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Comparative analysis of the effects of AO mini-plate and Kirschner wire pinning in the metacarpal fractures

A retrospective study

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Abstract

The aim of this study was to investigate the clinical effect of AO miniplate screw internal fixation and Kirschner wire (KW) in the treatment of metacarpal fractures.

We retrospectively analyzed the clinical data of 590 metacarpal fracture patients admitted to our hospital from March 2016 to March 2019. Among them, 290 patients were treated with KWs; 300 were treated with AO microplate internal fixation. The clinical, radiological results, time of surgery, and complications were observed and compared between the 2 groups.

The imaging characteristics and preoperative fracture types of the 2 groups were similar and comparable ($P > .05$). The operation time, length of hospital stay, and fracture healing time of AO group were shorter than those of KW group, and the differences were statistically significant (41.22 ± 7.23 vs 25.64 ± 6.29; 7.13 ± 2.38 vs 5.26 ± 1.71; 67.43 ± 22.01 vs 52.57 ± 17.46, $P < .05$). In addition, the incidence of postoperative complications in AO group was lower than that in KW group (8.3% vs 15.2%, $P < .05$). In terms of surgical knuckle extension, flexion, and total mobility (compared with the uninjured hand), patients in the AO plate group were significantly improved compared with patients in the KW group, and the difference was statistically significant (4 vs 10 degree; 19 vs 10 degree; 14 vs 29 degree, $P < .05$); The average degree of finger rotation deformity in AO plate group was significantly lower than that in KW group (1 vs 6 degree, $P < .05$). In terms of grip strength (compared with the healthy hand), the average grip strength of AO plate group was significantly higher than that of KW group (93% vs 83%, $P < .05$). Patients in the OA plate group had a lower Disabilities of the Arm, Shoulder and Hand score ($P < .05$).

Compared with KW fixation, AO mini-plate and screw fixation for the metacarpal fracture has a better effect, which can effectively shorten the operation time and reduce the trauma to patients. It can provide patients with better stability and realize the early movement of the palm, promote fracture healing and joint function recovery; it can reduce the incidence of postoperative complications, which has certain safety. In addition, it can effectively reduce the risk of poor finger rotation.

Abbreviations: DASH = disabilities of the arm, shoulder and hand, KW = Kirschner wire, PIPJ = proximal interphalangeal joint.

Keywords: AO mini-plate, finger rotation, Kirschner wire, metacarpal fracture

1. Introduction

Metacarpal fracture is a common injury disease in orthopedics, but it is relatively difficult to treat because the metacarpal and phalangeal bones are slender and the fracture position is small.[1] the treatment of metacarpal requires anatomical reduction, avoidance of angulation, and lateral rotation, among others. Internal fixation is the first selection of currently used in the treatment of metacarpal fracture in clinical, and Kirschner wire (KW) internal fixation and AO microplate screw fixation are the most common. Among them, KW internal fixation is mainly used for reduction and fixation of the fracture site. A certain therapeutic effect can be achieved, but KWs cannot provide a stable and reliable fixation to the fracture site. Therefore, it is not conducive to early postoperative joint function exercises.[2] The AO mini-plate and screw fixation can be performed with plate for internal fixation after reduction, which is beneficial to increase the stabilization of the fracture site, promote fracture healing, and facilitate the recovery of postoperative joint function of patients. However, in clinical application, the application effect of the above 2 kinds of internal fixation treatment is still controversial.[3,4] Therefore, this study further compared and analyzed the application effect of AO mini-plate screw and KW fixation in

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The authors report no conflicts of interest.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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the treatment of metacarpal fracture, which is reported as follows.

2. Methods

2.1. Study design and patient selection

The clinical data of 590 patients with the metacarpal fracture admitted to our hospital from March 2016 to March 2019 were retrospectively analyzed. Three hundred patients treated with AO mini-plate and screw fixation were included in the AO group, and 290 patients treated with KW fixation were included in the KW group.

