The THAI Journal of SURGERY 2009; 30:5-10.
*Official Publication of the Royal College of Surgeons of Thailand*

# *Comparison of Miniplate and K-wire in Treatment of Metacarpal and Phalangeal Fractures*

**Somboon Wutphiriya-angkul, MD**
*Sawangdandin Crown Prince Hospital, Sakon Nakhon, Thailand*

*Abstract*

***Background:*** **The most effective method for fixation of metacarpal and phalangeal fractures has not been established. Two commonly used surgical techniques are K-wire and miniplate fixations. We performed a prospective randomized trial to compare these two treatment strategies.**

***Materials and Methods:*** **A total of 112 patients with 122 metacarpal and phalangeal fractures were recruited into this study. The patients were randomized to receive fracture fixation with one of the two methods. The operative time, pain scale, success of union, time of union, total active range of motion (ROM), total active motion (TAM) and complications were assessed.**

***Results:*** **Sixty-three fractures were treated with K-wire fixation and the rest were treated with miniplate fixation. The K-wire group was associated with significantly shorter operative time ($P<0.01$). There were no differences in postoperative pain, rate of union, healing time of the successful case, total active ROM, TAM and complications.**

***Conclusion:*** **The K-wire technique has similar effective results compared to the miniplate technique in the treatment of metacarpal and phalangeal fracture with a shorter operative time.**

## INTRODUCTION

Fractures of the metacarpals and phalanges are among the most common fractures of the upper extremity[1,2]. For fractures with marked displacement or associated soft tissue damage, early mobilization particularly after open reduction and internal fixation is a desired goal to maximize eventual function. Immediate mobilization can reduce edema, adherence of normal free-gliding structures and joint stiffness.

Although the desired goal of early motion is universal, a preferred technique for stabilizing fracture requiring open treatment remains controversial. The ideal method of wound fixation consists of the simplest technique with minimal amount of materials that meets the following requirements: (1) primary bony union, (2) proper length, rotation, and alignment, and (3) return of the hand to active use without fear of displacement. Internal fixation can be accomplished by application of either K-wire or miniplate. K-wire has traditionally held the advantage over miniplate in terms of technical ease, minimal dissection and available and versatile of materials. However, with the new designs of miniplate available specifically for use in hand surgery, equally low-profile fixation can be achieved with greater rigidity[3] and maintain length. There has been no study comparing miniplate and K-

***Correspondence address :*** *Somboon Wutphiriya-angkul, MD, Sawangdandin Crown Prince Hospital, Sakon Nakhon 47110, Thailand; E-mail: joesomboon@hotmail.com*

wire in treatment of metacarpal and phalangeal fracture. The author presented a comparison between these two methods in the treatment of metacarpal and phalangeal fracture.

## Materials and Methods

We conducted a randomized, controlled trial to compare K-wire and miniplate in the management of fractures involving metacarpals and phalanges. All displaced fractures of the metacarpals and phalanges seen at the Emergency Department of the Sawang-dandin Crown Prince Hospital between July 2006 and December 2008 were included in the study unless they met any of the exclusion criteria. Patients with fracture of metacarpals and phalanges were prospectively randomized into two treatment groups either K-wire or miniplate. The inclusion criteria were fractures with the following features: irreducible, malrotation, intra-articular or subcapital open fracture, segmental bone loss, multiple trauma with hand fractures, multiple hand and wrist fractures, and soft tissue injury requiring reconstruction. The exclusion criteria were fractures with bone loss, osteoporosis, or comminution to the extent that accurate reconstruction with firm cortical apposition was impossible. All patients in this study gave informed consent. Patients were randomly assigned to either K-wire or miniplate by a sealed envelope.

### *Operative Technique*

All procedures were performed under digital nerve block with conscious sedation so that the patients could actively flex the digits to assess rotational alignment after reduction. A straight dorsal skin incision was the method for exposure of fractures. The extensor mechanism was either split in the midline, entered between the lateral band and central slip, through the rent created by the fracture, or on either side of the lateral bands. The periosteum was longitudinally incised and elevated to expose the fracture site. The fracture site was exposed only enough to place the proposed fixation, cleanse, and approximate gently with bone-holding clamps. The pin was drilled in a retrograde fashion from the fracture end out of the dorsal radial aspect of metacarpal head and then back down the shaft through the reduced fracture. After pin insertion, rotational alignment was checked by asking the patient to actively flex and extend the digit. If mal-alignment persisted, the pin was removed and re-inserted with another pin. Transarticular pins were generally bent outside the skin. Postoperatively, a bulky dressing was applied for 3 to 5 days, and was followed by an aggressive program of active mobilization and left in place for 4 weeks. Heavy lifting and gripping were not allowed for 6 weeks.

