage. Compared with PHILOS group, MultiLoc group had a shorter surgical duration (A) and a smaller amount of intraoperative hemorrhage (B) \((P < 0.05)\). *indicates the comparison between groups \((P < 0.05)\).

Surgical conditions

Compared with PHILOS group, MultiLoc group had a shorter surgical duration and a smaller amount of intraoperative hemorrhage \((81.46\pm 10.37\) min vs. \(98.76\pm 12.34\) min, \(186.42\pm 16.39\) mL vs. \(239.67\pm 21.13\) mL, \(P < 0.05)\) (Figure 1).

Degrees of postoperative pain

There was no statistical difference in VAS scores of pains at the fracture site on day 1 after surgery \((P > 0.05)\). At 1, 2, 3 and 4 weeks after surgery, VAS scores in the two groups were lower than those on day 1 after surgery \((P < 0.05)\). At 1 week after surgery, VAS scores in MultiLoc group were lower than those in PHILOS group \((P < 0.05)\). At 2, 3 and 4 weeks after surgery, there was no statistically significant difference in VAS scores between the two groups \((P > 0.05)\) (Figure 2).

Fracture healing time

After surgery, MultiLoc group had a shorter time of occurrence of bony callus and disappearance of fracture line than PHILOS group \((6.42\pm 1.13\) weeks vs. \(7.51\pm 1.26\) weeks, \(13.61\pm 1.08\) weeks vs. \(15.04\pm 1.27\) weeks, \(P < 0.05)\) (Figures 3, 4).

Postoperative complications

During the postoperative 6-month follow up, fracture nonunion, delayed union of fracture, rotator cuff injury, axillary nerve injury, and screw penetration did not occur in the two
Effects of internal fixation with intramedullary MultiLoc® nails

11790

Am J Transl Res 2021;13(10):11786-11796

groups, and there was 1 case with acromion impingement and 1 case with infection of incisional wound in PHILOS group. The incidences of postoperative complications in PHILOS group and MultiLoc group were lower than those in PHILOS group (P < 0.05). *indicates the comparison between the two groups (P < 0.05).

ROM of shoulder joint

There was no statistically significant difference in the angles of abduction, external rotation and anteflexion of shoulder joint between MultiLoc group and PHILOS group 3 days before surgery (P > 0.05). The angles of abduction, external rotation and anteflexion of shoulder joint in the two groups at 6 months after surgery were higher than those 3 days before surgery, and the angles of abduction and external rotation of shoulder joint in MultiLoc group were higher than those in PHILOS group at 6 months after surgery (P < 0.05). There was no statistically significantly difference in the angle of anteflexion of shoulder joint between the two groups (P > 0.05) (Figure 5).

Constant-Murley scores

There was no statistically significant difference in the scores of muscle strength, pain, ROM of shoulder joint, and level of daily living between the two groups 3 days before surgery (P > 0.05). At 6 months after surgery, the aforementioned scores in the two groups were higher than those 3 days before surgery (P < 0.05), and the aforementioned scores in MultiLoc group were higher than those in PHILOS group (P < 0.05) (Figure 6).

ASES scores

There was no statistically significant difference in the scores of pain, stability and function between the two groups 3 days before surgery (P > 0.05). At 6 months after surgery, the aforementioned scores in the two groups were higher than those 3 days before surgery (P < 0.05), and the aforementioned scores in MultiLoc group were higher than those in PHILOS group (P < 0.05) (Figure 7).

Discussion

PHF are multiple fractures of the upper limb. Clinically, the primary objective of PHF treatment is to improve pain, ROM and joint function [13]. With the improvement and development of internal fixation materials, the advancement of surgical techniques and the accumulation of experience, surgery has become the preferred option for the treatment of PHF [14]. The internal fixations with locking plate and intramedullary nail have been widely applied [15]. Regarding which option exhibits more prominent implementation value.

MultiLoc group had a shorter surgical duration and a smaller amount of intraoperative hemorrhage compared with PHILOS group (P < 0.05). This suggests that internal fixation with intramedullary MultiLoc® nails is superior to internal fixation with PHILOS plate in terms of surgical effects, surgical duration and the amount of intraoperative hemorrhage. At 1, 2, 3 and 4 weeks after surgery, the VAS scores in the two groups were lower than those on day 1 after surgery. The comparison between groups revealed that the VAS scores in MultiLoc group were lower than those in PHILOS group at 1 week after surgery, but there was no marked difference between the two groups at 2, 3 and
Figure 3. Fracture healing. Compared with PHILOS group, MultiLoc group had a shorter time of occurrence of bony callus (A) and disappearance of fracture line (B) ($P < 0.05$). * indicates the comparison between groups ($P < 0.05$).
Effects of internal fixation with intramedullary MultiLoc® nails

Figure 4. X-ray of PHILOS plate and intramedullary nail. A and C: Before fracture; B and D: After surgery with PHILOS plate; E: Before fracture; F: After surgery with intramedullary MultiLoc® nails.

