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COMPARATIVE STUDY OF PERCUTANEOUS KIRSCHNER WIRES AND OPEN REDUCTION WITH INTERNAL FIXATION IN MANAGEMENT OF UNSTABLE METACARPAL SHAFT FRACTURE

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ABSTRACT

Purpose: The aim of this study is to assess the clinical and radiographic outcome of unstable metacarpal shaft fractures treated with intramedullary nail (IMN) kirschner wires with the results of such fractures treated with open reduction and internal fixation with plate-screw (PS). **Methods:** Between **2014** and **2015**, we treated **33,** displaced, extra-articular metacarpal fractures operatively using **1** of **2** fixation methods: **IMN** or **PS.** Patient characteristics, mechanism of injury, pattern of fracture, and preoperative radiographic parameters were similar in both groups. The outcome data were collected and analyzed: total active motion of the digit (TAM), Disabilities of the Hand (DASH) scores and radiographic parameters. **Results: 22/33** patients received IMN fixation and **11** patients received PS fixation. Mean follow-up time was 6 months in the IMN group and 5 months in the PS group. The mean and median total active motion were 237° and 250° for the IMN group, 228° and 248° for the PS group, with no statistically significant difference between the groups. The mean Disabilities of the hand score was 9.47 in the IMN group and 8.07 in the PS group. The association between hardware type and fracture location (middle or distal third of metacarpal) was not statistically significant. Time to radiographic healing also did not reach statistical significance between groups. Operative time was significantly shorter with use of the K wires. Five patients in the IMN group are displayed with loss of reduction; no failure was observed in the PS group. **Conclusions:** There were no significant differences in the clinical outcomes using either technique. Although operative time was shorter in the IMN group than in the PS group, the incidences of loss of reduction, penetration to the metacarpal- phalangel joint and secondary

surgeries for hardware removal in the operating room were much higher in the IMN group the current results indicate that both procedures are highly effective in maintaining fracture restorations. Plate fixation provides earlier recovery of powerful hand function with shorter sick leave, which is of particular benefit to workers with specialized manual skills. And intramedullary nailing allows a wide range of finger motion.

INTRODUCTION

Metacarpal fractures are among the most common fractures of the skeletal system and account for 36 % of hand and wrist fractures.[2,14,15,22] The peak incidence of metacarpal shaft fractures is between 20 and 40 years and results in significant societal costs.[11] The majority of metacarpal shaft fractures can be treated conservatively.[24] Numerous indications for operative treatment include malrotation, angulation, longitudinally shortening, multiple fractures and fractures with associated soft tissue injuries or bone loss.[2,3,7,18,20,21,24,25] With the introduction of new fixation techniques for metacarpal fractures in the last 25 years, open reduction and internal fixation (ORIF) gained increasing popularity, because stable ORIF fixation allows early mobilization.[19,26] The reasons for surgeons to decide for open reduction and internal fixation also included the improvement of materials and instruments, better understanding of biomechanical principles of internal fixation, and the availability of antibiotics to reduce infection. A well-known alternative surgical treatment options is closed reduction and percutaneous fixation with Kirschner wires (K-wires).[18,24]

A fracture was considered as unstable if it was irreducible, if acceptable reduction could not be maintained, and/or motion at the adjacent joints could not be started without loss of reduction. Certain fracture patterns like displaced transverse, long spiral and short oblique fractures were recognized as inherently unstable and were selected for surgery if they met the above criteria for instability. Additional considerations include the patient's age, occupation, and socioeconomic status; the presence of systemic illnesses; the surgeon's skill; and the patient's compliance.[2]

Simple closed reduction and immobilization may be used to treat stable fractures. Percutaneous pinning may be added to stabilize the reduced metacarpal fragments to the adjacent metacarpal or in an axial or oblique manner to establish fixation. Open reduction and internal fixation are indicated in the event of multiple metacarpal fractures, inadequate reductions, and fractures that remain unstable despite pinning. Interfragmentary lag screws alone are used in unstable spiral or long oblique fractures. Kirschner wires, tension bands and AO mini plates are used for unstable transverse or short oblique fractures.[21,24]

Percutaneous Kirschner wires considered easy method of internal fixation without periosteal stripping but produce less rigid fixation with little rotational stability and the problems are compounded by the protruding of its ends, disturbance of endosteal nutrition, pin infection, non-union and joint stiffness. While, open reduction and internal fixation using tension bands, lag screws and mini-plates produce anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization of adjacent joints without allowing loss of reduction, thereby preventing stiffness and hence good functional results. But rupture of extensor tendons, stripping of periosteum with affection of nutrition, loosening and distraction of the implant and infection are common problems Patients with high-energy injuries, open and/or comminuted fractures were not included in the analysis to mitigate any confounding variables related to the soft tissue injury.[23,24]

In the PS group, 2.0- and 2.4-mm compressions plates (for shaft fractures) were used. For the IMN group, a 1.6-mm metacarpal nail was used in all cases. No difficulty was encountered in intramedullary metacarpalnail insertion due to the size of the medullary canal. After the surgery, patients in both groups were placed in bulky soft dressing leaving proximal interphalangeal joints completely free for early motion. Once sutures were removed, patients were allowed to perform activities of daily living as tolerated.[20]

The study was designed prospectively, and the following measures were used to evaluate the outcome: total active motion (TAM) of the digit, Disabilities of the Arm, Shoulder, and Hand (DASH) score, and radiographic parameters (preoperative and postoperative shortening, anteroposterior and lateral angulations, number of cortices with a bridging callus). A minimum of 3 cortices of bridging callus was considered sufficient for radiographic healing.

