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# Analysis of the Effect of Minimally Invasive Locking Plate Internal Fixation on Fracture Healing and Functional Recovery in Patients with Proximal Humerus Fractures

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**Abstract**: *Objective:* To investigate the effect of minimally invasive locking plate internal fixation on fracture healing and functional recovery in patients with proximal humerus fractures. *Methods:* 98 patients with proximal humerus fractures admitted to the hospital from August 2021 to July 2023 were selected and divided into the control group ($n$ = 49) and the observation group ($n$ = 49) according to the lottery method. The control group implemented conventional treatment, and the observation group implemented minimally invasive locking plate internal fixation. The treatment effect and complications, surgery-related indexes, and functional recovery of the shoulder joint in the two groups were compared. *Results:* Compared with the control group, the observation group (97.96%) had a better therapeutic effect than the control group (73.47%) ($\chi^2$ = 12.000, $P$ < 0.05); the complication rate of the observation group (2.04%) was lower than that of the control group (18.37%) ($\chi^2$ = 7.127, $P$ < 0.05); the fracture healing rate of the observation group (97.96%) was higher than that of the control group (81.63%) ($\chi2$ = 7.127, $P$ < 0.05). The operation time of the observation group (74.25 ± 10.30 minutes) was shorter than that of the control group (115.63 ± 20.30 minutes) ($t$ = 12.725, $P$ < 0.05), the intraoperative bleeding of the observation group (177.30 ± 19.63 ml) was less than that of the control group (306.63 ± 30.62 ml) ($t$ = 24.890, $P$ < 0.05). The fracture healing time was shorter in the observation group (12.30 ± 2.30 weeks) than in the control group (16.23 ± 2.66 weeks) ($t$ = 7.823, $P$ < 0.05), and the hospitalization time was shorter in the observation group (9.30 ± 0.99 days) than in the control group (12.66 ± 2.20 days) ($t$ = 9.749, $P$ < 0.05). Compared with the control group, the pain, muscle strength, activity function, and activity score of the observation group were significantly different ($t$ = 6.398, 12.817, 8.386, 7.892, $P$ < 0.05); compared with the control group, the observation group's abduction, forward flexion, external rotation, internal rotation, and posterior rotation were significantly different ($t$ = 3.042, 2.843, 3.633, 4.669, 9.176, $P$ < 0.05). *Conclusion:* Minimally invasive locking plate internal fixation for proximal humerus fracture can adjust its surgery-related indexes, increase the patients' shoulder joint mobility, enhance the shoulder joint function, improve the fracture healing rate and therapeutic effect, and reduce the complications, which is worth recommending in clinical practice.

**Keywords**: Minimally invasive locking plate internal fixation; Proximal humerus fracture; Fracture healing; Functional recovery

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# 1. Introduction

Humerus fracture is a common surgical disorder with a high incidence at present. It is mostly caused by trauma, in which proximal humerus fracture is half of the incidence of humerus fracture. Traditional manipulative treatment of proximal humerus fracture is mostly based on screw internal fixation. As the surgical operation is highly invasive and adverse to postoperative prognosis, it has a certain value in improving the condition of proximal humeral fractures [1]. With the continuous development of medical technology in recent years, minimally invasive surgery has been widely popularized, with the advantages of low trauma and bleeding, etc. Minimally invasive locking plate internal fixation is an effective means of treating this disease, which is of great significance for the improvement of patients' clinical symptoms [2,3]. The aim of this study is to investigate the application value of minimally invasive locking plate internal fixation for patients with proximal humerus fracture, and the treatment results of 98 patients included in the study are reported as follows.

# 2. Clinical data and methods

## 2.1. Clinical data

98 patients with proximal humerus fractures admitted to our hospital from August 2021 to July 2023 were taken as the study subjects and divided into the control group and the observation group according to the lottery method. There were 30 males and 19 females in the control group, ranging in age from 20–89 years old, with a mean value of 54.50 ± 10.22 years old; there were 15 cases in senior high school, 24 cases in junior high school, 10 cases in junior college and above. There were 29 males and 20 females in the observation group, their ages ranged from 21–89 years old, with a mean age of 55.00 ± 11.63 years old; there were 16 cases in high school, 25 cases in junior high school, and 8 cases in college and above. The basic data of the two groups were comparable ($P > 0.05$). Inclusion criteria included patients with proximal humerus fracture with complete data; patients meeting the indications for surgery; proximal humerus fracture diagnosed by imaging. Exclusion criteria were patients with proximal humerus fracture combined with psychiatric disorders; patients with fuzzy consciousness; patients with other diseases such as liver, kidney, and cardiac diseases; and those who withdrew from the study halfway.

