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A comparative study of the minimally invasive lateral shoulder approach and deltopectoral space approach for the treatment of proximal humerus fractures

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Abstract

Objective To compare the clinical efficacy of the minimally invasive lateral shoulder approach and deltopectoral space approach in the treatment of proximal humerus fractures.

Methods The clinical data of 95 patients with proximal humerus fractures admitted to the hospital from June 2018 to June 2023 were retrospectively collected. Forty-four patients were treated with a minimally invasive lateral shoulder approach (study group), and 51 patients were treated with a deltopectoral space approach (control group). The baseline data (age, sex, mechanism of injury, preoperative Neer classification, and time from injury to surgery), operation time, intraoperative blood loss, incision length, fracture healing time, and postoperative complications were compared between these two groups. The VAS score, shoulder range of motion (ROM) score, and Constant-Murley score were used to evaluate the shoulder joint function of the two groups one year after surgery.

Results There were no significant differences in operation time, blood loss, incision length or fracture healing time between the two groups ($P > 0.05$). The incidence of postoperative complications in the study group was significantly lower than that in the control group, and the difference between the groups was statistically significant ($P < 0.05$). There was no significant difference in shoulder joint function or VAS score between the two groups one year after surgery ($P > 0.05$).

Conclusion The treatment of proximal humerus fractures via the lateral shoulder approach is minimally invasive and can reduce the occurrence of complications such as ischemic necrosis of the humerus head, relieve shoulder pain in the short term, and restore good shoulder function. Therefore, given the strict grasp of indications and familiarity with surgical operations, the minimally invasive lateral shoulder approach for the treatment of proximal humeral fractures is safe and effective and is worth promoting and applying in clinical practice.

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Keywords Proximal humerus fracture, Deltopectoral space, Minimally invasive, Treatment

Introduction

Proximal humerus fracture refers to a fracture between the articular surface of the head of the humerus and the surgical neck of the humerus, including a fracture of the head of the humerus, the greater tubercle, the smaller tubercle and the diaphysis of the humerus. It is a common fracture with a clinical incidence accounting for 4-5% of all fractures in the body and more than 50% of all fractures involving the humerus [1]. Locking plates are currently the preferred treatment for proximal humerus fractures. The traditional locking plate approach for the treatment of proximal humerus fractures is the anteromedial approach, also known as the deltopectoral space approach. This approach has been widely used clinically, but it still has disadvantages, such as substantial surgical trauma and long operation times, which can easily cause postoperative infection, delayed fracture healing, and shoulder stiffness [2, 3]. In recent years, the use of a minimally invasive lateral approach to the shoulder joint has gradually emerged for the surgical treatment of proximal humerus fractures [4]. The small incision at the proximal end of the approach is the vertical incision at the transverse finger below the acromion, and the small incision at the distal end is the oblique incision far from the corresponding deltoid muscle [5]. This approach reduces damage to soft tissue and the blood supply to the fracture site and has achieved good clinical effects.

Thus, the purpose of this study was to investigate the clinical efficacy of a minimally invasive lateral shoulder approach and a deltopectoral space approach in the treatment of proximal humerus fractures. The baseline data, perioperative data, VAS scores, ROM scores and Constant-Murley scores were compared between these two groups.

Methods and materials

Patients

A total of 95 patients with proximal humerus fractures classified as Neer type II or type III fractures according to tile classification were selected from the General Hospital of Southern Theater Command of the PLA between June 2018 and June 2023. The collected data were analyzed anonymously, and this study adhered to the guidelines of the Declaration of Helsinki and received approval from the hospital ethics committee. Written informed consent was obtained from all patients.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) proximal humerus fracture; (2) consistent with surgical indications; (3) neer type II and type III, which can be determined by two senior orthopedic surgeons with plain films; and (4) follow-up of at least 12 months.

The exclusion criteria were as follows: (1) local or systemic infection; (2) patients with hematological diseases; (3) multiple fractures; and (4) neer Type IV.

Preoperative preparation

All patients underwent elective surgery and plaster fixation at an early stage to minimize patient pain. The patient was subsequently instructed to apply local ice and take oral medication to reduce swelling. All patients received anterior–lateral humerus radiographs.

Surgical procedures

All surgeries were performed by the same team of doctors.