MATERIALS AND METHODS

Between May 2011 and October 2012, we treated 40 consecutive patients with closed, displaced extra-articular metacarpal fractures operatively using 1 of 2 fixation methods: percutaneous Kirschner wires fixation and mini-set plate and screws fixation. Patients' ages ranges between 18 and 60 years.

Patients were equally divided into two groups. Inclusion criteria used to select candidates for operative fixation with either fixation techniques

1. Age between 18 and 60 years with closed extra articular metacarpal fractures;
2. No previous fracture of the same hand;
3. Rotational deformity of more than 5° or
4. For shaft fractures of the proximal third and of the middle third, lateral angulations of more than 10° in index and long fingers, 20° for ring finger, and 30° for small finger;
5. For fractures of the distal third, lateral angulations of more than 60° for small finger, 40° for index, Long and ring fingers.
6. Complete displacement of the fracture with no other associated injuries (fractures of soft tissue injuries).
7. Any rotational deformity.
8. Angulation of more than 10° in index and middle fingers, 20° for ring finger, and 30° for little finger.
9. Shaft displacement of greater than 50%.
10. Shortening greater than 3 mm.
11. Closed or G-type 1 open displaced metacarpal shaft fracture.

The assessment of functional results was made on the basis of the criteria of the American Society for Surgery of the Hand, in which total active movement (TAM) of the digit (other than the thumb) is measured. TAM is defined as the total active 3 flexion range of metacarpo phalangeal (MCP) and interphalangeal (IP) joints. The results were graded as follows: TAM ≥210°as good, TAM of 180-210° as fair and TAM of <180°as poor (normal TAM for fingers =260o). For the thumb TAM = active flexion MP + IP – extension deficit of MP + IP.

Thirty three patients were included in this study equally divided into 2 groups., 11 patients in mini plate group were8 male and 3 female and 22 patients in KW group were 16 male and 6 were female. The average age was 34.7 years in mini plate group and 30.1 years in KW group. The right hand was involved in 3 cases of mini plate group and 11 cases in KW group.

The distribution of the fractures was as follows: fifth metacarpal 14, third metacarpal 6, second metacarpal 4, and forth metacarpal 9.

Mechanism of injury included fall, direct blow and traffic accident. Of 33 fractures, 15 were transverse, 9 were oblique and 9 spiral. KW gave higher satisfactory results transverse fractures, while mini plates gave satisfactory results with oblique fractures.

The mean operative duration in mini plate group was 45 min, while in KW group was 20 min. It was found that the occurrence of complications during operative treatment of metacarpal fractures led to unsatisfactory results and this was statistically significant in both groups. The complications in mini plate group include 2 cases of extensor lag, a case of superficial infection, a case of malunion, a case of nonunion and a case of stiffness. While in KW group include 2 cases of pin tract infection and 2 cases of stiffness.

Surgical procedures

Intramedullary nail under Bier's block or general anesthesia and pneumonic tourniquet and image intensification, fractures were reduced by the Jahss technique,[17] which applies dorsal force to the distal fragment with the metacarpo phalangeal and proximal inter phalangeal joints fully flexed. Two Kirschner wires with a diameter of 1.6 mm were then inserted through a small incision at the metacarpal base Blunt dissection of the soft tissues was done and deepened to the bone surface. A hole was then made with a thin reamer. Two flexible 1.6 mm-K-wires, slightly pre-bent at the distal ends, were gently inserted and then advanced one after the other always in an anterograde direction in the canal up to the fracture site. The fracture was then held reduced by longitudinal traction under fluoroscopic guidance, and the K-wires were advanced with a clockwise- anticlockwise movement to facilitate penetration into the distal epiphysis until the curved ends of the wires entered the subchondral bone. The distal angulations of the first wire were oriented dorsally. The second K-wire was oriented in radial and ulnar directions to guarantee a better hold. At the proximal side, the wires were then bent 90°, cut, and buried subcutaneously. The small wound was sutured with two sutures after careful hemostasis.