Metacarpal fractures were exposed through a direct incision made on the radial border of the first and second metacarpals and the ulnar border of the fifth metacarpal. The third and fourth metacarpals were exposed by a longitudinal incision between these two bones. Phalangeal fractures were exposed through a mid-lateral incision. When necessary, the lateral band was incised and folded upward (dorsal) to provide optimal exposure at the base of the proximal phalanx. The periosteum of the phalanx was incised and elevated to expose the fracture, thus avoiding violation of the gliding space between the extensor tendon apparatus and the periosteum. The fracture was anatomically reduced by means of small bone clamps to maintain the reduction. The surgeon was usually limited to only one attempt at placing the drill hole in the correct position. It is a sound principle that fixation with screws is adequate if the length of the fracture exceeds twice the diameter of the bone. An oblique fracture line of less than twice the diameter of the bone should be backed up with a plate. Once the fixation was secured, the periosteal layer was returned to its original position and sutured if possible. The wound was closed, and a soft dressing was applied. In the first morning after operation, or indeed in some cases in the recovery room, active range of motion (ROM) exercises were begun under supervision. The mean length of follow-up was 8 weeks.

The patients were evaluated on a weekly basis after surgery. The X-ray films were taken to ensure that there was no loss of reduction and to evaluate bone healing. The active ROMs of all joints of each finger in the involved hand were measured. The patients were discharged when there was no further increase in ROM and their fractures had healed. Assessment was based on the criteria of the American Society for Surgery of the Hand[4].

The data recorded for all patient included surgical time, pain visual analogue scale (0, none to 10, severe)

on the first post-operative day, success of union, time to achieve radiographic union and complications. A p-value of less than 0.5 was considered statistically significant. Active ROM was determined for each joint and total active motion (TAM) was determined for each digit. Previously established values for normal AROM were used in the evaluation of the fractured digits: 0-85° at the metacarpophalangeal (MP) joint, 0-110° at the proximal interphalangeal (PIP) joint, 0-65° at the distal interphalangeal (DIP) joint, and 260° TAM. The results for metacarpal and phalangeal fractures of the fingers were evaluated separately. The thumb constituted a separate category.

**Table 1** Demographic characteristics of the K-wire and miniplate groups

| Characteristic | K-wire | Miniplate | P-value |
|---|---|---|---|
| Mean age (yr) | 26.8 | 28.2 | 0.67 |
| Male:Female | 45:13 | 44:10 | 0.61 |
| Mean time injury (hr) | 4 (1-51) | 5 (1-48) | 0.57 |
| Open fracture (%) | 17 (27) | 14 (23) | 0.68 |
| Intraarticular (%) | 17 (27) | 18 (30) | 0.66 |

**Table 2** Fracture category

| Fracture category | K-wire | Miniplate |
|---|---|---|
| Metacarpal | 35 | 27 |
| Phalanx | 25 | 25 |
| Thumb | 3 | 7 |

## Results

From July 2006 to December 2008, demographic data of the two groups were shown in Table 1.

Both groups showed no statistical difference in term of age (p = 0.67), gender (p = 0.61), the time from injury to operation (p = 0.57) , open fracture (p = 0.68), intra-articular (p = 0.66) (Table 1).

The K-wire group contained larger proportion of patients with metacarpal fractures but miniplate group contained larger proportion of patients with thumb fractures (Table 2). However, this difference did not reach significance (P = 0.29).

The mean total surgical time was 37 minutes (range, 25-60 minutes) for the K-wire group and 51 minutes (range, 35-70 minutes) for the miniplate group; this difference was significant (P <0.01). The pain scales on the first post operative day were 4 for the K-wire group and 5 for the miniplate group, which were not statistically significant (P = 0.12). The K-wire group achieved union in 58 out of 63 (92%) patients and the miniplate group achieved union in 56 out of 59 (95%) patients, which were not statistically significant (P = 0.52). The average time to radiographic union was 12 weeks (range, 8-20 weeks) in the K-wire group and 12 weeks (range, 8-20 weeks) in the miniplate group, which were not statistically significant (P = 0.78) (Table 3).

Total active ROM in miniplate group was more than K-wire group in all fracture categories, but this difference did not reach significance (Table 4).