Study group

In the study group, the minimally invasive lateral shoulder approach was adopted. The patient was in a beach chair or supine position, the affected limb was slightly inwardly rotated, the skin was routinely disinfected, and the mouth membrane was properly applied. A transverse skin incision approximately 5 cm long at the lateral shoulder 1.5 cm below the acromion was made, the space between the anterior and middle deltoid fasciculus was carefully identified, the incision was made along this gap, and the deltoid muscle, the length of which does not exceed 5 cm below the acromion, was bluntly separated to avoid damage to the axillary nerve, which can be seen in Fig. 1. The deltoid muscle bundle was retracted to both sides, the soft tissue surrounding the fracture was separated as much as possible, the humerus was exposed to the extraperiosteum, the distal end of the fracture was under traction, and the fracture was reduced by articular capsular exarticulation and manual compression. After satisfactory reduction, the fracture block was temporarily fixed with a Kirschner needle. The periosteal stripper was used to promote the tunnel along the deltoid deep facing the distal end of the humerus. A PHILOS bone plate of appropriate length was inserted along the deep surface of the deltoid muscle. The proximal end of the plate was placed on the lateral side of the humerus, which should be 5 ~ 8 mm below the apex of the greater tubercle of the humerus and 5 ~ 10 mm away from the posterior margin of the intertubercular groove of the humerus. Steel plates of the same length were selected for comparison, and an oblique incision approximately 3 cm long was made at the corresponding deltoid insertion point. After the partial insertion point of the deltoid was appropriately removed, the distal end of the steel plate was exposed,