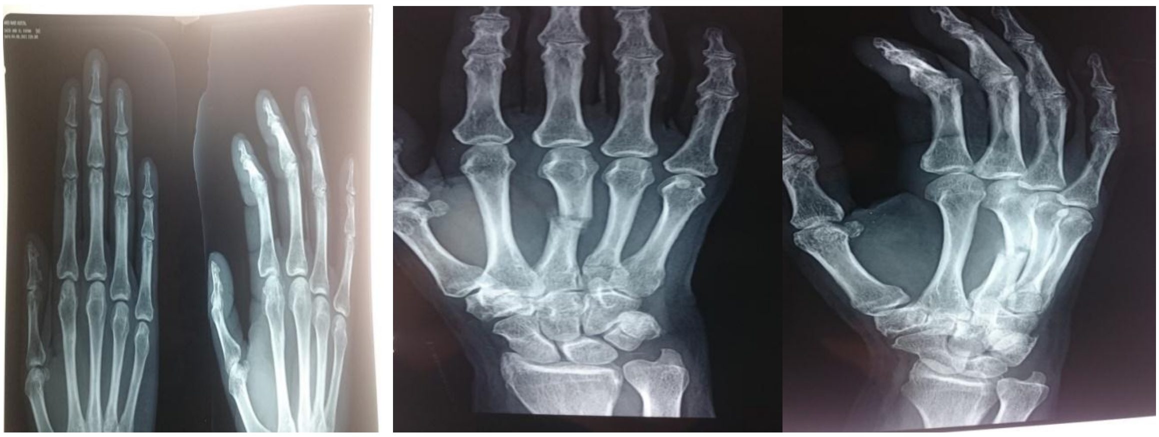
Figure 1 – 6: Demonstrates the selected studied cases X rays.

Case No 1: Pre .op 20/1/2014 Case No 1; Intra .op. 23/1/2014

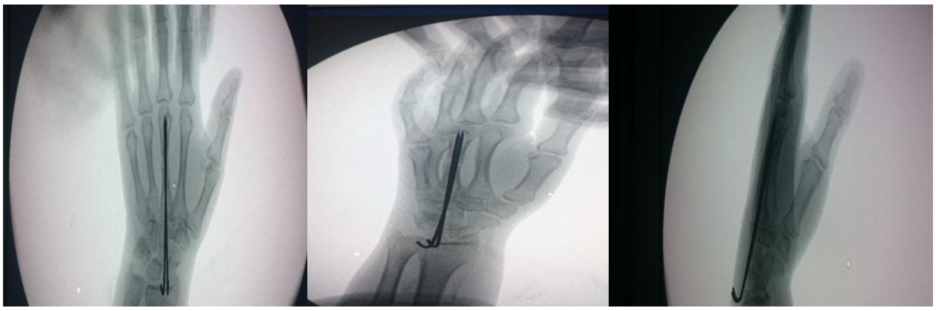
Figure 1: Case 1 pre and post operative.

Case No 6: Pre. op. 28/6/2014 Case No 6: Post. Op Case No 6; 14/9/2014

Figure 2: Case 6 pre and post operative



Case No 16; 4/8/2015 **Case No 16; Pre.op. 19/5/2015**



Case No 16; Intra.op. 21/5/2015.

Case No 16; 30/5/2015.

Case No 16; 27/6/2015.

Case No 16; 15/8/2015.

Case No 16; 6/10/2015.

Figure 3: Case 16 pre and post operative.

Low-profile plate a lazy dorsal curved incision at the metacarpal head was made, and the extensor tendon was retracted to the radial side. The low profile plate was placed on either the dorsal or the lateral surface of the metacarpus. After the plate Fixation, the periosteum was sutured to allow tendon gliding. Passive and active finger motion was allowed 3 days after the surgery. No brace was used during a postoperative course.

Case No 3: Pre. op. X-ray.

Case No 3; 6/2/2014.

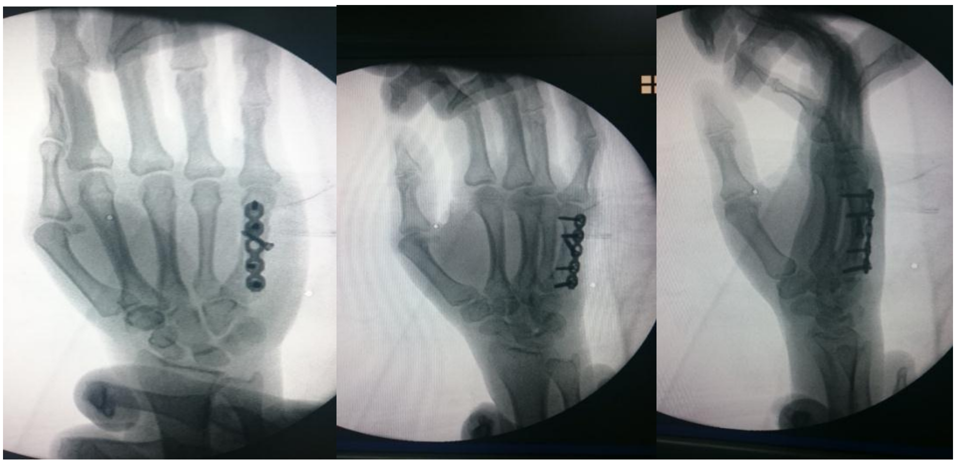
Case No 3; 13/2/2015

Figure 4: Case no 3 pre and post operative.