## 2.2. Methods

The control group was treated conventionally. The patients were given tracheal intubation anesthesia and kept in a supine position, with appropriate shoulder padding. An incision was made down the anterior edge of the deltoid muscle to the edge of the deltoid muscle and the length of the incision was 10–12 cm. The subcutaneous skin was incised layer by layer, and blunt separation of the pectoralis major muscle deltoid muscle gap was done to ensure that the fracture end of the humerus was completely exposed. Prying and traction reset were performed to assess the effect of the reset in the humerus after removing the lateral locking plate and screws of the greater tuberosity, and then it was cleaned with irrigation fluid, leaving the plate and the screw. Afterward, the incision was cleaned with a flushing solution, drains were left in place, and the incision was closed.

The observation group was treated with minimally invasive locking plate internal fixation. Maintaining the supine position with an appropriately padded shoulder, a longitudinal incision was made, blunt separation of the deltoid muscle, retraction, nodal groove, shoulder abduction, and internal rotation were done to promote fracture reset. Under fluoroscopic guidance, the humeral neck stem angle was restored and the unstable tuberosity fracture block was temporarily fixed with Kirschner wires. The plate channel was created, subsequently, the plate was inserted and the proximal end was fixed to assess the effect of reduction and fixation. This was followed by incision irrigation treatment, drainage management, and incision closure.

## 2.3. Observation indexes

### 2.3.1. Treatment effects and complications

The therapeutic effect was determined by highly effective, effective, and ineffective. Highly effective referred to the significant improvement of patients' shoulder joint mobility and function compared with that before treatment; effective referred to the certain improvement of patients' shoulder joint function and mobility compared with that before; ineffective referred to no change in patients' shoulder joint function and mobility compared with that before. Treatment effect = Highly effective + Effective / 49 × 100%. The evaluation of complications included the indicators of incision infection, joint dysfunction, femoral head necrosis, and poor fracture healing.

### 2.3.2. Surgery-related indexes

Surgery-related indexes included the evaluation of operation time, intraoperative bleeding, fracture healing time, and hospitalization time in both groups.

### 2.3.3. Shoulder joint recovery

Shoulder joint recovery was divided into shoulder joint mobility and shoulder joint function. The higher the shoulder function score, the better the functional recovery. Shoulder joint mobility included abduction (0–180°), forward flexion (0–180°), external rotation (0–90°), internal rotation (0–90°), and posterior extension (0–50°).

## 2.4. Statistical analysis

SPSS20.0 software was used to analyze the research data in the observation and control groups, and the measurement data conforming to normal distribution was described by mean ± standard deviation (SD), and *t*-test was performed; the count data was expressed by the number of cases and percentage, and the comparison between groups was performed by $\chi^2$ test. The difference was considered statistically significant at $P < 0.05$.

# 3. Results

## 3.1. Effect of surgical treatment and complications

Compared with the control group, the observation group (97.96%) had a higher treatment efficiency than the control group (73.47%) ($\chi^2 = 12.000$, $P < 0.05$), and the complication rate of the observation group (2.04%) was lower than that of the control group (18.37%) ($\chi^2 = 7.127$, $P < 0.05$); the fracture healing rate of the observation group (97.96%) was higher than that of the control group (81.63%) ($\chi^2 = 7.127$, $P < 0.05$), as shown in **Table 1**.

**Table 1.** Comparison of surgical treatment effects and complications between the two groups [*n* (%)]

| Groups | Treatment effects | | | | Complications | | | | | Fracture healing rate |
|---|---|---|---|---|---|---|---|---|---|---|
| | Highly effective | Effective | Ineffective | Effective rate of treatment | Incision infection | Joint dysfunction | Poor fracture healing | Necrosis of the humeral head | Complication rate | |
| Observation group ($n = 49$) | 40 | 8 | 1 | 97.96 | 0 | 0 | 1 | 0 | 2.04 | 97.96 |
| Control group ($n = 49$) | 11 | 25 | 13 | 73.47 | 2 | 3 | 1 | 3 | 18.37 | 81.63 |
| $\chi^2$ | - | - | - | 12.000 | - | - | - | - | 7.127 | 7.127 |
| $P$ | - | - | - | 0.001 | - | - | - | - | 0.007 | 0.007 |

## 3.2. Surgery-related indexes

The operation time of the observation group (74.25 ± 10.30) was shorter than that of the control group (115.63 ± 20.30) ($t$ = 12.725, $P$ < 0.05), the intraoperative bleeding of the observation group (177.30 ± 19.63) was less than that of the control group (306.63 ± 30.62) ($t$ = 24.890, $P$ < 0.05); the postoperative fracture healing time of the observation group (12.30 ± 2.30) was shorter than that of the control group (16.23 ± 2.66) ($t$ = 7.823, $P$ < 0.05), and the hospitalization time of the observation group (9.30 ± 0.99) was shorter than that of the control group (12.66 ± 2.20) ($t$ = 10.532, $P$ < 0.05), as presented in **Table 2**.