The inclusion criteria were as follows: age >18 years' old with no history of fracture; confirmed by x-ray examination; no mental illness, cognitive ability, and normal communication ability; and complete clinical and follow-up data. Patients with the following conditions were excluded from the study: open fractures, pathological fractures, and fractures requiring bone grafting; patients with severe organ dysfunction; patients with previous injuries to the upper limbs were also excluded. This study protocol was approved by the ethics committee of our college, and was performed in accordance with the Declaration of Helsinki. All patients signed an informed consent regarding their understanding of the procedure and its potential complications as well as their approval of participation in the research.

2.2. Surgical procedure

2.2.1. AO group. After brachial plexus anesthesia, the patient was placed in the supine position and was treated with conventional balloon tourniquet to stop bleeding. The open reduction was used for fracture fixation. AO mini-plate and screw were used for internal fixation in the form of type I or type T after the reduction was completed. The ligament and joint capsule of the patient were repaired intraoperatively, and the joint function was exercised 2 to 3 days after the operation according to the recovery of the patient under the guidance of professional nursing staff, so as to promote the recovery of joint function. An 18-year-old patient sustained a fracture of the right fifth metacarpal and was treated with internal fixation (Fig. 1A–C).

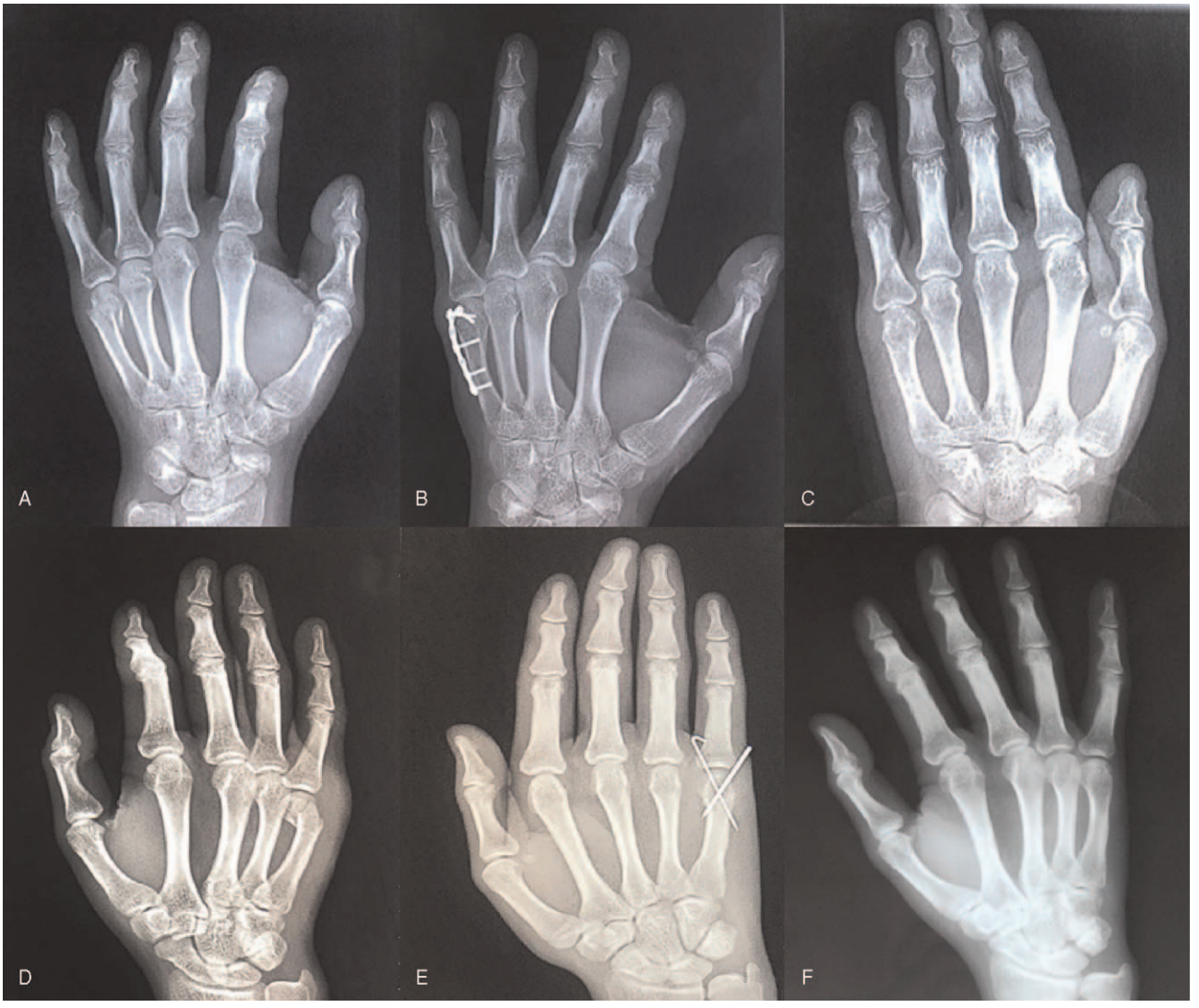

Figure 1. A 18-year-old patient sustained a fracture of the right fifth metacarpal and was treated with internal fixation: (A) Radiographic evaluation on the day of fracture; (B) Radiographic evaluation postoperation; (C) Radiographic evaluation after recovery. A 39-year-old patient sustained a fracture of the left fifth metacarpal and was treated with kirschner wire: (D) Radiographic evaluation on the day of fracture; (E) Radiographic evaluation postoperation; (F) Radiographic evaluation after recovery.