**Table 3** Comparison of outcome in both groups

| Outcome | K-wire | Miniplate | P-value |
|---|---|---|---|
| Surgical time (min) | 37 (range, 25-60) | 51 (range, 35-70) | <0.01 |
| Pain scale | 4 (range, 1-10) | 5 (range, 2-10) | 0.12 |
| Success of union (%) | 58 (92) | 56 (95) | 0.52 |
| Time of union (wk) | 12 (range, 8-20) | 12 (range, 8-20) | 0.78 |

**Table 4** Results of ROM

| Fracture category | Average ROM (degree) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | MP | | | PIP | | | DIP | | |
| | K-wire | miniplate | P-value | K-wire | miniplate | P-value | K-wire | miniplate | P-value |
| Normal | | 85 | | | 110 | | | 65 | |
| Metacarpal | 76 | 78 | 0.58 | 101 | 104 | 0.57 | 62 | 64 | 0.65 |
| Phalanx | 79 | 81 | 0.61 | 97 | 98 | 0.78 | 61 | 63 | 0.62 |
| Thumb | 77 | 78 | 0.72 | 95 | 97 | 0.63 | | | |

**Table 5** Results of TAM

| Fracture category | K-wire | Miniplate | P-value |
|---|---|---|---|
| Normal | | 260° (100%) | |
| Metacarpal | 246 | 253 | 0.72 |
| Phalanx | 215 | 243 | 0.56 |
| Thumb | 209 | 237 | 0.43 |

**Table 6** Complications of both groups

| Complications | K-wire | Miniplate |
|---|---|---|
| Infection | 4 | 3 |
| Implant loosening | 2 | 0 |
| Loss of reduction | 1 | 1 |
| Stiffness | 3 | 2 |
| Mal-union | 2 | 1 |
| **Total** | **12** | **7** |

Total active motion (TAM) in miniplate group was more than K-wire group in all fracture categories, but this difference did not reach significance (Table 5).

***Metacarpal Fractures***

The case of open fracture (n = 15) also included all of the cases with tendon involvement. There was no observed difference between these more extensive injuries (TAM = 250°) and the cases of closed fractures (n = 47, TAM = 248°). A comparison of cases without articular involvement of the MP joint (both closed and open, n = 46) with those with articular involvement (n = 16) demonstrated a significant difference ($P < 0.05$). Two cases of closed, non-articular metacarpal fractures (one patient) were immobilized in a cast, including the digits, for almost 4 weeks before active range of motion was begun. TAM values for these two digits were 245° and 240° respectively. In the other closed, non-articular metacarpal fractures (n = 37) all obtained a normal TAM of 260°. One patient failed to return to full activity. Loss of MP joint motion after a closed comminuted intra-articular fracture precluded his continued enrollment in a police academy. Other patients had no pain or functional limitation.

***Phalanx Fractures***

The closed fractures (n = 38) had a TAM of 232° and the open fractures (n = 12) had a TAM of 221° with no statistical difference between them. The presence of intra-articular involvement (n = 13, TAM 218°) did not result in an observed difference from the extra-articular fractures. There was also no effect from fracture configuration, patient age, or time from injury to operation on the final result. The presence of nerve, vessel, or tendon injury (n = 12, TAM 192°) was the only factor that demonstrated a negative influence on the motion obtained ($P < 0.05$). All patients with phalangeal fractures returned to their pre-injury employment and had no specific complaints regarding functional loss. One case of an intra-articular fracture at the PIP joint had persistent pain, which later required arthrodesis.

***Thumb***

There were ten fractures of the thumbs, four involving the metacarpals and six the proximal phalanges. All patients achieved a full range of motion compared with the opposite thumbs, and they had no pain or functional limitations.

Complications were recorded for each group (Table 6). Twelve of 63 patients with K-wire fixation had complications, whereas 7 of 59 patients with miniplate fixation had complications; this difference was not significant ($P = 0.27$). Complications were all believed to be the result of noncompliance with the postoperative protocol on the part of the physical or the patients. In K-wire group two metacarpal fractures were immobilized in a cast, including the digits, for almost 4 weeks in spite of stable internal fixation. An open proximal phalanx fracture was internally fixed along with repair of both flexor tendons and one neurovascular bundle. A controlled motion program was begun soon after operation. The patients failed to return for 1 month and did not attempt to extend his finger. A 70° flexion contracture developed at the PIP joint and he declined further treatment. In miniplate group, one proximal phalanx fracture had marked stiffness of the MP and PIP joints. In that case, a short oblique fracture was stabilized with only one screw, and the reduction was lost during the first week. This was considered a technical error by the surgeon; a backup plate should have been used. One metacarpal fracture resulted in significant stiffness at MP joint; that patient was advised to have extensor tendon lysis and possible capsulectomy, but he declined the operation.

