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# Percutaneous pinning with interphalangeal joint locked in phalanx fractures

## The surgical technique and the results

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**Abstract**

**Background:** The purpose of the study was to compare the operation time, the fracture healed time, the postoperative function recovery between the techniques that temporary locking of the interphalangeal joint and traditional manual reduction in the treatment of percutaneous pinning of the phalanx fractures.

**Methods:** Patients with phalanx fractures from January 2015 to January 2018 who were admitted to our hospital were retrospectively reviewed. Patients received surgery with traditional manual or temporary locking of the interphalangeal joint reduction. The information of patients, including age, gender, the length of the operation, the fracture healed time, the postoperative function recovery, complication, and length of postoperative hospital stay, was collected. All of the information were evaluated and compared between the 2 groups. All of the surgery were performed by 2 experienced hand surgeons of our department. The patients in the 2 groups were followed up for an average of 6 months after surgery.

**Results:** All patients completed the operation and were followed up completely. There was no significant difference in baseline data between the 2 groups ($P > .05$). The observation group who received surgery with the interphalangeal joint locked technique had significantly shorter in operative time than the control group ($P < .05$). And postoperative complications in the observation group were significantly less than those in the control group ($P < .05$). However, the postoperative functional recovery in both groups was no significant difference between the 2 groups ($P > .05$). And there were no significant differences in the fracture healed time and length of postoperative hospital stay between the 2 groups ($P > .05$).

**Conclusion:** Both surgical techniques can enable patients to achieve good function, but the technique of interphalangeal joint locked is effective in the treatment of the phalanx fractures, as it is characterized by short operations and a quick recovery. However, this technique is only suitable for extra-articular phalanx fractures that the AO/ASIF classification of type A2.3 and less than 2 weeks, not for other phalanx fractures.

**Abbreviations:** DIP = distal interphalangeal joint, MCP = metacarpophalangeal joint, PIP = proximal interphalangeal joint, TAFS = total active flexion scale.

**Keywords:** fracture, interphalangeal joint of finger, percutaneous pinning, phalanx, surgical technique

## 1. Introduction

With the development of industry and agriculture, the traffic accidents are increasing year by year, resulting in a gradual increase in the incidence of trauma. The hand is the most flexible organ, so trauma occurring in the hand is the most common trauma. Studies by Angermann and others show that injuries of hand and wrist account for 28.6% of all injuries.[1,2] The fractures of phalanges are found to be a common fractures in hand surgery.[3,4] The middle and proximal phalangeal fractures are also a common kind of phalanx fracture, accounting for about 10% of all phalanx fractures.[5] Most of the fractures of the phalanx are fractures that are close to the proximal interphalangeal joint (PIP). Most fractures occur when people are subjected to violent trauma in various sports and works.[4] Phalanx fractures can be successfully treated with closed reduction and splinting.[6] However, not all of the fractures can be successfully reduced, the surgery will be indicated when the fracture cannot be reduced or cannot maintain the position after reduction. The surgery usually involves 2 methods: 1 is closed reduction and percutaneous K-wires fixation, and another is open reduction and internal fixation with plates or K-wires.[7] But the closed reduction and percutaneous K-wires fixation are more recom-

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mended than others,[8–10] because the closed reduction and percutaneous K-wires fixation have less complication that includes infection, joint stiffness, bone non-union, soft tissue damage, etc. And closed reduction and internal fixation can reduce the damage of blood supply, and the fracture healing time is shorter than that of open reduction and internal fixation.[8–10]

The percutaneous K-wires fixation have many methods that are used to treat the phalanx fractures, but the most methods that use K-wires fixation to fix phalanx fractures that are the AO/ASIF classification of type A2.3 just have 2 methods. One is a longitudinal fixation fracture through the distal interphalangeal joint (DIP) or PIP, and another is a cross K-wire fixation fracture that not through the DIP (or PIP). Both methods can be successfully reduced and fixed.[11,12] But the longitudinal pin fixation that is easy to complete may lead to the existence of rotation and stiffness of the DIP (or PIP), because K-wires exist for a long time, the joints are immobilized for a long time, and the joint capsule contracture. Another method of cross K-wire fixation can reduce these complications, but it is difficult to be maintained during operation. And the traditional crossed K-wires fixation requires the operator or assistant to maintain the reduction of the fracture, which may lead to pricking wound on hand during the operation.