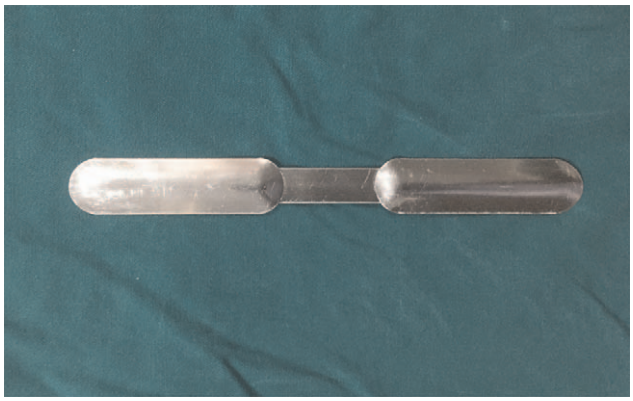

Figure 2. Aluminum plate. After the condition is stabilized, external fixation should be performed with aluminum plate for the KW group patients.

2.2.2. KW group. Brachial plexus anesthesia was performed, the fracture site was reduced manually, and the reduction of the fracture site was observed in detail with the assistance of C-arm X-ray. Two KWs of 1.1 or 0.9 mm were used to fix the fracture after the fracture reduction, and the tail of KW was left outside the skin. For patients with severe fractures, KW insertion can be used; however, for patients with comminuted fractures, the fragmented bone should be fixed locally, and then the metacarpal and phalanx fractures should be fixed with KW for observation for a period of time. After the condition is stabilized, external fixation should be performed with aluminum plate (Fig. 2). A 39-year-old patient sustained a fracture of the left fifth metacarpal and was treated with KW (Fig. 1 D–F). Patients in both groups were followed up for 3 to 6 months after operation.

2.3. Observation index

Operative indicators were recorded and compared between the 2 groups, including intraoperative blood loss, operative time, fracture healing time, joint function recovery, and postoperative complications. TAFS score was used to evaluate the postoperative palm function of the patients: the active flexion degree of 2 to 5 metacarpoparacular to interphalangeal joint >220 degree was excellent; the active flexion degree of 2 to 5 metacarpoparacular to interphalangeal joint 180 to 220 degree was good; the active flexion degree of metacarpal and phalangeal joints from 2 to 5 fingers to interphalangeal joints is <180 degree.[5]

2.4. Assessment of palmar finger range of motion

Active extension and flexion was tested in each digit-both the digits corresponding to the fractured metacarpals and the noninvolved digits.

