Journal of Orthopaedic Surgery and Research

RESEARCH

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Hook plate fixation and tension band wiring in the treatment of Mayo type II olecranon fractures

Jianyu Zhang[1†], Xigong Zhang[1†], Kehan Hua[1], Chen Chen[1], Maoqi Gong[1], Yejun Zha[1*] and Xieyuan Jiang[1*]

Abstract

Background Olecranon fractures account for 8 ~ 10% of all elbow fractures and usually require surgical intervention. Tension band wiring (TBW) is considered as the standard treatment while it is associated with high re-operation rates.

Objective This study aims to compare the functional outcomes, complications and re-operations of hook plate fixation (HPF) versus TBW in treating Mayo Type II olecranon fractures.

Methods A retrospective cohort study was conduct at Beijing Jishuitan Hospital. Medical records from May 2020 to April 2021 were reviewed. Functional outcomes, complications, and re-operations were assessed during the follow-up.

Results A total number of 62 patients were included, with a number of 27 undergoing HPF and 35 receiving TBW. The HPF group and the TBW group achieved similar range of motion (ROM), the Mayo Elbow Performance Score (MEPS), and the Disabilities of the Arm, Shoulder, and Hand (DASH) scores ($P > 0.05$). The HPF group had a significantly lower re-operation rate (44.4% vs. 80.0%, $P < 0.01$) comparing to the TBW group.

Conclusion Hook plate fixation can be considered as a viable alternative to tension band wiring, offering similar functional outcomes and complication rates but significantly lower re-operation rates.

Keywords Hook Plate Fixation, Tension Band Wiring, Olecranon Fracture, Re-operation

Introduction

Olecranon fractures accounts for 8 ~ 10% of all elbow fractures, presenting a bimodal distribution [1, 2]. As it involves the semilunar notch of the ulna [3], open reduction and internal fixation(ORIF), such as plate fixation and tension band wiring (TBW), is mandatory for satisfactory results and has been applied in clinical practice [4–7]. Tension band wiring, regarded as the standard treatment, remains the most commonly used technique in the management of displaced and minimally comminuted olecranon fractures [8, 9]. However, the complication of tension band wiring, such as symptomatic prominence of the Kirschner wires, has been a concern

†Jianyu Zhang and Xigong Zhang contributed equally to this work.

*Correspondence:
Yejun Zha
yijune23@126.com
Xieyuan Jiang
jxytrauma@163.com
[1]Department of Orthopedic Trauma, Beijing Jishuitan Hospital, Capital Medical University, No. 31 Xinjiekou East Street, Xicheng District, Beijing 100035, China

in this technique [10] and the bothering from this metalware itself may lead to a high re-operation rate [11].

The hook plate fixation (HPF) technique, firstly applied in 1948 with two right-angle hooks [12], has been reported yielding uniformly excellent or good results in its modification form with two real hooks in a 180-degree bending [13]. The HPF is also regarded as a safe procedure for olecranon osteotomies in distal humerus fractures with a low complication rate [14]. There has been literature comparing the biomechanical studies of various fixation methods in treating olecranon fractures with a novel scoring method [15]. Despite the report that hook plate fixation resulted in a longer time to union and slightly worse extension at the final follow-up, there is rare clinical study comparing the efficacy of these two techniques [16].

The aim of our study is to investigate the clinical outcomes and complications of using HPF versus TBW in the treatment of Mayo Type II olecranon fractures, providing reference in the management of olecranon fractures.

Methods and patients

Design and population

This study is a retrospective cohort study aiming at comparing the efficacy of HPF and TBW in the treatment of Mayo Type II olecranon fractures. Medical records were reviewed at our hospital from May 2020 to April 2021. The samples were identified by following the inclusion and exclusion criteria as listed below (Fig. 1). Inclusion criteria: (1) Patients diagnosed with Mayo type II olecranon fractures; (2) exclusively treated with hook plate fixation (HPF) or tension band wiring (TBW); (3) aged 18 years or older; and (4) with a follow-up duration of no less than 24 months. Exclusion criteria: (1) Presence of open fractures; (2) combined fractures within the same limb; (3) pathological fractures; and (4) refusal to participate in follow-up evaluations.