Case No 4; Pre. Op **Case No4; Post.o** **Case No4; 25/8/2015**

Figure 5: Case no 4 pre and post operative.

Case No 9; Pre.op. 11/7/2015.



Case No 9: Intra.op. 12/7/2015.

13/7/2015 Case No9; Post.op.

Case No9; 21/7/2015 **Case No9;15/8/2015**

Case No9; 28/9/2015

Figure 6: Case no 9 pre and post operative.

Clinical evaluation patients were routinely evaluated in our clinic once every 4 weeks after surgery. Range of motion of the affected digit was measured by a hand physiotherapist using a standard goniometer and evaluated as a proportion of total active motion (% TAM) compared with the contra lateral side at the follow-up. Other objective assessments included measurement of grip strength and the presence of postsurgical complications. Grip strength was measured using a Smedley dynamometer (Stoelting Co., Wood Dale, IL, USA). After confirming complete bone union and the patients' recovery to daily activities, intramedullary nail removal was planned. Plates were removed when the superficial location of the implant was a cause of discomfort and interference with tendon gliding and joint movement.

Radiological evaluation radiographs were taken preoperatively, and at 4, 8, 12, 16, and 20 weeks postoperatively to assess fracture deformity and healing. Bone union, which was defined as the disappearance of fracture lines, was confirmed by two of the authors (S.O., R.F.). Postero-anterior, lateral, and oblique radiographs of specimens were made using standard radiographic techniques. The oblique view was obtained by rotating the hand externally 45 of supination from the palm-down position. We measured radiological parameters indicating fracture deformities: palmar tilt angle, lateral tilt angle, and axial shortening of the injured digit. The palmar tilt angle was defined as the angle between a line from the center of the metacarpal head to the fracture site and a line along the longitudinal axis of the metacarpal shaft in a lateral or oblique hand view. In the intramedullary group, lateral views were obtained for 4 and oblique views were used for 11 cases. In the low profile plate group, lateral views were used in 3 and oblique views were applied in 12 cases. The lateral tilt angle was defined as the angle between a line from the center of the metacarpal head to the fracture site and a line of the longitudinal axis of the metacarpal shaft in a postero-anterior hand view. Axial shortening was defined as a distance of axial fracture compression in a postero-anterior view by measuring the difference of longitudinal distance of the metacarpal bone of the injured digit relative to the contra lateral digit. These data were collected from antero posterior, lateral, or oblique views of the hand radiographs, which were taken preoperatively and when the fracture healed completely.

Statistical analysis variables representing patient and fracture characteristics (age, gender, and affected finger) were compared between patients with intramedullary and plate fixations. Radiological parameters (palmar tilt angle, lateral tilt angle, and shortening deformity) before surgery and when fractures healed were compared between the two treatment groups. Objective outcome data (% grip strength, % TAM, and % metacarpophalangeal joint motion) at 3, 6, and 12 months of the postoperative periods were analyzed and compared between the two treatment groups. Percent metacarpo phalangeal joint motion was defined as a proportion of range of active motion at the metacarpo phalangeal joint compared with the contralateral hand. Differences between intramedullary and plate fixation were compared using Mann–Whitney U test for analysis of age and duration to bone union, and chi-square test was used for analysis of gender and affected finger. Differences of radiological parameters and objective outcome data between the two treatment groups were analyzed using non-paired Student's t test. A p value of\0.05 was considered significant.

COMPLICATIONS

Identification and, importantly, prevention of surgical complications were reviewed under the Technical Aspects section. However, complications of metacarpal fractures can also arise from nonsurgical treatment and postoperative decision making. Stiffness can develop after prolonged immobilization or delayed rehabilitation. In most cases, signs of clinical union will be present at 4 weeks after a closed metacarpal fracture. Although the fracture has not yet radiographically united, transitioning the patient to a removable splint and initiation of rehabilitation at this time can minimize stiffness. Patients with crush injuries or open surgical approaches also can form tendon adhesions. Recognition of these risk factors for stiffness should prompt the surgeon to choose the most rigid form of fixation and begin mobilization early. In cases with rigid internal fixation, mobilization should begin at the time of suture removal. Malunion primarily manifests as malrotation or dorsal angulation. At each visit the surgeon should confirm that the patient's fingertips point toward the scaphoid tuberosity in composite flexion. Five degrees of malrotation can produce 1.5 cm of digital overlap19 and diminish grip strength. Prominent palmar metacarpal heads from an apex dorsal malunion also can produce pain and secondary weakness. A compensatory hyperextension deformity at the MCP often accompanies a dorsal malunion. Corrective osteotomy is the treatment of choice for metacarpal shaft and neck malunions, whereas osteotomy or arthrodesis can be performed at the metacarpal base level. Nonunion is an uncommon complication of metacarpal fractures. Bone grafting and rigid internal fixation are the recommended treatments in the absence of osteomyelitis or soft-tissue defects.