Due to the variation between individual fingers in flexion and extension, the range of motion in each finger was compared with the same finger in the opposite hand. Based on the criteria proposed by Belsky, we defined digits as having an excellent range of motion when total flexion loss was <40 degree and proximal interphalangeal joint (PIPJ) flexion loss was <10 degree of the contralateral finger, good range of motion when total flexion loss was 40 to 80 degree or PIPJ flexion loss was 10 to 30 degree compared with the contralateral finger, and poor range of motion when total flexion loss was >80 degree or PIPJ flexion loss was >30 degree of the contralateral finger.[6]

2.5. Grip strength and Disabilities of the Arm, Shoulder and Hand score

Average grip strength was calculated for 3 attempts in both the injured and healthy hand, using a Jamar hydraulic hand dynamometer. Rotational deformity was measured for each finger, based on the angle of rotation of the distal phalanx in straight fist position, compared with the adjacent uninjured finger. Disabilities of the Arm, Shoulder and Hand (DASH) score was collected at the time of examination. Finally, the radiograph images were scanned for metacarpal angulation and shortening before surgery and at the final follow-up.[7]

2.6. Statistical analysis

Parametric tests (independent samples *t* test) were applied to data with a normal distribution, and nonparametric tests (Mann–Whiney *U* test) were applied to data with non-normally distributions. The data are expressed as the mean ± SD or median (interquartile range), as appropriate. All statistical analyses were performed using SPSS 23.0 (SPSS Inc., Chicago, IL), with a 2-sided $P < .05$ considered statistically significant.

3. Results

3.1. Patient clinical characteristics

A total of 590 patients with metacarpal fracture were recruited in this study, including 335 males and 255 females. The mean age of the patients was 28.45 years (range 18–45 years). There were no statistically significant differences in age, sex, BMI, smoking history, or injury rate of dominant side (63% vs 72%) between the 2 groups. The number of injured metacarpal bones and the fracture site of corresponding finger were comparable, and the difference was not statistically significant ($P > .05$) (Table 1).

Table 1

Demographic characteristics of patients.

Characteristic	KW group (n = 290)	OA group (n = 300)	*P*
Sex			.116
Male	157 (54.1)	178 (59.3)	
Female	133 (45.9)	122 (40.7)	
Age, y	27.5 ± 3.31	29.45 ± 2.51	.091
BMI	22.9 ± 3.06	23.1 ± 2.77	.194
Smoke			.797
Yes	213 (73.4)	230 (76.7)	
No	77 (26.6)	70 (23.3)	
Injured dominant hand, %	183 (63.1)	216 (72.0)	
No. of fractured metacarpals			.547
One metacarpal	220	250	
Two metacarpal	70	20	
Three metacarpal	10	20	
Fractured metacarpal digits			.832
Index finger	60	30	
Long finger	60	20	
Ring finger	70	140	
Little finger	200	160	

BMI = body mass index.

Table 2

Comparison of operation and postoperative complications between the 2 groups.

Characteristic	KW group (n = 290)	OA group (n = 300)	*P*
Operation time, min	41.22 ± 7.23	25.64 ± 6.29	.021
Volume of blood, mL	12.65 ± 3.08	11.66 ± 3.13	.892
Total hospitalization, days	7.13 ± 2.38	5.26 ± 1.71	.046
Healing time, days	67.43 ± 22.01	52.57 ± 17.46	.002
Complications			.027
No	70 (84.8)	275 (91.7)	
Yes	44 (15.2)	25 (8.3)	
Wound infection	10	7	
Loose internal fixation	4	6	
Tendon adhesion	18	7	
Delayed healing	12	5	

