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Comparison of the Incidence of Postoperative Complications and Upper Limb Function Scores Between Minimally Invasive Percutaneous Plate Osteosynthesis and Traditional Open Reduction and Internal Fixation in Treating Middle and Lower Humeral Shaft Fractures

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Abstract: *Objective:* To analyze the therapeutic effects of minimally invasive percutaneous plate osteosynthesis (MIPPO) and traditional open reduction and internal fixation (ORIF) for humeral shaft fractures (middle and lower segments). *Methods:* A total of 38 patients with humeral shaft fractures (middle and lower segments) admitted to the hospital from May 2022 to May 2025 were selected and evenly divided into two groups using a random number table. The experimental group received MIPPO treatment, while the reference group received ORIF treatment. The postoperative complication rates, upper limb function scores, and perioperative indicators were compared between the two groups. *Results:* The experimental group had a lower postoperative complication rate, higher upper limb function scores at one month postoperatively, and superior perioperative indicators compared to the reference group ($P < 0.05$). *Conclusion:* MIPPO treatment for patients with humeral shaft fractures (middle and lower segments) results in fewer postoperative complications than ORIF, with superior upper limb functional recovery and postoperative rehabilitation quality, demonstrating significant surgical advantages.

Keywords: Minimally invasive percutaneous plate osteosynthesis (MIPPO); Traditional open reduction and internal fixation (ORIF); Middle and lower third humeral shaft fractures; Postoperative complications; Upper limb function score

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1. Introduction

Humeral shaft fractures are a prevalent type of upper extremity fracture, predominantly occurring in the middle and lower thirds. These fractures result from direct or indirect violence and typically present with symptoms such

as joint pain, swelling, and restricted mobility. Early treatment is essential to improve disease prognosis [1]. Surgery serves as the foundational treatment for this condition, utilizing methods such as plating or external fixation to stabilize the fracture site. Among various internal fixation techniques, traditional open reduction and internal fixation (ORIF) offers ease of operation and allows for anatomical reduction of the fracture, thereby enhancing fracture healing rates. However, its invasive nature significantly disrupts the blood supply to the fracture site, leading to a higher incidence of postoperative complications. In contrast, minimally invasive percutaneous plate osteosynthesis (MIPPO) enables internal fixation under the guidance of minimally invasive techniques, offering strong anti-rotational properties and superior fixation effects. It ensures the quality of internal fixation while enhancing surgical safety [2]. Based on this, this study selected 38 patients with humeral shaft fractures (middle and lower thirds) to evaluate the differences in treatment outcomes between MIPPO and ORIF.

2. Materials and methods

2.1. General information

Thirty-eight patients with humeral shaft fractures (middle and lower segments) who were admitted for treatment between May 2022 and May 2025 were selected and evenly divided into two groups using a random number table. The experimental group consisted of 19 patients, including 11 males and 8 females, aged between 40 and 76 years old, with an average age of 54.29 ± 5.19 years old. The time from fracture to surgery ranged from 1 to 4 days, with an average of 2.52 ± 0.78 days. The causes of fractures were as follows: 10 cases were due to traffic accidents, 7 cases were due to falls, and 2 cases were due to other reasons. The reference group also consisted of 19 patients, including 10 males and 9 females, aged between 37 and 74 years old, with an average age of 54.37 ± 5.22 years old. The time from fracture to surgery ranged from 1 to 3 days, with an average of 2.18 ± 0.72 days. The causes of fractures were as follows: 9 cases were due to traffic accidents, 8 cases were due to falls, and 2 cases were due to other reasons. There was no significant difference in the data between the two groups ($P > 0.05$).

Inclusion criteria: Diagnosed with humeral shaft fractures (middle and lower segments) through imaging examinations such as CT; wrist extensor muscle strength > grade 4, closed fractures; although pain perception is reduced, it still exists; normal shoulder and elbow joint function before injury; complete basic information; informed consent to participate in the study. Exclusion criteria: Pathological fractures; old or open fractures; accompanied by severe nerve or vascular injuries; accompanied by cranial brain injuries; heart, liver, or kidney dysfunction; mental illness; withdrawal from the study midway.

2.2. Methods

The reference group underwent ORIF treatment: Patients were administered general anesthesia and assisted into a supine position. A centering point over the fracture line was selected to make an anterolateral incision. The muscle tissue was then separated layer by layer, after which the radial nerve was carefully dissected free to expose the fractured ends, with the periosteum precisely stripped. After performing appropriate traction reduction of the fracture ends, a plate of suitable length was selected and placed on the anterolateral aspect of the humerus. Three screws were inserted into the proximal and distal ends of the humerus, respectively, to secure the plate. The surgical field was irrigated, and the incision was sutured.