We use the technique that interphalangeal joint or metacarpophalangeal joint (MCP) locked technique to maintain fracture reduction during operation, but ultimately used cross K-wires to fix the fracture to reduce the occurrence of postoperative complications. This method can effectively solve intraoperative problems and successfully treat phalanx fractures, but compared with the traditional method of keeping reduction, whether there is any difference in operation time and postoperative recovery. This retrospective study analyzed the clinical efficacy of the interphalangeal joint locked technique in the treatment of percutaneous pinning of the phalanx fractures compared to traditional reduction methods.

## 2. Materials and methods

### 2.1. General information

Patients with middle (or proximal) phalanx fractures (the AO/ASIF classification of type A2.3) admitted to the Affiliated Hospital of Chengde Medical University from January 2015 to January 2018. Twenty-three were males and 19 females, aged 18 to 58 years with a mean age of 31.7 ± 11.4 years. Twenty patients who received surgery with the interphalangeal joint locked technique were included in the observation group, including 10 males and 10 females with a mean age of 33.1 ± 11.1 years. Twenty two patients who received surgery with traditional manual reduction were included in the control group, including 13 males and 9 females with a mean age of 29.9 ± 11.1 years. The study was approved by the Ethics Committee of the Affiliated Hospital of Chengde Medical University.

### 2.2. Inclusion and exclusion criteria

The same inclusion and exclusion criteria were used for each group.

The inclusion criteria included acute fracture that is less than 2 weeks after injury; the AO/ASIF classification of type A2.3; all patients are first treated by closed reduction and plaster (or splinting), but it is failed, surgery is indicated for the patient who cannot maintain after reduction; the type of fracture is an extra-articular acute unstable fracture; it is suitable for adolescences and adults.

The exclusion criteria included: displaced intra-articular fractures; the inability to fully move the PIP and DIP for any reason; more than 1 fracture; open fractures; fractures with osteoporosis; patients with incomplete data and no follow-up.

### 2.3. Surgical methods

Surgery was performed by 2 experienced hand surgeons of our department. In order to get a better judgment, we use the wide-wake technique for anesthesia that is the fluoroscopy and activity of DIP (or PIP) can be judged during the operation.[13]

For the observation group closed reduction of the fracture by traction (Fig. 1 A, B) assess the reduction of fracture with