**Table 2.** Comparison of surgery-related indexes between the two groups (mean ± SD)

| Groups | Surgical time (minutes) | Intraoperative bleeding (ml) | Fracture healing time (weeks) | Hospitalization time (days) |
|---|---|---|---|---|
| Observation group ($n$ = 49) | 74.25 ± 10.30 | 177.30 ± 19.63 | 12.30 ± 2.30 | 9.30 ± 0.99 |
| Control group ($n$ = 49) | 115.63 ± 20.30 | 306.63 ± 30.62 | 16.23 ± 2.66 | 12.66 ± 2.20 |
| $t$ | 12.725 | 24.890 | 7.823 | 10.532 |
| $P$ | < 0.05 | < 0.05 | < 0.05 | < 0.05 |

## 3.3. Recovery of shoulder joint

After the intervention, compared with the control group, the pain, muscle strength, activity function, and activity score of the observation group were significantly different ($t$ = 6.398, 12.817, 8.386, 7.892, $P$ < 0.05); the observation group had abduction, forward flexion, external rotation, internal rotation, and posterior rotation. Compared with the control group, the difference was significant ($t$ = 3.042, 2.843, 3.633, 4.669, 9.176, $P$ < 0.05), as shown in **Table 3**.

**Table 3.** Comparison of shoulder joint function scores (mean ± SD, points)

| Groups | Pain | | Muscle strength | | Activity function | | Activity score | |
|---|---|---|---|---|---|---|---|---|
| | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Observation group ($n$ = 49) | 9.20 ± 0.96 | 14.30 ± 2.02 | 8.30 ± 1.30 | 14.30 ± 1.33 | 11.30 ± 1.52 | 17.30 ± 1.63 | 23.30 ± 2.36 | 33.30 ± 3.02 |
| Control group ($n$ = 49) | 9.26 ± 0.89 | 11.63 ± 2.11 | 8.63 ± 1.25 | 11.02 ± 1.20 | 11.36 ± 1.36 | 14.63 ± 1.52 | 23.63 ± 2.66 | 29.02 ± 2.30 |
| $t$ | 0.321 | 6.398 | 1.281 | 12.817 | 0.206 | 8.386 | 0.650 | 7.892 |
| $P$ | > 0.05 | < 0.001 | > 0.05 | < 0.001 | > 0.05 | < 0.001 | > 0.05 | < 0.001 |

| Groups | Abduction | | Forward flexion | | External rotation | | Internal rotation | | Posterior rotation | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Observation group ($n$ = 49) | 9.20 ± 1.33 | 125.30 ± 12.66 | 12.30 ± 2.30 | 144.30 ± 14.52 | 45.30 ± 4.25 | 64.30 ± 6.52 | 12.30 ± 1.55 | 65.30 ± 6.55 | 20.30 ± 2.66 | 40.30 ± 4.22 |
| Control group ($n$ = 49) | 9.31 ± 1.26 | 117.63 ± 12.30 | 12.63 ± 2.30 | 136.33 ± 13.20 | 45.88 ± 4.82 | 59.63 ± 6.20 | 12.63 ± 1.63 | 59.33 ± 6.10 | 20.63 ± 2.55 | 32.66 ± 4.02 |
| $t$ | 0.420 | 3.042 | 0.710 | 2.843 | 0.632 | 3.633 | 1.027 | 4.669 | 0.627 | 9.176 |
| $P$ | > 0.05 | < 0.01 | > 0.05 | < 0.01 | > 0.05 | < 0.001 | > 0.05 | < 0.001 | > 0.05 | < 0.001 |

## 4. Discussion

Proximal humerus fracture is a harmful disease, which also affects the joint function of patients. The application of conventional screw fixation for proximal humerus fractures has a certain significance in improving patients' clinical symptoms and quality of life scores [4,5]. However, there are some limitations, and the large amount of bleeding may threaten the patient's safety. The application of conventional screw fixation treatment has disadvantages of surgical invasiveness, extensive exposure, extensive stripping, serious ischemic symptoms of the humeral head, and poor functional recovery of the shoulder joint, thus affecting the patient's prognosis. Minimally invasive locking plate internal fixation is the treatment of choice for the treatment of proximal humerus fractures, with the understanding of the anatomy of the proximal humerus as well as the discovery of internal fixation, it offers a significant advantage for the popularity and development of minimally invasive surgery [6,7]. The steel plate applied in minimally invasive locking plate internal fixation is small and can enter the muscle tissue, which has less impact on the patient's soft tissues, and the combination of plate and locking screw fixation normalizes the patient's local blood supply and contributes to fracture healing [8,9]. The plate used in minimally invasive locking plate internal fixation has good biomechanical stability and anchoring force, which can accelerate fracture healing as well as joint function recovery.