Rehabilitation

Joint mobilization is contingent on fracture location and stability. Fractures treated none surgically that involve the distal shaft, neck, and head have a greater tendency for secondary displacement; aggressive rehabilitation should be delayed for 3 to 4 weeks after injury.

Metacarpal base and proximal shaft fractures are immobilized in an intrinsic plus splint with interphalangeal joints free to start active and passive motion. Gentle active motion at the MCP level is allowed in the most proximal stable fractures. Passive MCP mobilization is added when there are signs of clinical union, typically at 5 to 6 weeks after injury. Strengthening exercises are added at 8 weeks. Surgically managed metacarpal fractures are immobilized for 2 weeks postoperatively in a bulky intrinsic plus splint until sutures are removed. The rehabilitation plan is individualized based on rigidity of internal fixation, patient compliance, and the complexity of associated soft-tissue injuries and repairs. Active MCP and active/passive interphalangeal motion is initiated within days of surgery in compliant patients with rigid internal fixation. Passive MCP motion is added at 4 weeks after surgery. Dynamic assist motion programs are started within 3 to 5 days of tendon reconstruction. Cast immobilization is used for 4 to 6 weeks in noncompliant patients with rigid fixation. Mobilization follows thereafter, according to the protocol described previously for nonsurgical fractures. Elastic wrapping is used for edema control and adjustments are made to manage concomitant soft-tissue injury as needed.

RESULTS

In the present study, it was found that percutaneous fixation of metacarpal bones with K. wires had higher satisfactory results than open reduction and internal fixation with mini-plates and screws but without statistical significant, where open reduction and internal fixation of metacarpal fractures with mini-plates gave 70% satisfactory results while percutaneous fixation with Kirschner wires yielded 85% satisfactory results.

It was also found that, percutaneous pinning had a shorter operative time, easier operative techniques and cosmetically better results. But it had radiological exposure hazards, less rigid fixation and necessity for secondary surgeries for hardware removal. While open reduction and internal fixation with mini-set plates and screws was a technically demanding operation, higher risk of infection, longer operative time and higher risk of soft tissue adhesions. In the present series, it was found that most of excellent results were found in employees, students and house wives. They approach to the rehabilitation process following fracture healing, while manual workers have high pain threshold and tend to do aggressive hand movement applying stress on the implants or exposed to direct trauma at the site of fixation which may lead to loosening of screws or even breakdown of plate.

The combination of open reduction and plaster immobilization is unfavorable as tendon gliding function can be impaired by surgical trauma and closely situated implants. By the unavoidable plaster cast **immobilization** for several weeks, the risks inherent in any operative procedure are inevitably combined with the shortcomings of non-operative fracture treatment (Joint stiffness, tissue atrophy). Immediate resumption of tendon function is the answer to the argument that operative intervention causes additional tendons and soft tissue damage. These requirements are met only by rigid internal fixation allowing early functional after care.

Rigid internal fixation of the metacarpal fractures allowed early active motion. Patients who started motion after the first two weeks postoperatively had a higher incidence of satisfactory results than patients who started motion after one month.

No statistically significant differences were found between the groups in comparing postoperative shortening (3mm with IMN fixation and 0 mm with PS fixation, 5), anteroposterior angulation (2° in PS group, 0° inIMN group), lateral angulation (8° in IMN group, 0° in PS group), and radiographic healing time (5.4 weeks in IMN group, 5.2 weeks in PSgroup).

Comparison of the TAM between the groups showed no statistically significant difference (766). The same comparison of the DASH score between the groups also did not reveal a statistically significant difference (786). the site of entry and the original fracture The other 4 cases were all located at the distal third of the shaft, and the nail violated the cortex of the metacarpal head and protruded through the metacarpal-phalangeal joint in 3 cases One case had a malrotation of the metacarpal head. All 5cases were later treated with PS fixation. Fifteen patients in the IMN group (5 ring finger and 10 small finger metacarpals) had extensor tendon irritation and needed hardware removal without tenolysis. Hardware removals were all performed in the operating room under conscious sedation. In the PS group, 2 patients (both small finger metacarpals) had hardware removal with extensor tenolysis in the operating room significant difference the association between hardware type and fracture location revealed no statistically significant differencein middle and distal third fractures. Proximal third fractures did not have adequate number of patients in each hardware group for comparison. However, loss of reduction and nail penetration had occurred in 5 patients in the IMN group, whereas no hardware has failed in the PS group. Of these 5 cases in the IMN group, 1 occurred at the proximal third of the shaft and failed due to the fracture of the cortex between

DISCUSSION

Percutaneous Pin Fixation

many types of metacarpal fractures are amenable to percutaneous pinning. Smooth 0.9- to 1.1-mm (0.035- to 0.045-in) K-wires are appropriate for fixation of the metacarpal base, shaft, and neck levels. Smaller pins are needed in paediatric populations. Pins with trocar and diamond-shaped tips have greater pull-out strength immediately after drilling and at 3 weeks compared with manually cut pin tips.[1] If retrograde pinning is planned, a set of double-ended K-wires should be available. In addition, experimental data supports higher pull-out strength among pins inserted at low drill rpm compared with those inserted at high rpm.[2] In sites where nerve injury is possible, a nick-and-spread technique is useful to clear soft tissues from the area. Drill guides and hypodermic needles work well as soft-tissue protectors and facilitate pin insertion, especially when the pin is directed at acute angles to the bone (Fig 1). A 14-gauge hypodermic needle accommodates a 0.9-mm (0.035-in) K-wire. Once placed, pins can be cut and capped above skin level or cut and buried beneath the skin. As a general rule, pins, which are intended to be in place longer than 6 weeks, are buried beneath the skin, all others are left out of the skin.