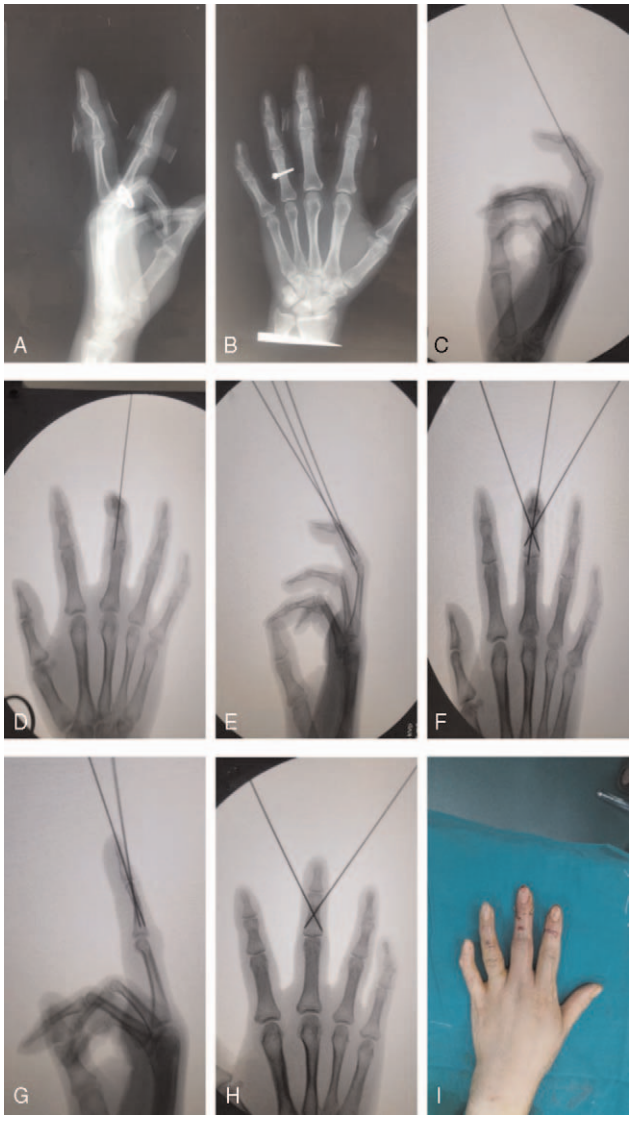


**Figure 1.** A-B: A 36-year-old woman presented with the middle finger fracture. C-D: The K-wire is drilled in a retrograde fashion across DIP, the fracture and PIP in line with the long axis of the bone. E-F: The cross K-wires are inserted into middle phalangeal. G-H: The first K-wire is removed. I: The K-wires tails are cut when all of the steps are finished. DIP = distal interphalangeal joint, PIP = proximal interphalangeal joint.

fluoroscopy, correcting angle, and rotation displacement. Maintained by holding the PIP joint in flexion, a 1.0-mm (or 1.2-mm for the proximal phalanx) K-wire is percutaneous inserted into from the dorsal side of the base of the distal phalanx, and be drilled through DIP, the fracture (or not), and PIP, or PIP, the fracture (or not), and MCP in line with the long axis of the bone, and stopped when the PIP or MCP is locked (Fig. 1 C, D). C-arm fluoroscopy confirmed that the reduction of fracture is satisfactory. Crossed fixation by two 1.0-mm (or 1.2-mm for the proximal phalanx) K-wires that is percutaneous inserted into from both sides of the neck of the middle (or proximal) phalanx and the cross K-wires to avoid fixing the joints (Fig. 1 E, F). C-arm fluoroscopy confirms that the fracture reduction is satisfactory, the cross K-wires' position is satisfactory, the fixation is reliable to maintain the stability of the fracture when the first K-wire is removed (Fig. 1 G, H), the cross K-wires' tails are cutoff, and the appropriate length is retained on the skin surface without bending the pins' tails (Fig. 1 I).

For the control group, maintained by hand or forceps when crossed fixation by two 1.0-mm (or 1.2-mm) K-wires that is percutaneous inserted into from both sides of the neck of the middle (or proximal) phalanx, and the cross K-wires avoid fixing the joints. C-arm fluoroscopy confirm that the fracture reduction is satisfactory, the cross K-wires' position is satisfactory, the fixation is reliable to maintain the stability of the fracture. The cross K-wires' tails are cutoff, and the appropriate length is retained on the skin surface without bending the pins' tails.

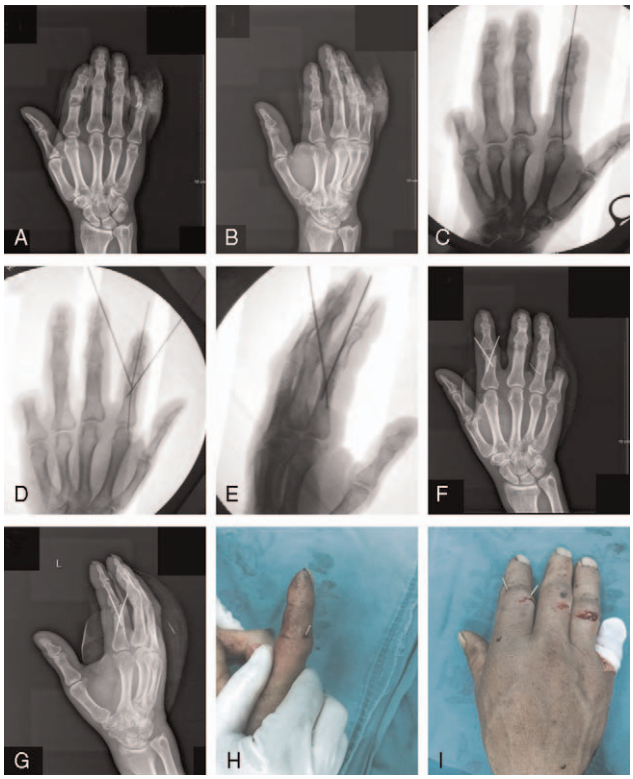


**Figure 2.** A-B: A 48-year-old man with proximal fracture of index finger and ruined injury of middle and distal segment of little finger. C-D: The index fingers' fracture was locked the PIP and MCP. E-I: Make the reduction of fracture was stability by one 1.2-mm K-wire. MCP = metacarpophalangeal joint, PIP = proximal interphalangeal joint.