3.2. Comparison of operation related indexes

Intraoperative blood loss was similar between the two groups, with no statistically significant difference (12.65 ± 3.08 vs 11.66 ± 3.13, $P > .05$). The operation time, length of hospital stay and fracture healing time of AO group were shorter than those of KW group, and the differences were statistically significant (41.22 ± 7.23 vs 25.64 ± 6.29; 7.13 ± 2.38 vs 5.26 ± 1.71; 67.43 ± 22.01 vs 52.57 ± 17.46, $P < .05$), the incidence of postoperative complications in AO group was lower than that in KW group, with a statistically significant difference (8.3% vs 15.2%, $P < .05$) (Table 2).

3.3. Finger movement, grip strength, and DASH score

In terms of postoperative finger joint extension, flexion, and total range of motion (compared to the uninhibited hand), patients in the AO group had significant improvements compared with patients in the KW group, and the difference was statistically significant (4 vs 10 degree; 10 vs 19 degree; 14 vs 29 degree, $P < .05$); the average rotation deformity of the fingers of the AO group was significantly lower than that of the KW group (1 vs 6 degree, $P < .05$); in terms of grip strength (compared with the healthy hand), the average grip strength of the OA group patients was significantly greater than that of the KW group (93% vs 83%, $P < .05$); the DASH score of the patients in the OA group was lower (10.5 vs 15.6) ($P < .05$) (Table 3).

Table 4

Imaging results of the patients.

Characteristic	KW group (n = 290)	AO group (n = 300)	*P*
Radiographic preoperative angulation, degree (range)			
Anterior–posterior	6 (0–38)	7 (0–28)	
Lateral	13 (0–54)	15 (0–32)	
Radiographic postoperative angulation, degree (range)			
Anterior–posterior	1 (0–11)	0	
Lateral	1 (0–9)	0	
Radiographic preoperative shortening, mm (range)	3 (0–15)	2 (0–8)	
Radiographic postoperative shortening, mm (range)	1 (0–5)	0	

3.4. Imaging results

The anteroposterior and lateral anterior and posterior angulations of the metacarpal bones in the two groups were significantly smaller than those before the operation, and the difference was statistically significant (6 vs 1 degree, 13 vs 1 degree; 7 vs 0 degree, 15 vs 0 degree, $P < .05$), but there was no statistical difference in the comparison of the preoperative and postoperative imaging results between the 2 groups ($P > .05$); in addition, the reduction of metacarpal x-rays in the 2 groups was significantly reduced after surgery (Table 4).

3.5. Recovery of joint function

The excellent and good joint function recovery rate of AO group was higher than that of KW group, and the difference was statistically significant ($P < .05$) (Table 5).

4. Discussion

Metacarpal and phalangeal bone is an important part of the human palm, which is often stressed and mainly bears the motor

Table 3

Finger motion of the patients.

Characteristic	KW group (n = 290)	AO group (n = 300)	*P*
Loss of extension compared with contralateral digit, degree (range)			
Injured digit	10 (0–50)	4 (0–25)	.032
Noninjured digit	4 (0–30)	4 (0–30)	
Loss of flexion compared with contralateral digit, degree (range)			
Injured digit	19 (0–110)	10 (0–70)	.033
Noninjured digit	7 (0–100)	5 (0–70)	
Loss of total range of motion compared with contralateral digit, degree (range)			
Injured digit	29 (0–145)	14 (0–75)	.005
Noninjured digit	11 (0–110)	9 (0–75)	
Rotated digits, n	150/390	50/350	.038
Index finger	30	0	
Long finger	20	0	
Ring finger	0	30	
Little finger	100	20	
Rotational deformity at fingertip, ° (range)	6 (0–30)	1 (0–20)	.023
Grip strength compared with contralateral hand, % (range)	83 (40–110)	93 (42–125)	.05
DASH score	15.6 (0–53)	10.5 (0–40)	.043

DASH = disabilities of the arm, shoulder and hand.

Table 5

Comparison of the recovery of affected limb joint function 3 months after operation between the 2 groups.