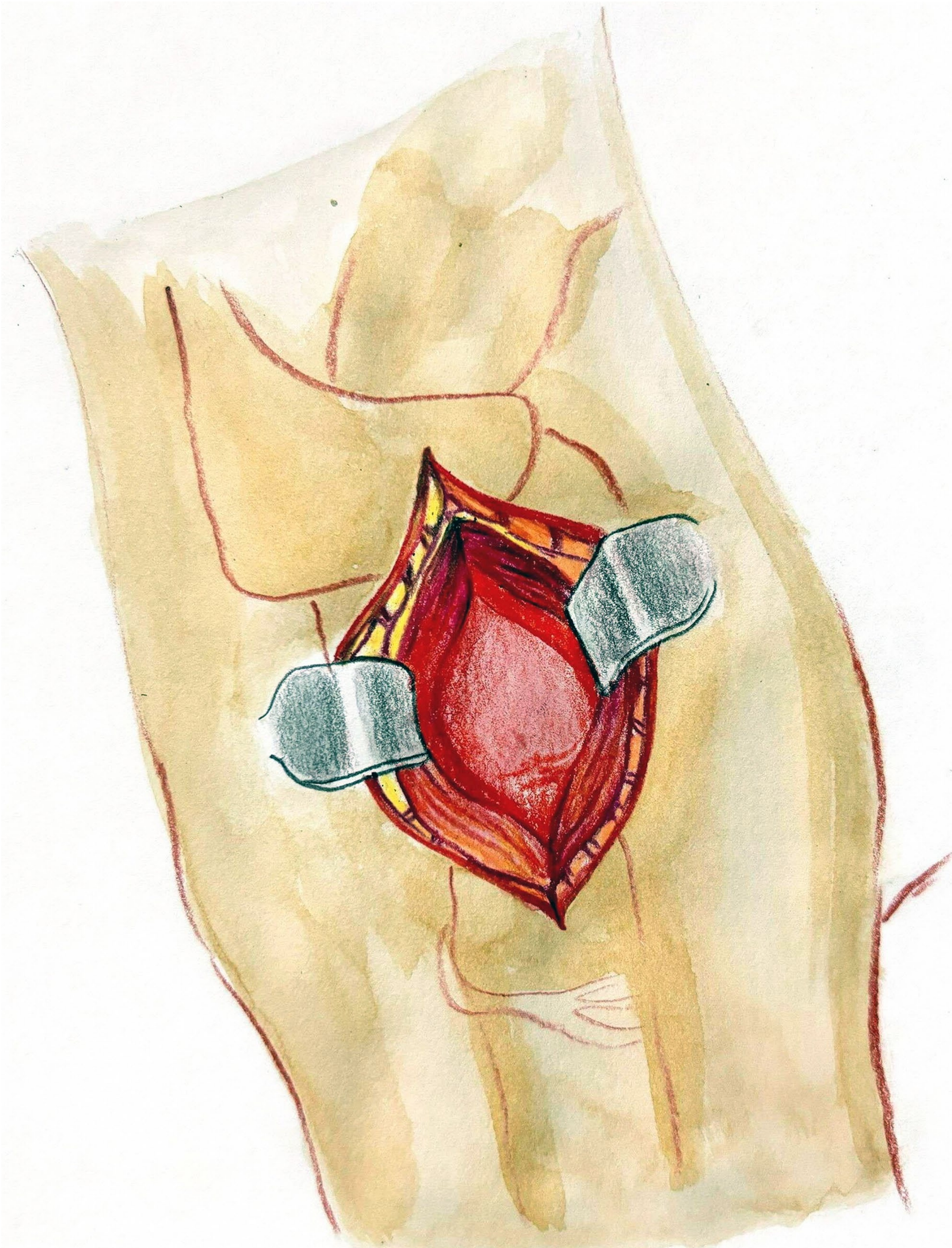

Fig. 1 Schematic diagram of the minimally invasive lateral approach

the proximal end of the steel plate was locked, a suitably sized sleeve was selected for guidance, the drill bit was drilled successively, and the depth was measured (the distance between the humerus head screw and the articular surface was 5 mm). They were screwed with appropriate locking screws (4–5 locking screws were generally inserted into the head of the humerus), and 3 locking nails were inserted into the distal end of the same method for bicortical fixation. X-ray fracture alignment with the "C" arm machine was good, and the position of the plate and screw was satisfactory. The passive mobility of the shoulder joint can help investigate rotator cuff injury. If there was any injury, it was repaired with stitches and fixed in the suture hole. The fracture site for bone defects was inspected, and autogenous bone or allogeneic bone was implanted if necessary. After the instrument gauze was checked, the wound drainage device was placed, and the subcutaneous material and skin were sutured successively to close the wound. After the operation, the forearm sling was used to bend the elbow 90° for protection.

Control group

In the control group, the deltoid-pectoralis major approach was used to directly expose the fracture site for anatomic reduction, internal fixation was performed according to conventional methods, and the same plates were placed as those in the study group.

Postoperative treatment

All postoperative care was performed by the same nursing team. Patients in both groups were given continuous oxygen inhalation after surgery, vital signs were monitored, antibiotics were routinely applied for 1 ~ 2 d, and nutritional status, severe anemia and electrolyte imbalance were noted. Immediately after surgery, the patient could perform appropriate active activities of the wrist and elbow joints of the affected limb, and the drainage film and drainage tube (drainage volume < 50 ml/d) could be removed on the second day after surgery. On the third day after surgery, passive forward bending and abduction activities of the affected shoulder joint were performed under the guidance of doctors, nurses and rehabilitation physiotherapists. The patient was instructed to start active flexion and outreach activities 7 days after surgery. Finally, a postoperative review of the shoulder joint X-ray was performed to understand the reduction and fixation of the fracture, combined with the patient's own conditions and the intraoperative fixation of the fracture, to further develop the rehabilitation exercise plan.

Rehabilitation

Early in the postoperative period (0–2 weeks), passive movements, such as pendulum movements, and active movement exercises of the shoulder blades and neck should be started immediately after surgery to reduce muscle stiffness and improve blood circulation. The focus at this stage is to control postoperative pain and swelling.

Two weeks after surgery, more extensive passive motion exercises, including forward bending, abduction, and light internal and external rotation of the shoulder joint, were initiated, while suspension braking continued to protect the repaired area.

Six weeks after surgery, the suspension brake was removed, and more active passive movement exercises were performed to avoid capsular stiffness. At this point, patients could start strength exercises, but needed to do them within the scope of the pain.

3–6 months: Gradually carry out strength exercises within the maximum active range of motion. All exercise exercises should ensure that the humerus head is always under active pressure when the glenoid plane is lifted to avoid impact.

6–12 months: Continued strengthening and passive range of motion exercises, with forward flexion and abduction up to 120° for patients undergoing trans shoulder replacement. The focus is on improving the patient's ability to perform activities of daily living so that the patient can actively perform functional activities without pain.