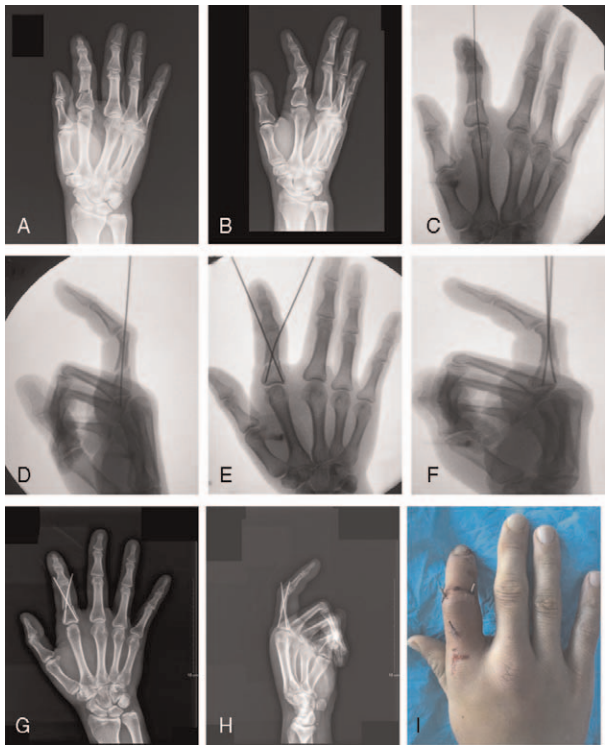


**Figure 3.** A-B: A 40-year-old man with proximal fracture of index finger. C-D: The index fingers' fracture was locked the PIP and MCP. E-I: Make the reduction of fracture was stability by 1 1.2-mm K-wire. MCP = metacarpophalangeal joint, PIP = proximal interphalangeal joint.

A 36-year-old woman presented with the middle finger fracture that was AO/ASIF classification A2.3, the fracture was closed and caused by crush injury (see Fig. 1). A 48-year-old man with proximal fracture of index finger and ruined injury of middle and distal segment of little finger, and skin abrasions on part of the index finger, the injury was caused by machine (see Fig. 2 A, B). The little finger was performed stump revision, the index fingers' fracture was locked the PIP and MCP (Fig. 2 C, D), to make the reduction of fracture was stability by 1 1.2-mm K-wire (Fig. 2 E–I). A 40-year-old man with proximal fracture of index finger (see Fig. 3), the injury was caused by crush injury.

### *2.4. Outcome measures*

The primary outcome measures included the length of the operation, the fracture healed time, the postoperative function recovery, the complication, and the length of stay. The length of the operation was calculated as the time from when the reduction was made to the K-wires' tails were cutoff. The fracture healing time is defined as the time from the completion of the operation to the imaging X-ray film showing that the fracture line is invisible and there is continuous callus passing through the fracture line, the radiological confirmation of fracture healing time was made by the radiologist or by the surgeon. The postoperative function recovery was evaluated by the regained total active flexion scale (TAFS) after the fracture healed. The pin tract infection, complex regional pain syndrome, osteomyelitis, delayed union, malunion and nonunion were documented as complications.

### 2.5. Total active flexion scale

The TAFS was used to evaluate postoperative recovery of hand function in an adult population. Total active motion is the sum of the angles formed by the maximum flexion of the MCP, PIP and DIP joints. If the total active motion was >220°, 180 to 220°, <180°, the outcome was considered excellent, good, poor.

### 2.6. Follow-up

According to the reduction during operation, the joints may be immediately and slightly mobilized, and to be splinted when go sleeping. Patients should follow up 1 week postoperatively to check wound for preventing infection and assessed maintenance of reduction by a radiograph. Four to 6 weeks postoperatively should be to give an X-ray examination of fractures, the K-wires are removed when the fracture is healed. If pin-site infection occurs, the K-wires are removed as soon as possible and changed to splinting until the fracture is healed radio graphically (Fig. 4).