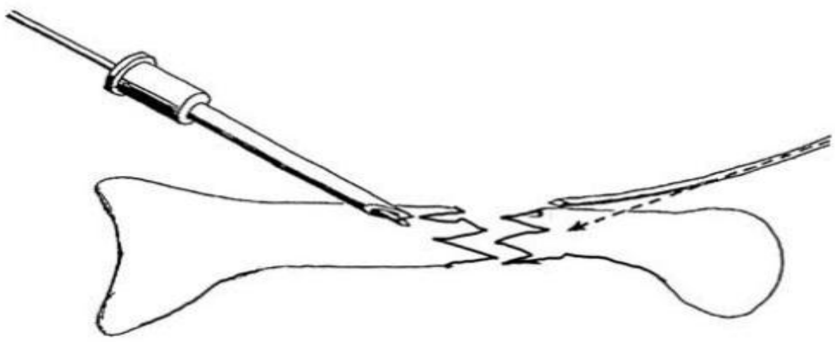


FIGURE 1. A 14-gauge hypodermic needle serves as a tissue guard and helps direct the passage of 0.9-mm (0.035-inch) K-wires.

Several pinning techniques can be used for metacarpal head, neck, shaft, and base fractures (Fig 2). The easiest technique is transfixion pinning of the fractured metacarpal to an intact adjacent metacarpal (Fig 2A). Instead of placing the hand flat with digits extended, as would be expected for an antero posterior radiograph, we recommend bringing the fingers into a flexed position in the palm for pinning. This facilitates reduction and allows clinical correction of rotational alignment before and during pinning. In addition, this maneuver aids the surgeon in visualization of the transverse metacarpal arches for optimal pin targeting (Fig 3). Two transfixion pins are recommended distally and at least one proximally. Placing the distal pins out of plane can add rotational stability, and pin divergence can be used to reduce lateral translation of the distal fragment. The bending stiffness of transfixion constructs approaches that of plate and screw fixation.[3]

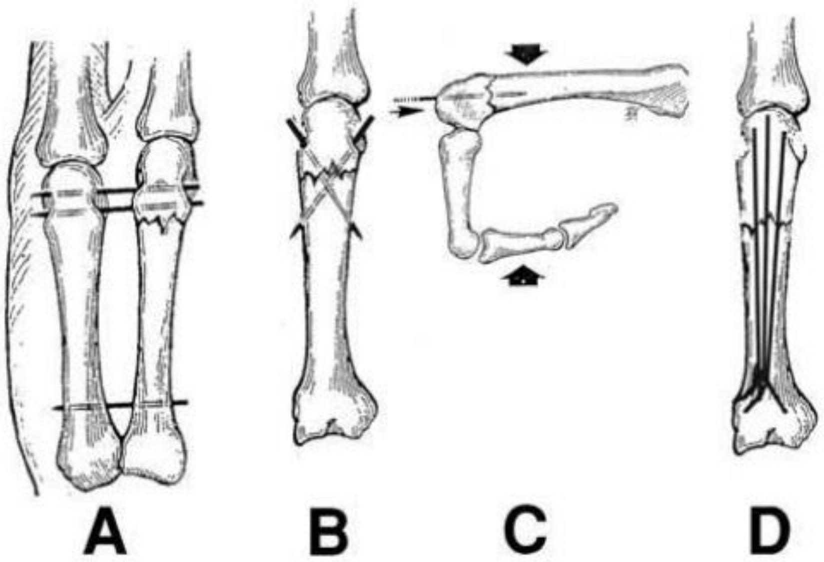


FIGURE 2. Of the various pin fixation techniques described for the management of metacarpal fractures, transfixion pinning (A), cross k-wires (B), retro grade intramedullary fixation (C), and antegrade intramedullary fixation (D), the easiest method is the transfixion technique illustrated in 3A.