The patient's pain level and functional recovery were assessed regularly, and the rehabilitation plan was adjusted according to the patient's progress.

Follow-up and prognosis

All patients were followed up for a minimum of one year with radiographic assessments obtained at postoperative 1, 3, 6 and 12 months in the two groups [6, 7]. We defined fracture healing by resolution of pain and X-ray films. One month after the operation, the wound of the patient was healed and the fracture was not displaced, Patients may begin passive joint mobility exercises to reduce stiffness and improve blood circulation.Three months after surgery, the patient will continue with physical therapy to build muscle strength and further improve the range of motion of the joint. Due to the patient's appointment time, the patient will be reviewed in the hospital in 10–14 weeks, and most patients will heal the fracture in about 3 months, which was responsible for the difference in fracture healing time in the Table 1. the fracture line is becoming more and more blurred by X-Ray films. Six

Table 1 Clinical data of the two groups

Characteristics	Study group	Control group	*p*
Blood loss (ml)	80.5 ± 14.8	85.1 ± 18.6	0.630
Operation time (mins)	114.4 ± 25.3	120.5 ± 24.7	0.188
Incision length (cm)	6.7 ± 2.1	7.5 ± 1.9	0.320
Hospital stays (days)	7.65 ± 2.05	7.32 ± 2.25	0.505
Fracture union time (weeks)	10.5 ± 2.2	10.8 ± 1.9	0.611

months after surgery, most patients will have significant improvements in joint range of motion and function. The fracture line is very blurred and you can see the fracture healing. One year after surgery, most patients should have regained a significant degree of function, including full range of motion and muscle strength. The fracture has healed and the plate can be removed by X-Ray films.

Perioperative evaluation

The operation time, intraoperative blood loss, incision length, fracture healing time, and length of hospital stay were evaluated. We calculated blood loss by the total amount of fluid in the suction bottle minus the amount of fluid flushed. The operation time was calculated as the time from incision to closure.

Postoperative evaluation

VAS score, ROM (forward flexion (fixed arm: parallel to the midaxillary line; moving arm: parallel to the longitudinal axis of the humerus), abduction (fixed arm: parallel to the centerline of the body; moving arm: parallel to the longitudinal axis of the humerus), external rotation (fixed arm: parallel to the midaxillary line; moving arm: parallel to the longitudinal axis of the forearm), internal rotation (fixed arm: parallel to the midaxillary line; moving arm: parallel to the longitudinal axis of the forearm)), and Constant–Murley score of shoulder joint function, complications Incidence of cranial varus deformity, ischemic necrosis of the humerus head, and axillary nerve injury) were assessed.

Statistical analysis

SPSS 21.0 software was used to analyze the data. The measurement data are presented as the means ± standard deviations. If two groups had a normal distribution and homogeneity of variance, a group t test was used; otherwise, a rank sum test was used. The rate of counting data is expressed by the chi-square test.

Results

Patient characteristics

A total of ninety-five patients were included in this study; the average age was 64.13 ± 13.84 years in the study group and 61.23 ± 12.53 years in the control group. Twenty-six patients were female in the study group, and 33 patients were female in the control group. The main cause of injury was high falling injury in both groups. All proximal humerus fractures were classified according to the Neer classification system; 25 patients with Neer type II proximal humerus fractures and 19 patients with Neer type III proximal humerus fractures were included in the study. In the control group, 32 patients had Neer type II proximal humerus fractures, and 19 patients had Neer type III proximal humerus fractures. The baseline data of both groups are shown in Table 2, which demonstrated that the patients in each characteristic group were similar.

Table 2 Baseline characteristics of the two groups

Characteristics	Study group	Control group	*p*
Age (mean, years)	64.13 ± 13.84	61.23 ± 12.53	0.505
Sex			0.426
Male	18	18	
Female	26	33	
Cause of injury			0.269
High falling injury	28	36	
Traffic injury	16	15	
Neer type			0.342
Type II	25	32	
Typer III	19	19	