When the K-wires are removed, the therapist should be contacted to instruct the patient's hand rehabilitation practices as soon as possible. According to everyone's situation is different, the appropriate exercise method according to the fracture situation should be chosen by the therapist.[14] The main purpose is to exercise the joints of the hand, reduce the contracture of the collateral ligament, and increase the range of motion of the joints.

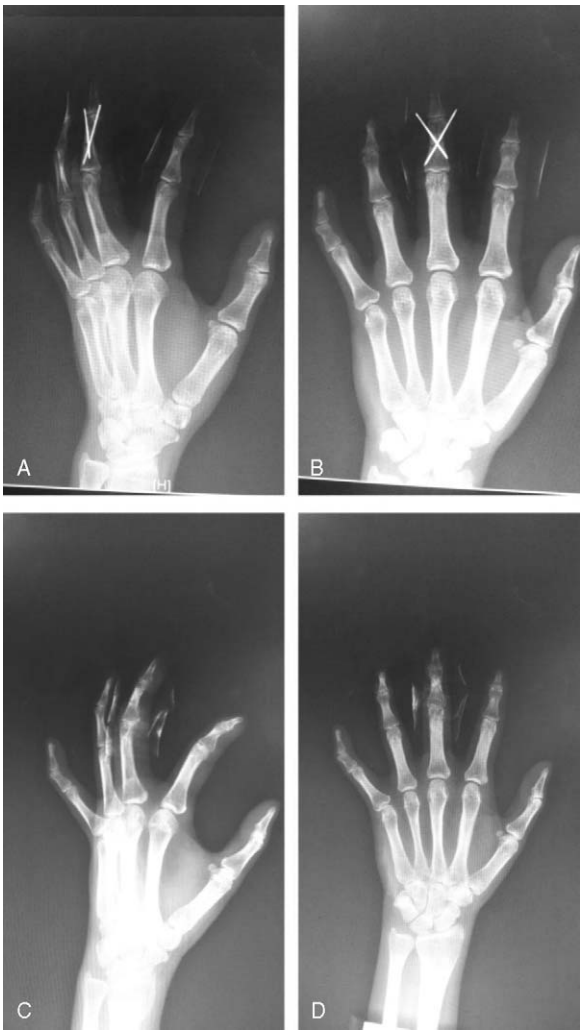


**Figure 4.** A-B: The fracture is healed. C-D: The K-wires were removed.

**Table 1**

**Comparison of the general data between the 2 groups.**

| | The observation group (n = 20) | The control group (n = 22) | $\chi$2/F | *P* |
|---|---|---|---|---|
| Sex (male/female) | 10:10 | 13:9 | 0.349 | .554 |
| Age (years) | 33.55 ± 11.11 | 29.86 ± 11.68 | 0.004 | .950 |
| TAFS* (excellent/good/poor) | 16:4:0 | 16:5:1 | 1.018 | .601 |
| Complication | 19:1 | 14:8 | 4.400 | .036 |

TAFS = total active flexion scale.

* If the total active motion was >220°, 180 to 220°, and <180°, the outcome was considered excellent, good, and poor, respectively.

### 2.7. Statistical analysis

All statistical data were processed using the SPSS v 18.0 software package (IBM Corp., Armonk, NY). The continuous variables were expressed as the means ± standard deviations ('$\chi$ ± SD). The comparison of the intraoperative data and the healing time between groups were based on independent *t* tests, the comparison of the general data between the 2 groups were based on chi-square test. $P < .05$ was considered statistically significant.

## 3. Results

In the observation group, the average age was 33.55 ± 11.11 years (10 [50%] men and 10 [50%] women), and in the control group, the average age was 29.86 ± 11.68 years (13 [59%] men and 9 [41%] women). No statistical differences of the 2 groups were identified with baseline characteristics (Table 1). The TAFS scored excellent 16 patients, good 4 patients in the observation group; in the control group, excellent 16 patients, good 5 patients, and poor 1 patient. The TAFS score in the observation group was no significant differences with in the control group ($P > .05$). The complication in the observation group was significantly lower than they were in the control group ($P < .05$). In the observation group, 1 patient had postoperative infection after 4 weeks, and had to remove the K-wires, but the result of patient was good. In the control group, postoperative infection occurred in 2 cases and had to be treated with splinting instead of K-wires, which was improved after treatment and without osteomyelitis, delayed union occurred in 3 cases, 1 patient removed the K-wires at 8 weeks after operation, 2 patient removed the K-wires at 12 weeks after operation, malunion occurred in 2 cases, but did not affect the patient's life, and no further surgical treatment was performed. One case developed local numbness and gradually improved after the removal of K-wires (Table 1).