Based on the follow-up records, functional outcomes, re-operations, and complications were evaluated. This study received ethical approval from the Ethics Committee of Beijing Jishuitan Hospital, in compliance with the Declaration of Helsinki and local regulations (Approval No. 202204-01). Written informed consent was obtained from all the participants prior to the enrollment of this study.

Follow up

At follow-ups, we ordered standard anteroposterior and lateral radiographs of the elbow routinely for all patients (Figs. 2 and 3). The MEPS and DASH scores were documented in outpatient department. The ROM of the elbow, including extension, flexion, supination, and pronation was measured. The measurement was conducted by one individual observer. Complications such as

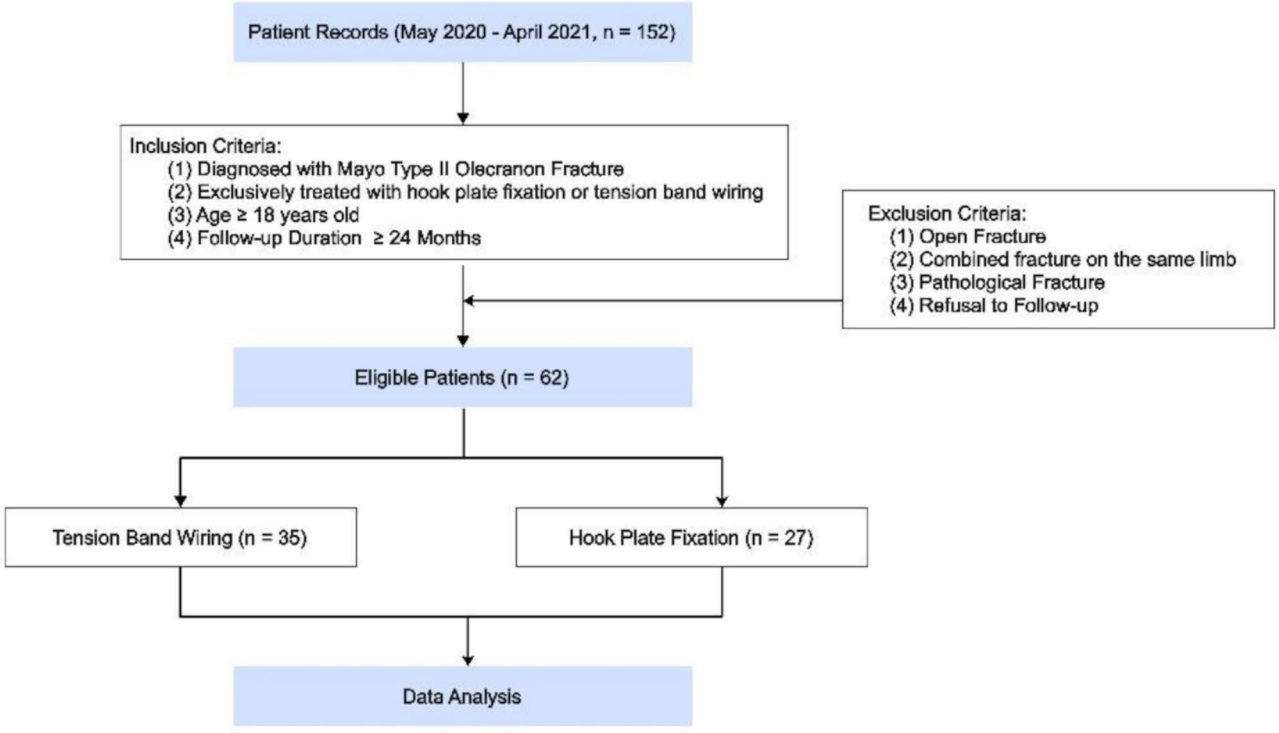

Fig. 1 Diagram illustrating patient selection criteria and study design

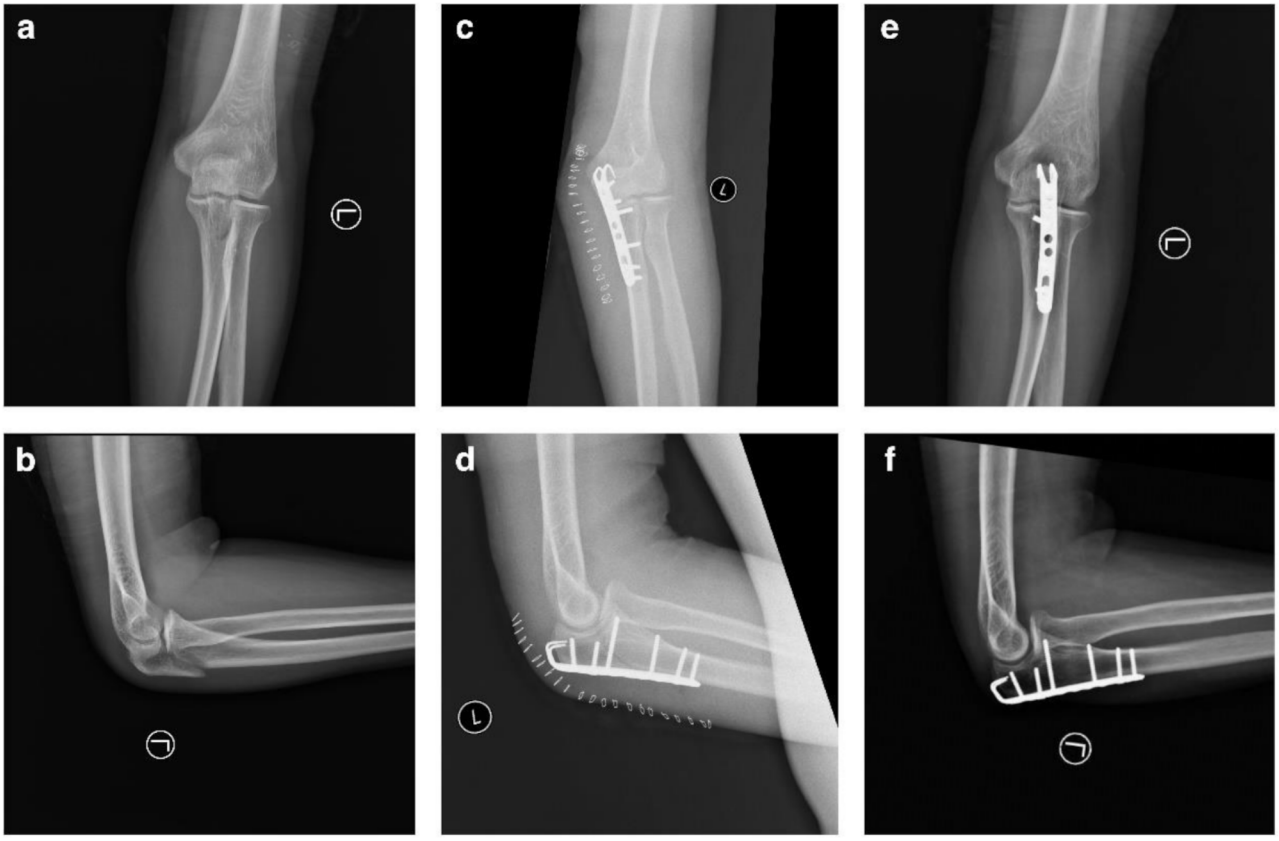

Fig. 2 Radiological records and follow-ups of a Mayo type II olecranon fracture treated with hook plate fixation. Preoperative radiograph (**a**: anteroposterior view, **b**: lateral view); Postoperative radiograph (**c**: anteroposterior view, **d**: lateral view); 24-months postoperative follow-up (**e**: anteroposterior view, **f**: lateral view)

nonunion, elbow stiffness, infection, implant irritation, and re-operations were also recorded.