	KW group (n = 290)	AO group (n = 300)	*P*
Rate of excellent and good, %	73.4	93.4	.038
Excellent	136 (46.9)	170 (56.7)	
Good	77 (26.5)	110 (36.7)	
Bed	77 (26.5)	20 (6.6)	

function of the palm. Once metacarpal bone fracture occurs, it will damage the stability of the palm, affect the muscular-tendon tension, reduce the function of the palm joints, and bring negative effects to the daily life and work of patients.[8] In clinical surgery, internal fixation was adopted to promote the recovery of the function of the palm joint after surgery.[9,10]

KW fixation is a kind of internal fixation used in clinical treatment of metacarpal fractures. It has the characteristics of complicated operation and less trauma. However, intraoperative KW fixation is not stable, and joint adhesion complications are prone to occur, affecting the healing of the fracture site, which is not conducive to the recovery of the patient's postoperative joint function.[11] AO mini-plate is a new method of internal fixation in recent years. It has the characteristics of less trauma and stable internal fixation. It not only facilitates the fixation of the fracture, but also reduces the impact on the tendon and bone joints.[12,13] In addition, AO mini-plate and screw internal fixation has a wide range of indications, and has a high fitness for proximal, distal, and comminuted fractures of the palmaris and diaphysis.[14] At the same time, the normal anatomical position of the joint surface can be restored to the maximum extent during the operation, which is conducive to increase the stability and flexibility of the joint.[15,16]

The results of this study showed that the operation time and fracture healing time of AO group were significantly shorter than that of KW group, and the excellent and good rate of fracture healing was higher than that of KW group ($P < .05$). The incidence of postoperative complications in AO group was lower than that in KW group, with a statistically significant difference. It shows that KW and AO mini plate and screw internal fixation in the treatment of metacarpal fractures have certain effect, and both have high safety, but AO mini plate and screw internal fixation is more conducive to postoperative fracture healing, and promote the improvement of joint function.

Previous studies have shown that patients with KW fixation may have residual rotational deformity in their fingers, and 1 degree of metacarpal fracture rotation has been shown to produce 5 degree of fingertip rotation.[17] In our study, we measured the rotation of the fingertips, and the rotation of the fracture site was 0 to 6 degree in KW group and 0 to 4 degree in OA group. Some of these rotation abnormalities may be due to the use of a single KW, with no locking device to fix the fracture.[18]

In most cases (<10 degree), the lack of shear on adjacent fingers and a small degree of rotation result in little dysfunction, and some patients do not detect any deformity until examination.[19] There was no statistical correlation between the DASH score and the patients with circumphalanges. However, patients who rotated their middle or ring fingers, and those who rotated their finger margin inward, had higher DASH scores than average (21.2 points for KW and 19.1 points for OA). One patient with intradermal pinkie underwent an orthodontic rotatory osteotomy. In other studies comparing metacarpal fixation methods, we did not find any records of residual rotational deformity.

Our research has some limitations. First, since a retrospective design was used in this study, there may be confounders affecting the results. Second, our study was a single-center retrospective study, and a multicenter study with longer follow-up is needed to verify whether our findings are universally applicable. In the future, multi-center clinical studies can be conducted on an international scale to minimize research bias.

5. Conclusions

Compared with KW fixation, AO mini-plate and screw fixation for metacarpal fracture have a better effect, which can effectively shorten the operation time and reduce the trauma to patients. It can provide patients with better stability and realize the early movement of the palm, promote fracture healing and joint function recovery; it can reduce the stimulation to the tendon and lower the incidence of postoperative complications, which has certain safety. In addition, it can effectively reduce the risk of poor finger rotation and is worthy of promotion in clinical practice.

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Author contributions

Zhoufu Lv contributed to the study design and literature search. Qiang Nie and Jing Guo contributed to the literature search and the writing of the manuscript. Meiyu Tang contributed to the review and revise of the manuscript.
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