The difference was statistically significant in the average operative time ($P < .05$), in the observation group was 21.10 ± 2.77 minutes, and 32.82 ± 5.50 minutes in the control group; the average healing time was 4.75 ± 0.77 weeks in the observation group and 4.86 ± 0.77 weeks in the control group; there were no significant differences between the 2 groups in terms of healing time. There was no statistical significance found between the 2 groups in respect to length of postoperative hospital stay (Table 2).

**Table 2**

**Comparison of the intraoperative data and the healing time.**

| | The observation group (n = 20) | The control group (n = 22) | T | P |
|---|---|---|---|---|
| Operative time (minutes) | 21.10 ± 2.77 | 32.82 ± 5.50 | 8.583 | .00 |
| Healing time (weeks) | 4.75 ± 0.77 | 4.86 ± 0.77 | 0.471 | .640 |
| Length of stay (days) | 5.40 ± 0.50 | 5.41 ± 0.734 | 0.046 | .963 |

## 4. Discussion

This study presents a method to help the surgeon reduce and fix middle (or proximal) phalanx fractures (AO/ASIF classification A2.3) during surgery. This process of the fixation of percutaneous cross K-wires and maintain a stable anatomical reduction can be completed easily with the method. This reduction method can reduce the operation time, difficulty of process of the operation, and postoperative complications.

The optimal treatment for phalanx fractures remains controversial. For minimally displaced fractures, conservative methods produced satisfactory outcomes, the phalanx fractures have been treated conservatively with strapping and splinting. But the results of these techniques are not satisfactory, and the incidence of stiffness and deformity is high,[15–17] so more and more surgeon favor operative methods not only in severely displaced or comminuted fracture, but also in minimally displaced fractures that can stain by conservative methods.

In the surgical treatment of closed phalangeal fracture (AO/ASIF classification A2.3), the traditional open reduction plate fixation is easier to achieve anatomical fracture reduction. However, excessive peeling of soft tissue can lead to tendon adhesion and disrupt the blood supply of fractures, which is the main cause of iatrogenic dysfunction and bone non-union.[12,18] Therefore, closed reduction and fixation is needed under the principle of minimally invasive treatment. Closed reduction and percutaneous K-wire fixation was performed in our study.

To the best of our knowledge, in the process of percutaneous pinning, maintaining the stability of fracture reduction is an important and difficult step in closed reduction, especially when the position of the inserted crossed K-wires is not in a satisfactory position in the C-arm fluorescence.[19] In traditional methods, almost of surgeons are used to maintaining a stable anatomical reduction with point reduction forceps or Alice forceps, and also a large number of surgeons who like to use hand to maintain the fracture reduction, which would add to the risk of pricking wound and operation time. In addition, this method often fails during the insertion of the K-wires, resulting in multiple repositioning, causing damage to the blood flow and joint surface, resulting in delayed union and non-union of fractures, and joint stiffness; in some cases, after repeatedly failing to reduce the fractures, it even has to be replaced by incision and internal fixation.[12,18,20] In our study, locking of the interphalangeal joint can not only directly stabilize the reduction, but also take advantage of the role of joint capsule in maintaining anatomical reduction that may save operation time and minimizing iatrogenic injury. The traditional manual reduction, sometimes, requires an assistant to help, which not only increases labor costs, but also increases the risk of needle stick injuries that pose significant health hazards.[20] In our study, only 1 stable and accurate reduction is needed, and without assistant's help, thereby reducing the risk of needle stick injures, therefore, this method has an advantage in reducing the time of operation, have a shorter time (average 21.10 ± 2.77 minutes) than in the control group (average 32.82 ± 5.50 minutes). Although no pricking wound occurred with either approach, probably because of the operator's experience or the small number of cases, but the choice of an inappropriate fracture reduction method still increases the risk of this occurrence.