Surgical procedure

Brachial plexus block anesthesia was performed on all patients. A posterior approach was performed to expose the fracture site. The fracture was then reduced after the compressed fracture being addressed. Afterwards, reduce the proximal fracture of the triceps brachii tendon. The fracture was temporarily fixed with two 2.0 mm Kirschner wires.

For TBW, a titanium cable was passed through the drilled hole transversely and crossed over itself, forming a 'figure 8' on the posterior aspect of the proximal end of the ulna. The titanium cable was then tightened and secured in place, followed by bending and trimming the tail of the Kirschner wire. For HPF, two longitudinal incisions were made in line with the fibers of the triceps insertion down to the proximal tip of the olecranon. A Hook Drill Guide was applied to the olecranon ensuring the guide is completely seated. Two holes were drilled through the outer cortex with a 2.3 mm drill. Then, the plate's hooks were insert into the holes drilled in the olecranon. The Impactor was seated between the two hooks and the plate was impacted into the distal fragment. After confirming that the reduction is adequate, a non-locking 3.2 mm cortical screw was placed in the end of the slotted hole that is the farthest from the fracture. The screwdriver tip of the Expander/Compression Tool was then Insert into screw head and jaw was engaged into the adjacent screw hole away from the fracture. Then, the fixation was completed with 3.2 mm cortical screws, as needed. The distal site of plate was buried within the fascia to minimize implant irritation on the ulnar shaft side.

The postoperative protocols did not differ: all patients had an analgesia pump within the first three days following surgery. Exercises for elbow flexion and extension as well as forearm rotation began on the second day. The exercise method was based primarily on active motions. Partial weight-bearing exercises might be permitted one month after surgery.

Statistical analysis

We used IBM SPSS 25.0 statistical software to process and analyze the data. The normality of continuous data was evaluated using the Shapiro-Wilk test, and the