A second pinning technique uses K-wires to cross near the fracture site (Fig 3B). These can be placed antegrade with an entry point on the dorsal metacarpal surface or retrograde from the MCP joint. By flexing the MCP joint to 90°, retrograde pins can enter near the origin of the collateral ligaments (dorsal, central, or volar) and avoid injury to the articular surface. The pins should cross each other proximal or distal to the fracture site for maximal stability. Several biomechanical studies have shown crossed pins to be inferior to other pin, wire, and plate constructs.[3,4,5]

A third method for metacarpal pinning is the intra medullary approach (Figs 3C and 3D). Pins can be placed retrograde through the MCP joint at the origin of the collaterals or antegrade through a dorsal cortical window.[6,7] Two to 5 pins are placed across the fracture site, spread distally, and impacted into subchondral bone. Metacarpal shortening, rotation, and pin migration are reported complications.[7] This technique should be reserved for transverse or short oblique fractures without significant comminution. Supplementary buddy taping should be added to maintain rotational control. A fourth pinning technique has been described for Bennett fractures: Trans articular pinning. Placing one or 2 pins from the metacarpal shaft into the trapezium while maintaining reduction can counteract the deforming force of the abductor pollicis longus.[8]

In some cases, a combination of pinning techniques is useful. For Bennett and CMC base fractures, crossed pins are useful for securing fracture alignment while trans fixation or trans articular pins are helpful to maintain reduction of a CMC dislocation (Fig 4). Though less invasive than alternative methods of fixation, percutaneous pinning is not an entirely benign procedure.

Laboratory studies, which identify the failure mode of K-wires, noted that loosening at the bone-wire interface allowed the pin to slide and distract the fracture fragments.[3] K-wire loosening is prevented by using trocar-tipped pins, delivered at low rpm, and avoiding repeat passes in and out of the same drill hole.[9]

Percutaneous K-wire fixation for phalangeal fractures was first described by VomSaal.[10] in 1953. A wire was inserted longitudinally from the distal end of the fractured phalangeal bonet through the middle of the extensor tendon sleeve at the edge of the joint. This technique, which is called percutaneous intramedullary K-wire fixation, may be applicable for stable short oblique and transverse fractures, but not for long oblique fractures, because a single K-wire cannot control the rotation and shortening of the oblique fracture fragments,[11,12] Two wires are introduced near the mid-lateral line, by avoiding the lateral bands and the extensor aponeurosis, and inserted across the fracture site. They reported that 18 of 26 patients with proximal phalangeal long oblique fractures regained full range of motion by this technique.[13]

The advantage of percutaneous K-wire fixation technique is that the swelling and stiffness that are frequently associated with other open reduction and internal fixation techniques are minimized.[11] however, percutaneous K-wire fixation has disadvantages, such as potential for pin track infection, soft-tissue impingement, and a relative lack of rigidity. The complication rate of K-wire fixation in hand and wrist was reported as 18% by Botte and coworkers[15] and 15% by Stahl and Schwartz.[16] These complications included pin tract infection (7%), pin loosening or migration (5%), and non-union (4%).[15] Nerve injury and tendon rupture were uncommon complications.

Open Reduction Internal Fixation With Plate and Screws

Plate and screw fixation is used for metacarpal fractures that are short oblique, transverse, or comminuted. In comminuted fractures they act as a bridge, spanning the fracture site (Figs 5A and 5B). In simple 2-part fractures they function as a tension band to resist displacement from digital flexor activity (Fig 5C). Plate design accommodates varied fracture configurations and anatomic locations. Periarticular fractures such as comminuted head and neck fractures or Rolando fractures are amenable to blade plate fixation or T, L, and Y plate fixation (Figs 5A, 5B, and 5D).[8]

When these devices are used the articular fragments are reduced first, provisionally fixed with K-wires, and the blade or the angled portion of the plate is introduced first. Plate position is confirmed and the stem of the plate is secured. Doing this in the opposite order is impossible with a blade plate and will lead to rational misalignment when using angled plates. Because plate fixation is so rigid, alignment and rotation must be perfect before the plate is applied. Reduction maneuvers that place the digits in an intrinsic plus posture and take advantage of provisional K-wire fixation are helpful. In the setting of multiple metacarpal fractures, all of the digits are flexed at the MCP joints and aligned relative to an uninjured digit. A 0.9-mm (0.035-in) K-wire is passed retrograde from the fracture site though the medullary canal and out the metacarpal head of the flexed MCP joint (Fig6A). The fracture is reduced and the K-wire is delivered into the proximal medullary canal (Fig 6B).[8]

The maneuver is repeated for the other fractured metacarpals. Starting with the central-most rays, plates are affixed by placing one uni cortical screw adjacent to the fracture site that creates an acute angle between the fracture and the plate, rotational alignment is rechecked, and a second unicortical screw is placed on the opposite side of the fracture (Fig 6C). If alignment and rotation are correct, the intramedullary K-wire is removed and the remainder of the screws are inserted. Addition of a lag screw, through or adjacent to the plate, enhances rigid fixation (Fig 6D).[8]

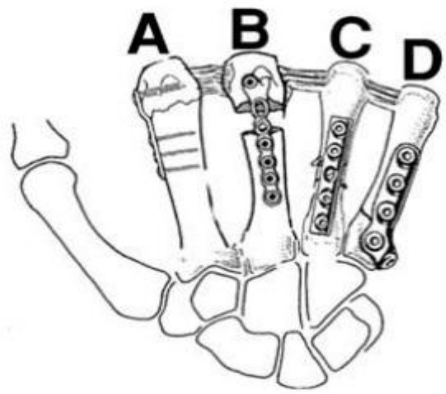


FIGURE 5. Examples of plates used in fracture fixation. Plates are named for the function they serve, bridging or spanning plates (B), compression or tension bands (A, C, and D); their shape, straight (C), L (D); or for their anatomic location such as condylar-blade plates (A and B).