It is well known that fracture healing time is mainly related to blood supply at the fracture end, firmness of fixation, and stress stimulation. In addition, the factors such as age, sex, site of injury also have relationship with fracture healing; In some studies it found that the level of platelet content and irisin hormone (in lower extremity fractures) in blood is also a factor in fracture healing.[21,22] But our study was retrospective, and the data of the level of platelet content and irisin hormone in blood were not collected, so the results may be partially biased and need to be included in future studies to obtain more accurate results. However, other factors, except for blood supply factors, were not statistically different between the 2 groups in this study. In this study, both fixations were made with K-wires and cross fixations, so the injuries of blood supply with multiple fixations was the main factor affecting fracture healing in our study. In the results we also see that in the measurement of fracture healing time, there was no significant difference between the observation group and the control group. This is mainly because the 2 groups did not perform violent operations during fracture reduction and fixation, reducing soft tissue dissection and blood damage.[23,24] However, the fracture healing time in the control group was slightly longer (4.86 ± 0.77 weeks) than the observation group (4.75 ± 0.77 weeks), but there was no significant difference between the 2 groups of statistics. This may be that the control group required multiple repeated fracture reductions to cause more damage of the blood supply in the phalanx than the observation group. So, there were 3 cases occurred by delayed union in the control group, and healed by remove the K-wires.

In the function of the hand as Sterling Bunnell said, any hand surgery can result in stiffness in the joints of the hand. And as it is well known that hand function is primarily related to these 3 tissues (bone, soft tissue, and scar) when treating hand fractures; people always worry the K-wires may damage the articular surface when locking the interphalangeal joint temporarily, but no such side effects were found during postoperative follow-up.[14] And in our study, the process was consistent with the principle that mentioned by Gu, which is the surgeon try their best to achieve anatomical reduction under light and firm fixation, allowing patients to move and exercise early, which can effectively reduce dysfunction.[25] Joint dysfunction is mainly caused by contracture of articular capsule and severe destruction of articular surface. But the observation group removed the first K-wire at the end of the operation, and the both groups ensured that the crossed K-wires did not exist in the joint capsule by the X-ray perspective, so as to effectively reduce the occurrence of dysfunction. Literature studies have shown that the destruction of the articular surface by a single K-wire will not cause joint stiffness.[26] But in the control group, there was 1 case with poor function, which was caused by the repeated fracture reduction and the internal fixation, long fracture healing time, and late rehabilitation intervention time. In the control group,the 2 cases of the K-wires' fixation failed due to repeated fracture reduction and the internal fixation, and were changed to splint or cast fixation, resulting in malunion, but the 2 cases no further surgical treatment was performed due to the low demand of the patients

and did not affect the patient's most of normal life, and one of them finally had good function that was obtained with proper functional training. So, most patients have good function and there was no significant difference in functional score between 2 groups ($P > .05$); but as to the complication, they have a significant difference ($P < .05$).

This study is a retrospective study, and the data collection in the observation group is relatively comprehensive, but the number of cases is small. However, it is difficult to collect data in the control group because some cases are lost or lost during follow-up, and were not selected for this study, but there are many cases in clinical practice. Based on the above reasons, there is some bias in this retrospective study. The more cases should be collected in the future study, and prospective study should be conducted to reduce the occurrence of bizarreness. In addition, in this study, there were no data that whether the patient was engaged in the original work and the time required to resume normal work was collected; the data should be analyzed in future.

## 5. Conclusion

In conclusion, locking of the interphalangeal joint temporarily has a significant effect on the treatment of middle phalanx fractures, the AO/ASIF classification of type A2.3, because of its a short operation time and its quick postoperative recovery; the operation can do by single, suggesting that this technique is worth considering as a novel surgical option for patients with phalanx fractures. However, this technique is not suitable for all of phalanx fractures, it can be used for the phalanx fractures that the injury time less than 2 weeks.

## Author contributions

Shibo Liu, Shijie Fu wrote the manuscript and Shibo Liu, Bo Sun, Pei Wang, Shijie Fu conducted the experiments, collected the data, collected and analyzed the data, Shibo Liu, Shijie Fu designed the study and all authors approved the submission.
**Conceptualization:** Shijie Fu.
**Data curation:** Shibo Liu, Bo Sun, Pei Wang.
**Formal analysis:** Shibo Liu, Bo Sun, Pei Wang.
**Writing – original draft:** Shijie Fu.
**Writing – review & editing:** Shijie Fu.

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