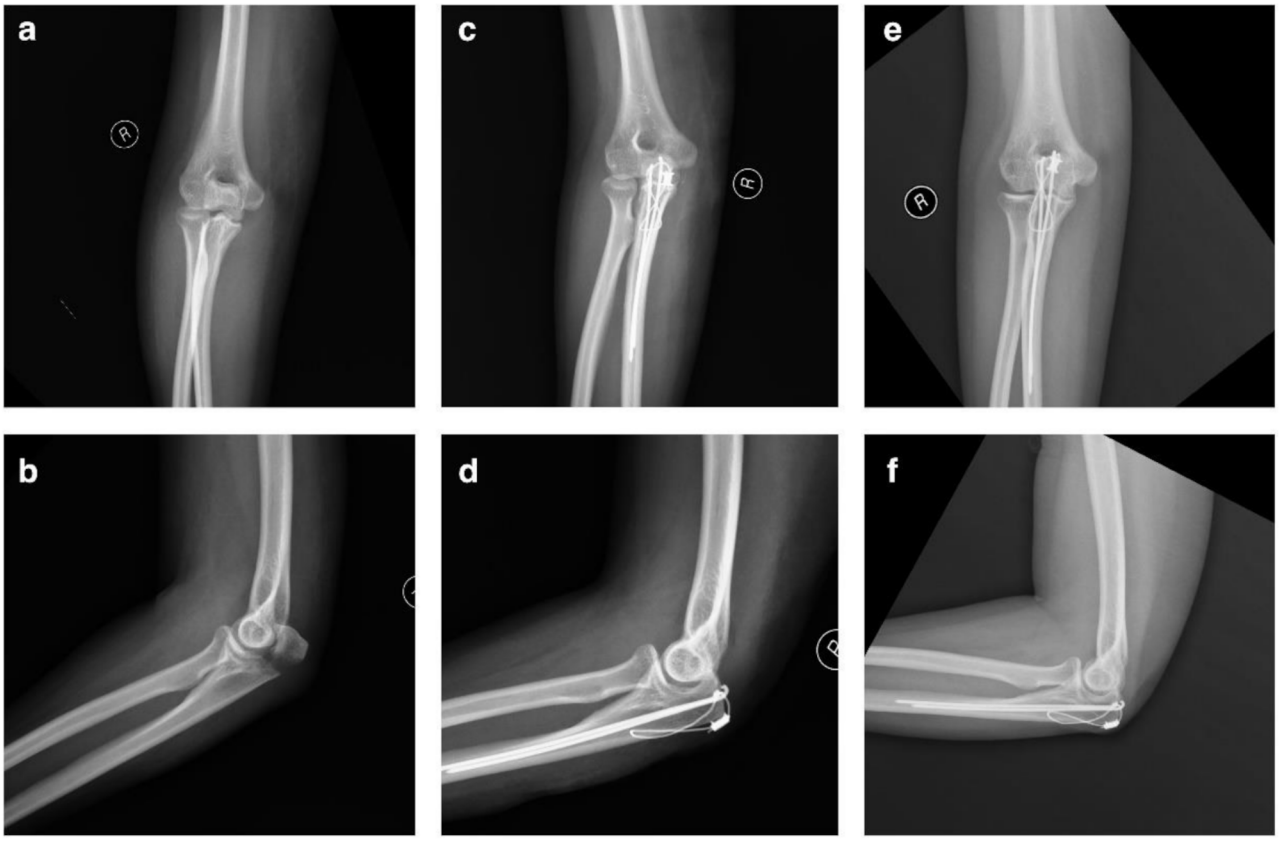

Fig. 3 Radiological records and follow-ups of a Mayo type II olecranon fracture treated with hook plate fixation. Preoperative radiograph (**a**: anteroposterior view, **b**: lateral view); Postoperative radiograph (**c**: anteroposterior view, **d**: lateral view); 24-months postoperative follow-up (**e**: anteroposterior view, **f**: lateral view)

Table 1 Patients' baseline characteristics

	HPF (*N* = 27)	TBW (*N* = 35)	*P*
Age †	51.7 (13.9)	48.7 (16.7)	0.33
Gender (no. [%])			
Male	10 (37.0%)	15 (42.9%)	0.91
Female	17 (63.0%)	20 (57.1%)	
Injured side (no. [%])			
Left	16 (59.3%)	15 (42.9%)	0.14
Right	11 (40.7%)	20 (57.1%)	
Injury Mechanism (no. [%])			
Fall	19 (70.4%)	28 (80.0%)	0.31
Traffic accident	8 (29.6%)	7 (20.0%)	
Mayo Classification (no. [%])			
IIA	20 (74.1%)	27 (77.1%)	0.88
IIB	7 (25.9%)	8 (22.9%)	
BMI †	23.1 (2.7)	22.8 (2.7)	0.75
Duration of follow-Up † (mo)	35.6 (9.2)	37.4 (10.1)	0.52

† The values are given as the mean and standard deviation

Levene test was applied to assess homogeneity of variance. Data that were normally distributed were presented as the mean ± standard deviation ($\bar{x} \pm s$). If variance was homogeneous, an independent sample t-test was conducted. For data that did not follow a normal distribution, we employed the Mann-Whitney U test. Categorical variables were analyzed with Pearson's chi-square test or Fisher's exact test in thecomparisons between the two groups. A *P*-value of < 0.05 was considered statistically significant our study.

Results

A total number of 62 patients' data were analyzed from 152 patients included in this study from May 2020 to April 2021. Patients' baseline characteristics were compared between the two groups (Table 1). There is no statistically significant difference to be found in age ($P = 0.33$), gender ($P = 0.91$), BMI ($P = 0.75$) or injured side ($P = 0.14$) between the two groups. For duration of follow-up and duration of surgery, there is no statistical difference observed between the two groups ($P = 0.52$, $P = 0.52$) respectively.