The experimental group received MIPPO treatment: Patients were assisted to assume a supinated forearm position with the upper arm abducted at 90 degrees. Incisions, each 2 cm in length, were made at the proximal

and distal ends of the anterolateral aspect of the upper arm. Starting from the proximal end, the biceps brachii was separated longitudinally, passing through the deep brachialis muscle to the distal end of the humerus, exposing both the proximal and distal ends of the humerus. A locking plate (narrow humeral type, 3–26 holes) was inserted at the fracture site and placed along the edge of the humerus, ensuring that the distal end of the plate was positioned at the superior margin of the coronoid fossa. The patient was asked to flex the elbow, and longitudinal traction and reduction maneuvers were performed on the fracture ends. Kirschner wires (2.0 mm) were inserted into the holes at both ends of the plate for temporary fixation. Real-time guidance was provided using a C-arm X-ray machine to ensure that the distal end of the plate was positioned at the superior margin of the coronoid fossa. After achieving the desired reduction, the Kirschner wires were removed, and screws were inserted into the drilled holes, with 3–4 screws inserted into both the proximal and distal ends. The surgical field was irrigated, and the incision was sutured.

Both groups received routine antibiotic therapy postoperatively, with drainage tubes left in place. Patients were instructed to engage in early functional training after the drainage tubes were removed, and were followed up for 1 month.

2.3. Observation indicators

(1) Postoperative complication rate: Observe the incidence rates of delayed fracture healing, postoperative movement disorders, incision infections, and iatrogenic radial nerve injuries, among others.

(2) Upper limb function scores: (a) Shoulder joint function: Assess shoulder joint function using the Neer Shoulder Score before surgery and one month after surgery, which includes movement (25 points), function (30 points), anatomy (10 points), and pain (35 points), totaling 100 points, with positive scoring for shoulder joint function. (b) Elbow joint function: During the same time period, use the Mayo Elbow Performance Score, which includes stability (10 points), movement function (20 points), pain (45 points), and daily activities (25 points), totaling 100 points, with positive scoring for elbow joint function.

(3) Perioperative indicators: Observe indicators such as operation time, intraoperative blood loss, incision length, hospital stay, and fracture healing time.

2.4. Statistical analysis

Data were processed using SPSS 28.0 statistical software. Count data were expressed as [*n* (%)], and comparisons were made using the chi-square (c^2) test. Measurement data were tested for normal distribution using the Kolmogorov-Smirnov (K-S) test and expressed as mean ± standard deviation (SD). Comparisons between groups were made using the independent samples *t*-test, and comparisons within groups were made using the paired *t*-test. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of postoperative complication rates between the two groups

The postoperative complication rate in the experimental group was lower than that in the reference group ($P < 0.05$). See **Table 1**.

Table 1. Comparison of postoperative complication rates between the two groups [*n* (%)]

Group	Number of cases (*n*)	Delayed fracture healing	Postoperative motor dysfunction	Incision infection	Iatrogenic radial nerve injury	Incidence rate
Experimental group	19	0	1	0	0	5.26 (1/19)
Reference group	19	2	1	1	2	31.58 (6/19)
χ^2 (Chi-square)	-	-	-	-	-	4.378
P-value	-	-	-	-	-	0.036

3.2. Comparison of upper limb function scores between the two groups

Before surgery, there was no significant difference in the functional scores of the shoulder and elbow joints between the two groups ($P > 0.05$). One month after surgery, the functional scores of the shoulder and elbow joints in the experimental group were higher than those in the reference group ($P < 0.05$). See **Tables 2** and **3**.

Table 2. Comparison of shoulder joint function scores between the two groups (mean ± SD, points)

Group	*n*	Motion		Function		Anatomy		Pain	
		Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
Experimental group	19	14.62 ± 2.54	20.45 ± 2.94	16.95 ± 2.85	23.89 ± 3.64	4.05 ± 1.32	7.58 ± 1.06	18.67 ± 2.75	29.65 ± 2.62
Reference group	19	14.60 ± 2.56	18.13 ± 2.90	16.97 ± 2.81	21.11 ± 3.61	4.07 ± 1.31	6.81 ± 1.04	18.70 ± 2.77	26.31 ± 2.53
t-value	-	0.024	2.449	0.022	2.364	0.047	2.260	0.034	3.997
P-value	-	0.981	0.019	0.983	0.024	0.963	0.030	0.973	<0.001

Table 3. Comparison of elbow joint function scores between the two groups (mean ± SD, points)

Group	*n*	Stability		Motor function		Pain		Daily activity	
		Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
Experimental group	19	4.52 ± 1.32	7.11 ± 0.87	10.56 ± 2.04	17.21 ± 1.36	21.48 ± 3.15	37.53 ± 4.09	14.25 ± 2.64	20.16 ± 3.17
Reference group	19	4.54 ± 1.29	6.19 ± 0.92	10.59 ± 2.08	15.01 ± 1.33	21.51 ± 3.18	33.05 ± 4.04	14.21 ± 2.60	18.02 ± 3.13
t-value	-	0.047	3.167	0.045	5.041	0.029	3.397	0.047	2.094
P-value	-	0.963	0.003	0.964	<0.001	0.977	0.002	0.963	0.043

3.3. Comparison of perioperative indicators between the two groups

The perioperative indicators in the experimental group were superior to those in the reference group ($P < 0.05$). See **Table 4**.