Table 3 Shoulder joint function scores of the study group and control group

Characteristics	Study group	Control group	*p*
VAS score	5.47 ± 1.25	5.61 ± 1.47	0.440
Antexion (°)	124.86 ± 36.01	120.43 ± 38.23	0.406
Abduction (°)	110.67 ± 33.62	113.59 ± 35.72	0.183
Exotation (°)	54.50 ± 12.19	56.48 ± 10.08	0.628
Intorsion (°)	72.31 ± 13.24	67.00 ± 14.89	0.349
Constant scores	85.71 ± 10.17	80.94 ± 11.68	0.147
DASH score	35.23 ± 13.86	33.68 ± 15.09	0.236

Clinical data analysis

The operation time was 114.4 ± 25.3 min in the study group and 120.5 ± 24.7 min in the control group ($P = 0.630$, Table 1). Blood loss was 80.5 ± 14.8 ml in the study group and 85.1 ± 18.6 ml in the control group ($P = 0.188$). The duration of hospital stay was 7.65 ± 2.05 days in the study group and 7.32 ± 2.25 days in the control group ($P = 0.505$). The incision length was 6.7 ± 2.1 cm in the study group and 7.5 ± 1.9 cm in the control group ($P = 0.320$). The fracture healing time was 10.5 ± 2.2 weeks in the study group and 10.8 ± 1.9 in the control group ($P = 0.611$). Furthermore, we assessed shoulder joint function and the VAS score (Table 3). The VAS score was 5.47 ± 1.25 in the study group and 5.61 ± 1.47 in the control group ($P = 0.44$). The forward flexion angle was 124.86 ± 36.01° in the study group and 120.43 ± 38.23° in the control group ($P = 0.406$). Abduction was 110.67 ± 33.62° in the study group and 113.59 ± 35.72° in the control group ($P = 0.183$). The external rotation angle was 54.50 ± 12.19° in the study group and 56.48 ± 10.08° in the control group ($P = 0.628$). The internal rotation angle was 72.31 ± 13.24° in the study group and 67.00 ± 14.89° in the control group ($P = 0.349$). The DASH score was 35.23 ± 13.86 in the study group and 33.68 ± 15.09 in the control group ($P = 0.236$). Moreover, the complication rates were 22.73% (10/44) in the study group and 39.21% (20/51) in the control group ($P = 0.026$) (Table 4) (Fig. 2).

Table 4 Occurrence of complications in the two groups

Characteristics	Study group	Control group	*p*
Acromial impingement	3	6	
Fixation loosening	1	3	
Varus deformity	1	4	
Humeral necrosis	1	3	
Axillary nerve damage	0	0	
Infection	2	2	
Delay healing	1	2	
Total	9	20	0.026

Discussion

The deltoid space approach, which is the traditional approach used to expose the proximal humerus, is suitable for most shoulder surgeries. This approach provides satisfactory exposure to the anterior glenohumeral joint and the upper humerus, but it is less appropriate to expose the posterolateral proximal humerus, especially in muscular patients. When accompanied by a greater tubercle fracture, the anterior deltoid muscle and some of the pectoralis major muscle fibers must be severed and an extensive soft tissue dissection must be perfomed, which will inevitably aggravate the injury to the periosteum and joint capsule, destroy the blood flow of the fracture block, and easily damage the anterolateral branch of the adjacent anterior brachial circumflex artery, the musculocutaneous nerve and the anterior branch of the axillary nerve [8]. The probability of humeral head necrosis, bone nonunion or infection significantly increases after surgery. The minimally invasive lateral shoulder approach adopted in this study involved a transverse skin incision under the acromion, where the anatomical level was