The majority of patients suffered from the mechanism of falls in the both groups with no significant difference ($P = 0.31$). It was noted that there were 20 patients ($n = 20$, 74.1%) in the HPF fixation group and 27 patients ($n = 27$, 77.1%) in the TBW group having type IIA fractures($P = 0.88$) while 7 patients ($n = 7$, 25.9%) in

the HPF group and 8 patients ($n = 8$, 22.9%) in the TBW group having type IIB fractures according to the Mayo Classification.

In the perspective of clinical outcomes, the flexion ($P = 0.51$), extension ($P = 0.11$), pronation ($P = 0.32$), supination ($P = 0.25$), the ROM in flexion-extension ($P = 0.49$) and rotation ($P = 0.38$) did not differ between the HPF group and the TBW group (Table 2). The mean MEPS was 90.9 ± 13.5 in the HPF group and 96.0 ± 7.6 in the TBW group, with no statistically significant difference ($P = 0.14$). The mean DASH score was 7.4 ± 5.0 in the HPF group and 8.2 ± 5.5 in the TBW group, with no statistically significant difference ($P = 0.66$).

In regarding re-operation, a significantly higher re-operation rate was identified in the TBW group ($n = 28$, 80.0%) compared to the HPF group ($n = 12$, 44.4%), with a statistically significant difference ($p < 0.01$). In the HPF group, there was one case of postoperative infection and the patient received debridement and vacuum-sealed drainage subsequently. In the TBW group, one patient received elbow arthrolysis and internal fixation removal due to elbow stiffness. A total number of 38 ($n = 11$, $n = 27$, HPF and TBW, respectively) patients received implant removal due to implant irritation or patient preference only, with major withdrawal of the Kirschner wires observed in 4 patients during follow-up in the TBW group (Fig. 4). Implant removal rate due to irritation in the TBW group was higher than the HPF group with a statistically significant difference ($p = 0.03$) (Table 2).

Discussion

Tension band wiring, with its technique gradually evolving including individualized 3D-printed navigation [17], is the most commonly used surgical technique in managing olecranon fracture [8]. There were also attempts using a hook plate to achieve anatomical reduction [12–14]. Due to the nature of olecranon fracture as an intra-articular fracture, open procedure including careful reduction of the fracture fragments is of necessity in obtaining satisfactory clinical outcomes [18]. In our study, a comparison of these two distinctive surgical techniques was conducted in terms of clinical outcome and complication. The HPF group and the TBW group achieved similar ROM in flexion-extension and rotation, as well as the MEPS and the DASH scores at the last follow-up with no statistically significant difference in duration of follow-up. Notably, the HPF group had a significantly lower re-operation rate(44.4% vs. 80.0%, $P < 0.01$).

The tension band wiring technique has been shown to achieve satisfactory clinical outcomes in the treatment of olecranon fractures in terms of ROM and the MEPS [19–21], which are compatible with our findings. However, the symptomatic prominence of the Kirschner wires [10] and a high re-operation rate are concerns of the tension band wiring technique. There has been research indicating a re-operation rate as high as 71.7% [11].

There has been limited literature comparing HPF and TBW techniques, which reported an excellent functional outcome with follow-up durations of 13.5 ± 9.7 and 14.4 ± 11.6 months for TBW and HPF groups, respectively [22]. This result is consistent with our findings except a lower re-operation rate. In our study, a relatively longer follow-up time of 37.4 ± 10.1 and 35.6 ± 9.2 months for the TBW and the HPF group, which could have an impact on re-operation rate. Thus, different structure of hooks may also contribute to this inconsistency.