Table 4. Comparison of perioperative indicators between the two groups (mean ± SD)

Group	Number of cases (*n*)	Operative time (min)	Intraoperative blood loss (ml)	Incision length (cm)	Hospital stay (days)	Fracture healing time (weeks)
Experimental group	19	89.29 ± 7.15	82.94 ± 6.48	5.51 ± 1.36	7.22 ± 1.53	13.01 ± 2.02
Reference group	19	87.91 ± 7.23	123.67 ± 9.15	13.19 ± 1.52	10.51 ± 1.97	14.92 ± 2.06
t-value	-	0.592	15.834	16.413	5.749	2.886
P-value	-	0.558	<0.001	<0.001	<0.001	0.007

4. Discussion

Humeral shaft fractures (middle and lower segments) occur approximately 2 cm below the surgical neck of the humerus to about 2 cm above the supracondylar region of the humerus. They are caused by violent factors such as traffic accidents or falls [3,4]. Symptoms include severe pain at the fracture site and joint swelling, which significantly reduce the patient's quality of life.

ORIF is a commonly used surgical approach for patients with this condition, offering a favorable anatomical reduction and a high success rate. However, the surgical procedure requires extensive stripping of soft tissues, which can easily damage the radial nerve around the fracture, reduce local blood supply, and subsequently lead to complications [5]. MIPPO is a relatively novel internal fixation surgery that enhances the stability of fracture reduction, improves the fracture healing environment, and offers high surgical safety and greater practicality.

The results indicated that the complication rate in the experimental group was lower than that in the reference group ($P < 0.05$). The analysis attributed this to the fact that MIPPO allows the plate to be parallel to the radial nerve, separating it from the soft tissue, thereby eliminating the need for the radial nerve to straddle the plate and reducing the likelihood of nerve injury [6,7]. The surgical approach involved an anterolateral incision, with patients instructed to maintain their forearms in a supinated position to increase the distance between the radial nerve and the distal end of the plate. Covering the brachialis muscle at the plate placement site along the humeral margin prevented direct contact between the radial nerve and the plate, thereby preventing iatrogenic radial nerve injury and reducing other postoperative complications. However, it is important to note that the distal incision must expose the radial nerve and implement corresponding protective measures to prevent the plate from compressing the soft tissue during fixation. Additionally, real-time fluoroscopy using a C-arm is necessary to fully assess the plate's position and prevent risk factors such as delayed fracture healing, ensuring surgical safety [8]. The upper limb function score of the experimental group one month after surgery was higher than that of the reference group ($P < 0.05$). The analysis attributed this to the fact that MIPPO enables internal fixation of the plate within the fracture, improving fracture reduction and creating a favorable fixation environment that prevents displacement or misalignment of the fracture ends, accelerating fracture healing. This allows patients to commence postoperative rehabilitation training early, thereby gradually restoring upper limb mobility. This surgical approach features small incisions and offers significant advantages in minimally invasive treatment. It can prevent damage to surrounding tissues, protect the bone metabolic function at the fracture site, prevent excessive bone loss, and thereby safeguard the physiological function of bones and joints [9]. Additionally, this method does not significantly interfere with the periosteal arteries or nutrient arteries of the humeral shaft, maintaining the blood supply to the fracture site and thus facilitating the restoration of shoulder and elbow joint functions. More importantly, patients experience milder pain after MIPPO surgery. By adjusting the plate fixation technique according to the shape characteristics of the proximal humerus, the plate can be firmly attached to the fracture ends, ensuring the robustness of the central fixation. This creates a rigid structure at the fixation site, preventing displacement of the fracture ends, reducing friction between the plate and surrounding tissues, and alleviating postoperative pain [10]. Effective pain control facilitates patients in regularly conducting functional exercises, promoting the recovery of joint function. The perioperative indicators in the experimental group were superior to those in the reference group ($P < 0.05$). The analysis suggests that MIPPO does not require excessive separation of soft tissues, allowing direct exposure of the fracture ends of the humeral shaft, maximally protecting the blood supply around the fracture site, and reducing surgical stress responses [11]. Consequently, intraoperative blood loss can be significantly reduced, and the microcirculation at the fracture site remains favorable, minimizing surgical trauma and promoting postoperative

recovery. Furthermore, the fixation plate in this surgical approach is positioned deep to the brachialis muscle, having minimal negative impact on the flexor muscle group, which accelerates fracture healing and shortens the patient's treatment duration.

5. Conclusion

In conclusion, MIPPO treatment for patients with humeral shaft fractures (middle and lower segments) demonstrates higher effectiveness compared to ORIF. It reduces postoperative complications, enhances upper limb function, shortens the rehabilitation period, and accelerates fracture healing. Therefore, MIPPO can be considered a commonly used surgical approach for these patients, possessing high potential for widespread adoption.

Disclosure statement

The authors declare no conflict of interest.

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