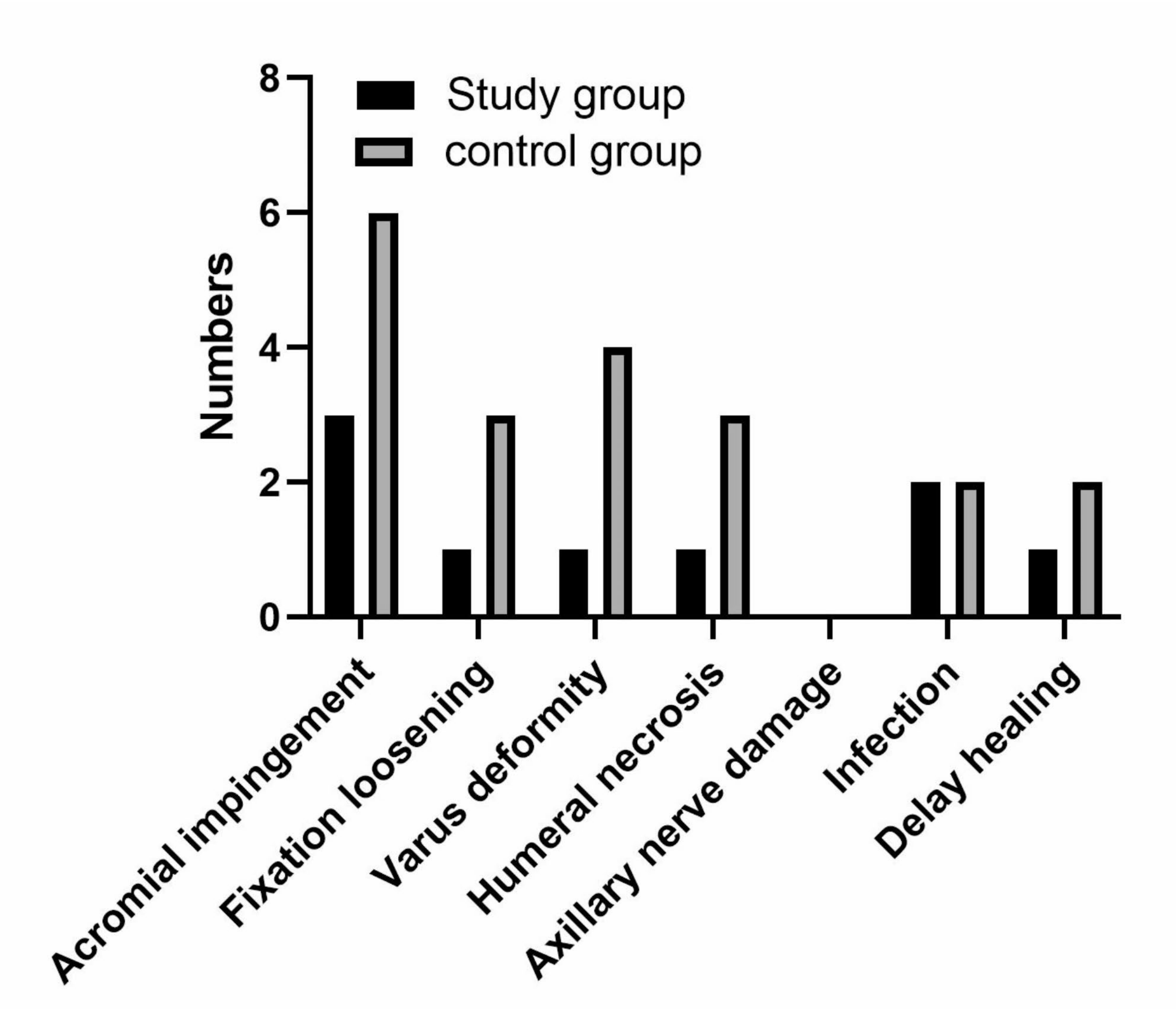

Fig. 2 Occurrence of complications in the two groups

relatively simple and only the deltoid muscle covered the muscle layer. There is a fat gap between the anterior and middle bands of the deltoid muscle, and the lateral shoulder approach can enter the deep layer through this gap without cutting the deltoid muscle fibers, so it can reduce the possibility of deltoid scar adhesion and interference with deltoid muscle strength. Compared with the traditional approach, the minimally invasive lateral shoulder approach can better reveal the proximal humerus, the greater tubercle and the intertubercular sulcus and facilitate the reduction of the greater tubercle, the placement of plates and screws, and the exploration and repair of the rotator cuff [6, 9]. The minimally invasive lateral shoulder approach makes full use of the advantages of indirect reduction technology and locking plate bridges, and indirect reduction results in little damage to the periosteum and blood flow of the fracture mass, which is beneficial for reducing the occurrence of complications such as ischemic necrosis of the humeral head, delayed union or nonunion of the fracture. The locking plate bridging principle requires the use of as many long plates as possible, which significantly reduces the stress concentration and significantly reduces the incidence of implant complications. In summary, compared with the traditional approach, this approach involves smaller incisions, less trauma, faster recovery, less risk of infection, a short operation time, and short-term functional exercise loss, which can provide sufficient mechanical stability for fractures and does not damage the local biological environment, which is conducive to fracture healing and functional recovery of the shoulder joint.