It shall be noted that in the previous studies involving hook plate fixation, the structure of the 'hooks' evolves in different forms. In the firstly applied cases, the hooks was made in two right-angle at the end of the plate [12]. Later, its modification form appears in two 180-degree bending hooks [13]. Single hook in a sharp appearance of the central tension plate has been applied as well [18]. In our study, two 90–90° bending hooks were featured to be able

Table 2 Patients' clinical outcomes, complications and re-operations

	HPF ($N = 27$)	TBW ($N = 35$)	P
Flexion † (°)	4.1 (11.5)	3 (5.2)	0.51
Extension † (°)	147.0 (8.7)	147.7 (7.6)	0.11
Pronation † (°)	85.2 (5.1)	86.0 (5.0)	0.32
Supination † (°)	87.0 (4.7)	87.7 (4.3)	0.25
Flexion-extension ROM † (°)	143.0 (15.4)	144.7 (9.9)	0.49
Pronation-supination ROM † (°)	172.2 (6.9)	173.7 (6.8)	0.38
MEPS †	90.9 (13.5)	96.0 (7.6)	0.14
DASH †	7.4 (5.0)	8.2 (5.5)	0.66
Total re-operations (no. [%])	12 (44.4%)	28 (80.0%)	**<0.01**
Implant removal by irritation (no. [%])	2 (7.4%)	11 (31.4%)	**0.03**
Implant removal by patient preference (no. [%])	9 (33.3%)	16 (45.7%)	0.32
Duration of surgery † (min)	70.9 (16.7)	68.7 (17.5)	0.52