## Discussion

The patients in K-wire and miniplate groups were similar in terms of age, gender, mean time of injury and fracture type, indicating that the randomization had been effective. The weaknesses and limitations in this study were recognized. There was an unequal distribution of patients in the 2 groups, with 63 patients in the K-wire group and 59 in the miniplate group. This was because a block randomization process was not used . It was also not possible to blind the patient or surgeon to the type of fixation.

The reports of clinical experience indicate that treatment of unstable fractures all too frequently has a less than satisfying result. As previously noted, James[5] reported that with closed treatment of unstable phalangeal fractures, 77% of fingers lost function and results were considered unsatisfactory, primarily because of loss of active ROM at the PIP joint. With open treatment with K-wire, 8% regained full function. Green and Anderson[6] reported satisfactory results of 69% with closed reduction and percutaneous pin fixation of fractures of the proximal phalanges. They recommended that technique be used only for long oblique fractures of the proximal phalanx and that comminution was a contraindication for this percutaneous pinning technique. Duncan and Kettlecamp[7] analyzed 32 low-velocity bullet wounds to the hand associated with fractures. Treatment consisted of cleansing, minimal debridement, splinting of fractures, and antibiotics. Healing occurred without infection, but the unstable fractures resulted in uniformly poor ROM of associated joints. Barton[8] reported satisfactory results of 57% in a group of 39 comminuted and 109 non-comminuted fractures. Huffaker et al[9] studied the factors influencing final ROM in 150 finger fractures. This thorough article reported satisfactory results of 67% regardless of the method of treatment. Twenty percent had decreased ROM in unfractured fingers in the same hand. The median TAM was 220˚ without joint involvement and 174˚ with joint involvement. Crush injuries involving the flexor and/or extensor tendons or skin significantly affected the end result. Strickland et al[10] stated that more than 2 weeks' immobilization substantially decreased TAM. Twenty-five percent of their mid-shaft phalangeal fractures treated by open reduction and internal fixation with K-wire fixation produced an average TAM of 142˚. In an internal review, Lister[11] showed that K-wire fixation with immobilization for 3 weeks produced a TAM of 157˚. He recommended K-wire for phalangeal fractures, which in his group achieved a TAM of 199˚. Contrary to the above experience, however, Belsky et al[12], who used an alternate technique of closed reduction, intramedullary fixation, and 3 weeks of immobilization, reported 69% excellent, 29% good, and 10% poor results.

The miniplate biomechanically is one of the most effective tools available to the surgeon. It can even resist to failure load of intact bone[13-15]. K-wire is less rigid than miniplate, which tends to slide through bone and loosen[16]. More important is the implant's fatigue failure properties in response to cyclic stress. The most important consideration is that the surgeon should choose the method of internal fixation with which he feels most comfortable. In a series of 33 patients internally fixed using K-wire by surgeons who were very skilled and familiar with this technique, TAM was 256˚ with no complications[17]. Similarly a series of 27 patients treated with miniplate had a TAM of 252˚[18]. Biomechanical studies by Fyfe and Mason[19], and Massengill et al[20], showed that Kirschner wire fixation methods produced weaker fixation than miniplate. Miniplate provided equivalent solid stabilization that would allow early ROM.

Because the K-wire technique was best suited for a transverse fracture, we decided to study the clinical applicability of miniplate for a more diverse group of fractures. The initial concern was that the anatomical dissection would involve too much tissue and that gliding layers would be adversely affected. Studies in the anatomic laboratory showed that a direct approach to the metacarpals was feasible and that a midlateral approach, as previously shown, would allow access to the phalangeal bones. Lifting the lateral bands and incising the periosteum graciously expose the fracture. In some cases, the oblique fibers of the wing must be incised to provide access to the base of the proximal phalanx. The final ROM of the associated joints of at least 90% of normal indicates that the gliding tissues were not adversely affected by the surgical dissection.

The next question to be considered was whether these screws and plates were too bulky and would interfere with balance and function of joints and tendons. Application of the plates on the dorsal aspect of the metacarpals did not affect excursion of the tendons, and tendon erosion did not occur. Many

patients have not put the time aside to have the hardware removed, and there have been no adverse sequelae. The phalanges have highly complex surfaces, and the anatomic studies indicated that plates could best be applied on the dorsolateral aspect of these bones. For an intimate fit, the plates must be contoured before fixation with the screws. There were no tendon problems. Miniplates provide sufficient stabilization so that motion can be started immediately. The hand is usually bandaged with a soft dressing, and active ROM activities are started the next day under supervision. With this type of fixation, we have been able to mobilize the joint without loss of fracture position while the bone is healing. We conclude that this technique is applicable for selected unstable metacarpal and phalangeal fractures. The demand of this type of surgery is meticulous and precise drilling of holes, and fitting of plates is a prerequisite part of this method.

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