The lateral shoulder approach can be used to perform minimally invasive surgery for most proximal humerus fractures. It is suitable for the treatment of displaced two-part fractures, three-part fractures, and some upper humerus fractures. In addition, some upper humerus fractures can be treated with an extended PHILOS plate via this approach [10]. However, for complex comminuted proximal humerus fractures, proximal humerus fractures with glenohumeral dislocation, vascular and nerve injury, deltoid hypertrophy and poor soft tissue incision sites, the traditional deltopectoral space approach is currently considered more appropriate. In particular, for patients with fractures combined with glenohumeral dislocation, manual reduction of shoulder dislocation can be performed before surgery. If the reduction is successful, this approach can be used to complete internal fixation of the fracture. However, in general, the humeral head of such patients has completely lost stability, and it is difficult to reduce it by manipulation; even if it can be reduced reluctantly, it is difficult to maintain.

The transverse incision of the lateral shoulder in the minimally invasive approach should be approximately 1.5 cm below the acromion [11]. If the incision is too low, it will not only seriously affect the exposure of the fracture block and screw insertion but also may cause axillary nerve injury. Therefore, when lateral shoulder approach surgery is performed, the length of the blunt deltoid muscle should not be more than 5 cm, which can prevent the loss of the anterior branch of the axillary nerve. Although the anterior branch of the axillary nerve passes through the deep surface of the deltoid muscle, its surface is surrounded by the deltoid muscle membrane, and there is loose connective tissue between the periosteum of the humerus. The deltoid and axillary nerves can be safely pulled away from the proximal humerus bone cortex at an average distance of 13.5 mm without damaging nerve function. The space is sufficient to insert a locking plate from the proximal end deep to the distal end of the muscle without causing injury to the axillary nerve. However, for surgeons who have just started operations, nerve damage can easily occur because of their negligence. Therefore, it is necessary to have a high understanding of anatomical knowledge to perform surgery with relevant approaches.

For the management of complications, patients with acromial impingement is advised to rest and avoid lifting exercises, and some oral N.S.-aids may be prescribed. If the internal fixation is loose, revision surgery is performed to further resolve the internal fixation problem. Furthermore, none of the patients had deep infection, and there were two cases of wound infection in each case. We carried out intensive dressing change and extended the time of antibiotic use. All received good treatment.

In this study, the results were somewhat limited due to the relatively small number of cases in the study group and the experimental group. The follow-up time was 1–2 years. Therefore, the long-term complications of the patient remain unclear. While the study revealed differences in clinical outcome scores, it did not reveal differences in the incidence of rare complications such as bone nonunion or fixation failure. In summary, the minimally invasive lateral shoulder approach for the treatment of proximal humerus fractures is in line with the concept of minimally invasive treatment and has the advantages of less damage and less disruption of fractured blood flow, thus reducing the occurrence of complications such as ischemic necrosis of the humerus head, relieving shoulder pain and restoring good shoulder function in the short term. Therefore, under the conditions of a strict grasp of indications and being familiar with surgical operations, the lateral shoulder minimally invasive approach for the treatment of proximal humeral fractures is safe and effective and is worth promoting and applying in clinical practice.

Conclusion

The treatment of proximal humerus fracture via a lateral shoulder approach is in line with the concept of minimal invasiveness and can reduce the occurrence of complications such as ischemic necrosis of the humerus head, relieve shoulder pain in the short term, and restore good shoulder function. Therefore, under the conditions of a strict grasp of indications and being familiar with surgical operations, the lateral shoulder minimally invasive approach for the treatment of proximal humeral fractures is safe and effective and is worth promoting and applying in clinical practice.

Author contributions

K.M., X.W. and Z.P. wrote the main manuscript text, R.W. and Y.Z. contributed to the design of this study and acquired financial support. All authors reviewed the manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Research Ethics Board of the General Hospital of Southern Theater Command of the PLA. All participants were fully informed of the purpose, procedure, potential risks, and benefits of the study prior to their participation. We provided detailed informed consent forms and ensured that each participant signed a consent form voluntarily after fully understanding the study. All methods were carried out in accordance with relevant guidelines and regulations.

Informed consent

None.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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