† The values are given as the mean and standard deviation

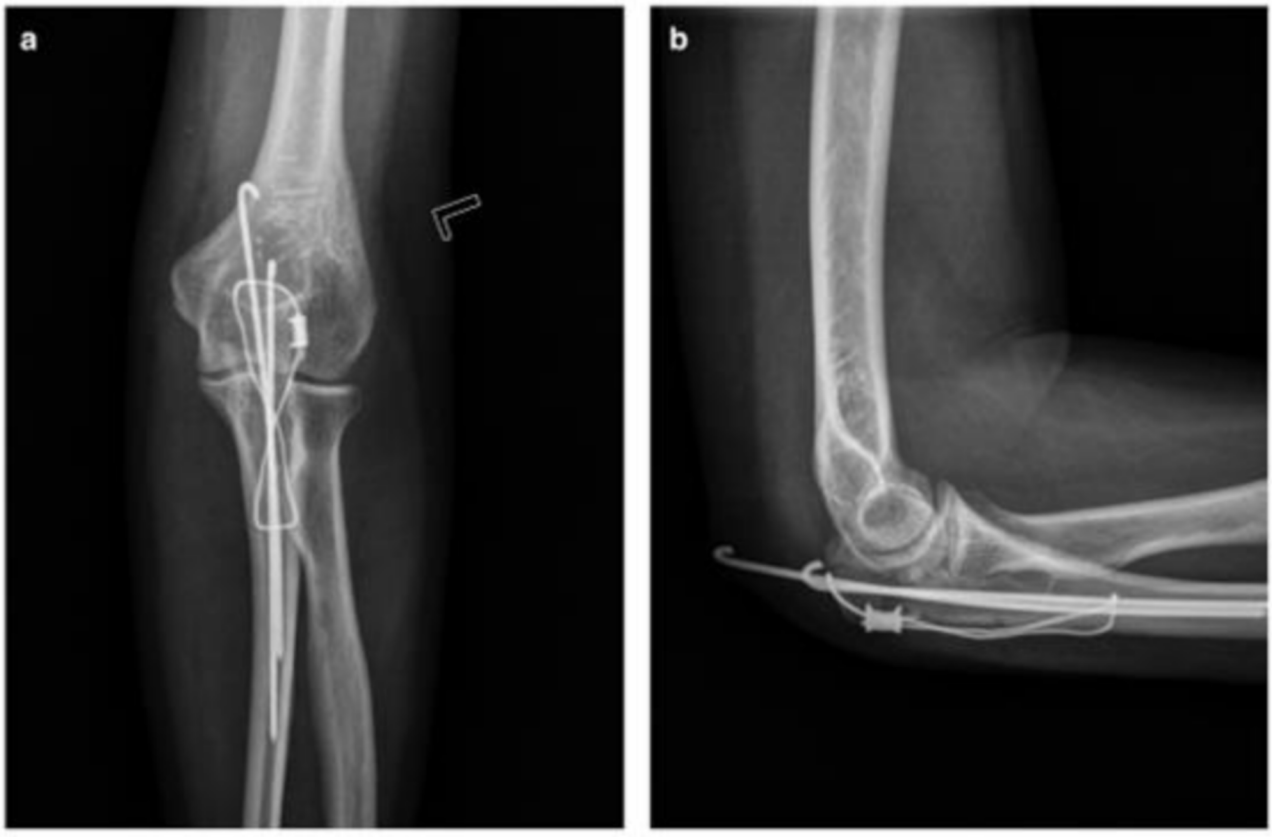

Fig. 4 Radiological records of a patient after tension bang wiring with a Kirschner wire withdrawal (**a**: anteroposterior view, **b**: lateral view)

to penetrate olecranon to prevent rotational and translational movement (Fig. 2).

The 90–90° configuration provides better fracture fragment grip, with screws providing additional stabilization of the reduction. Therefore, HPF can achieve favorable clinical outcomes. In our study, the flexion-extension ROM and pronation-supination ROM were 143.0 ± 15.4 and 172.2 ± 6.9, respectively. The MEPS, and the DASH score were 90.9 ± 13.5 and 7.4 ± 5.0. The hook plate features an integrated design with a proximal notch minimizes implant migration, thereby reducing the need for removal. Consequently, the re-operation rate is significantly lower in the HPF group than the TBW group (44.4% vs. 80.0%, $p < 0.01$) in our study. Furthermore, there has been study examining the stability of olecranon osteotomy in distal humerus fracture, olecranon hook plate exhibits significantly higher stability compared with tension band wiring [23], which could give a hint in its potential benefit.

There are several limitations in our study. Firstly, intramedullary pins were applied in all of our cases and may not represent tension band wiring technique using double cortical pins, which was reported to be able to provide better stiffness [24]. Double cortical pins were also reported to be relative stronger against loading than multifilament cable in TBW [25]. Secondly, selection bias might be existed due the nature as a retrospective cohort study. In term of sample size, though our sample size is comparable to the available research, a larger sample size is still needed. Furthermore, there could be studies to investigate the biomechanical properties of this specific type of hook plate to provide more evidence in its application.

The principal finding of our study indicate that while achieving similar functional outcomes and complication rates compared to the gold standard [26], the use of hook plates provides a lower re-operation rate. This suggests that hook plate fixation may be an ideal alternative in managing olecranon fractures and may bring potential benefit.

Conclusion

Hook plate fixation is a viable alternative to tension band wiring for Mayo Type II olecranon fractures. While both techniques had similar functional outcomes and complication rates, hook plate fixation achieved a significantly lower re-operation rate.

Acknowledgements
None.

Author contributions
J.Z.: Writing - review & editing, Writing-original draft, Visualization, Validaton, Project administration, Methodology, Datacuration, Conceptualization. X.Z.: Writing - review & editing, Writing-original draft, Visualization, Validation, Project administration, Methodology, Data curation, Conceptualization. C.C.: Visualization, Validation, Project administration, Investigation, Formal analysis, Datacuration. K.H.: Visualization, Validation, Project administration, Investigation, Formal analysis, Datacuration. M.G.: Visualization, Validation, Project administration, Investigation, Formal analysis, Datacuration. Y.Z.: Writing - review & editing, Writing-original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. X.J.: Writing - review & editing, Writing-original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Funding
This research was supported by Beijing Natural Science Foundation (L244014), Young Elite Scientist Sponsorship Program by Beijing Association for Science and Technology (No. BYESS2023115), Beijing Municipal Public Welfare Development and Reform Pilot Project for Medical Research Institutes (JYY2023-8).

Data availability
No datasets were generated or analysed during the current study.

Declarations

Conflict of interest
None.

Competing interests
The authors declare no competing interests.

Received: 13 December 2024 / Accepted: 21 January 2025
Published online: 30 January 2025

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