The results of this study showed the observation group (97.96%) had a higher treatment efficiency than the control group (73.47%) ($\chi^2 = 12.000$, $P < 0.05$), and the complication rate of the observation group (2.04%) was lower than that of the control group (18.37%) ($\chi^2 = 7.127$, $P < 0.05$); the fracture healing rate of the observation group (97.96%) was higher than that of the control group (81.63%) ($\chi^2 = 7.127$, $P < 0.05$). It can be seen that the implementation of minimally invasive locking plate internal fixation for patients with proximal humerus fracture significantly reduces the complications and improves the fracture healing rate and treatment effect. This is mostly because the fixation of the locking screw and plate promotes pressurization and stabilization of the whole fracture site, reduces the manipulation of the plate and maintains the normal blood supply to bone and periosteum, accelerates the fracture healing rate, and promotes the improvement of the treatment effect, ensures the stability of fixation within a certain range, and reduces the complications.

After the intervention, compared with the control group, the pain, muscle strength, activity function, and activity score of the observation group were significantly different ($t = 6.398$, 12.817, 8.386, 7.892, $P < 0.05$); the observation group had abduction, forward flexion, external rotation, internal rotation, and posterior rotation. Compared with the control group, the difference was significant ($t = 3.042$, 2.843, 3.633, 4.669, 9.176, $P < 0.05$). The implementation of minimally invasive locking plate internal fixation in patients with proximal humerus fracture accelerates the functional recovery and mobility of the shoulder joint in patients. In minimally invasive locking steel plate internal fixation, the screw and locking steel plate have biomechanical characteristics of angular stability. It accelerates the fixation of fracture through the locking formation of anchoring force and resistance to pull-out force to improve the functional recovery of the shoulder joint and increase joint mobility [10,11]. The operation time of the observation group (74.25 ± 10.30) was shorter than that of the control group (115.63 ± 20.30) ($t = 12.725$, $P < 0.05$), the intraoperative bleeding of the observation group (177.30 ± 19.63) was less than that of the control group (306.63 ± 30.62) ($t = 24.890$, $P < 0.05$); the postoperative fracture healing time of the observation group (12.30 ± 2.30) was shorter than that of the control group (16.23 ± 2.66) ($t = 7.823$, $P < 0.05$), and the hospitalization time of the observation group (9.30 ± 0.99) was shorter than that of the control group (12.66 ± 2.20) ($t = 10.532$, $P < 0.05$). Proximal humerus fracture should be fully assessed preoperatively to evaluate the patient's orthopedic injury, assisted by relevant examinations; minimally invasive locking plate internal fixation is done to fix the locking screws and steel plate, to maintain a normal blood supply of the bone and the periosteum under the steel plate, to reduce the damage of relevant tissues

of the patient, to improve the stability, and adjust the surgical indexes. To ensure the surgical effect, it is also necessary to make full use of the role of the locking plate suture holes, comminuted fracture blocks, rupture of the joint capsule, displaced large nodes of the suture; the plate is fixed in a reasonable position and not too close to the proximal end; locking screws of moderate length should be selected to avoid locking screws into the joint, affecting the patients with proximal humerus fractures in the early exercise and functional recovery; after the operation, the patients with proximal humerus fractures should be instructed to carry out early functional exercise to accelerate fracture recovery. This study has some limitations, including a small sample size and a short study period, which may affect the quality of the study. Further study needs to increase the sample size of patients with proximal humerus fracture according to the actual situation and extend the study period, as well as ensure that the professional skills of the researchers meet the requirements and have a wealth of experience of more than 6 years.

## 5. Conclusion

In conclusion, the application of minimally invasive locking plate internal fixation for proximal humerus fracture can adjust its surgery-related indexes, increase the patients' shoulder joint mobility, enhance their shoulder joint function, improve the fracture healing rate and therapeutic effect, and reduce the complications, which is worthy of recommendation.

## Disclosure statement

The authors declare no conflict of interest.

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