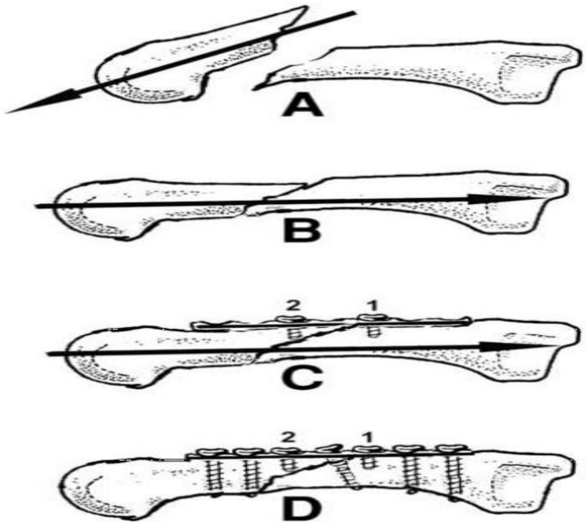


FIGURE 6. A method of metacarpal shaft fixation that takes advantage of provisional fixation with an intramedullary k-wire introduced retrograde through the metacarpal head (A) followed by fracture reduction passage of the k-wire antegrade through the proximal medullary canal (B). In this illustration (C), a 7-hole plate has been placed on the fracture and the screw holes immediately adjacent to the fracture are secured with unicortical screws. The k-wire is removed and the remainder of the screws is placed.

Early editions of the AO manual espouse that 2.7-mm plates engaging a minimum of 4 cortices on either side of the fracture are essential for the fixation of metacarpal fractures. Subsequent series have shown effective fixation with smaller implants.[17] We routinely use 2.4-mm plates for border digits and multiple metacarpal fractures and 2.0-mm implants for smaller patients and those unstable fractures of the middle and ring finger not amenable to the K-wire techniques mentioned earlier. The use of fixed angle devices such as condylar blade plates provides rigid fixation in which fragment size accommodates only one screw (Figs 5A and 5B).[8]

The results of this study indicate that IMN fixation of extra-articular metacarpal fractures does not provide a better functional outcome compared with that of conventional PS fixation as reflected in TAM of the digit, DASH score, and radiographic parameters.

Whereas IMN fixation required much shorter operative times than did PS fixation (15 minutes in IMN group vs. 34minutes in PS group), in the IMN fixation group there were higher incidences of loss of reduction, nail penetration of the metacarpal-phalangeal joint (5 cases in IMN group vs. none in PS group), and tendon irritation, requiring hardware removal (15 of 38 cases in the IMN group versus 2 of 14 cases in the PS group).

Intramedullary fixation of metacarpal fractures was initially recommended for extra-articular transverse and short oblique fractures.5–7 In earlier studies, the authors used the anterograde insertion method and thin wires or K-wires for fixation. Antegrade insertion of a K-wire to the metacarpal shaft may be difficult due to poor control of the tip and the angle of introduction.

The complication rate after PS fixation in the current study is parallel to that of previous studies with the low-profile plates. All studies found less than 15% complication rate including secondary surgeries for hardware removal and tenolysis.1–3 Comparison with the previous studies using the outcome scores is not entirely possible due to lack of uniformity in study designs and outcome measures. Secondary surgeries in the IMN group were performed either for revising the fixation (5 cases) or for removing the hardware (15 cases). Patients were taken to the operating room for these procedures. Although it may be possible to perform intramedullary metacarpal nail removal under local anaesthesia, initial attempts to remove 2 nails in the outpatient setting were unsuccessful in our hands, therefore the rest of them were all removed under conscious sedation. Secondary surgeries in the PS group (2 cases) were performed for hardware removal and stiffness at the metacarpal-phalangeal joint. Both cases had notable adhesions formed between the plate and the extensor tendons. To our knowledge, this is the first study comparing the outcome of intramedullary fixation with that of conventional plating of metacarpal fractures. The strengths of the study are its prospective design using a widely accepted and validated outcome measure. The weakness of the study is the lack of its true randomization between the 2 eatment groups and the approximately3:1 ratio of the population of the IMN group versus that of the PS group. The selection between the surgical techniques was based on the surgeon's preference. However, careful subgroup analysis for age, gender hand dominance, time from injury to surgery, mechanism of injury, and location/pattern of fracture did not reveal any statistical significance between the 2treatment groups. Minimal soft tissue dissection, smaller scar formation, and less tendon irritation are potential advantages of intramedullary fixation over conventional plating. The results of this study indicate that these theoretical advantages do not have an impact on the outcome.

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