Figure 5. ROM of shoulder joint. The angles of abduction (A), external rotation (B) and anteflexion (C) of shoulder joint in the two groups 3 days before surgery were lower than those at 6 months after surgery (P < 0.05). The angles of abduction and external rotation of shoulder joint in MultiLoc group were higher than those in PHILOS group at 6 months after surgery (P < 0.05). There was no statistically significant difference in the angle of anteflexion of shoulder joint between the two groups (P > 0.05). *indicates the comparison between groups (P < 0.05).
Effects of internal fixation with intramedullary MultiLoc® nails

4 weeks after surgery. This demonstrates that the degree of pain at the fracture site will be reduced in a time-dependent way with time, and the internal fixation with intramedullary MultiLoc® nails can reduce the degree of postoperative pain earlier. We notice that a study exhibited that there was no statistically significant difference in the scores of pains between the internal fixations with intramedullary MultiLoc® nails and PHILOS plate at different time points after surgery [16], which was inconsistent with this study conclusion. This may be attributable to the different conditions and pain thresholds of the subjects. A study has revealed that the VAS scores of postoperative pains in intramedullary nail group were lower than those in locking plate group [17]. This is because the internal fixation with intramedullary MultiLoc® nails leads to a small surgical incision, and the fractures are indirectly reduced using the joystick technique to prevent extensive dissection of the broken end of fractures and reduce the soft tissue injuries. In addition, since the intramedullary nails are a straight nail, and the site for insertion of the needle is inward, resulting in a reduced incidence rate of rotator cuff injuries. A proper and correct insertion can effectively reduce the acromion impingement related to the insertion. Therefore, the postoperative pain can be obviously alleviated [18].

We have shown that MultiLoc group had a shorter time of occurrence of bony callus and
disappearance of fracture line ($P < 0.05$). This demonstrates that internal fixation with intramedullary MultiLoc® nails is superior to internal fixation with PHILOS plate in fracture healing effects. This may be attributed to the fact that the intramedullary nail provides more effective support and higher degree of compliance with biomechanics, resulting in a more stable fixation, so as to enable patients to conduct postoperative rehabilitation exercises earlier, and expedite fracture healing [19]. A study demonstrated that the fracture healing time in intramedullary nail group was significantly shorter than that in locking plate group [20]. This is due to the small diameter and short length of the intramedullary MultiLoc® nails, and the distal end is fixed by two screws with different planes and directions to effectively improve the swing and stability of the humeral intramedullary nail, contributing to early postoperative exercises and fracture healing [21]. In this study, the incidences of postoperative complications in PHILOS group and MultiLoc group were 3.51% and 0%, respectively, suggesting that the two surgical options exhibit a high safety profile and will not negatively affect postoperative recovery and prognosis because of complications. It is believed that the occurrence of acromion impingement in PHILOS group is related to the deviations in the site of placement as a result of the large volume of locking plate system, and the infection of incisional wound is believed to be related to the longer surgical duration and the massive amount of intraoper-

**Figure 7.** ASES scores. The scores of pain (A), stability (B) and function (C) in the two groups 3 days before surgery were lower than those at 6 months after surgery ($P < 0.05$). At 6 months after surgery, the aforementioned scores in MultiLoc group were higher than those in PHILOS group ($P < 0.05$). * indicates the comparison between groups ($P < 0.05$).
Effects of internal fixation with intramedullary MultiLoc® nails

In summary, the internal fixations with PHILOS plate and intramedullary MultiLoc® nails are effective in the treatment of PHF. However, the internal fixation with intramedullary MultiLoc® nails is superior to the internal fixation with PHILOS plate in alleviating pain and expediting the postoperative restoration of joint function. Therefore, the internal fixation with intramedullary MultiLoc® nails is worthy of promotion and implementation. However, this study was a retrospective analysis, with fewer evaluation indicators. It may not be sufficient to compare the differences in the effectiveness of the two surgical procedures. In addition, only two surgical procedures were compared, and the effects were not compared with other surgical procedures, which need to be further investigated.

Disclosure of conflict of interest

None.

Address correspondence to: Xianfeng Meng, Department of Traumatic Orthopedic, Dongying Shengli Oilfield Central Hospital, No. 31, Jinan Road, Dongying City, Shandong Province, 257034, China. Tel: +86-0546-8770971; E-mail: slytzxyycsgk@126.com

References

[12] Vincent JI, MacDermid JC, King GJW and Grewal R. The patient-rated elbow evaluation and the American shoulder and elbow surgeons
Effects of internal fixation with intramedullary MultiLoc® nails

- elbow form capture aspects of functioning that are important to patients with elbow injuries. J Hand Ther 2021; 34: 415-422.


