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Original article

Comparison of percutaneous intramedullary Kirschner wire and interfragmentary screw fixation of displaced extra-articular metacarpal fractures

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Summary. *Background and aim of the work:* the management of the displaced extra-articular metacarpal fractures is still a subject of debate in the literature. The purposes of this study were to report the outcomes of unstable extra-articular metacarpal fractures treated by using intramedullary Kirschner wires or inter-fragmentary screws and to determinate which techniques provide better clinical and radiographic results. *Methods:* we retrospectively reviewed a series of 49 consecutive patients operated for 53 closed, unstable metacarpal fractures. The fractures were divided into two groups, according to the fixation method used: the percutaneous intramedullary K-wire fixation group and the interfragmentary screw fixation group. The injuries were classified on the basis of fracture level and type. Assessment of patients was carried out according to the Mayo Wrist and Dash Scoring systems. Finally, radiographic and clinical outcomes of both groups were assessed and compared. *Results:* there were no significant differences between the two groups related to follow-up, hospitalization days, operating time, and Mayo Wrist and Dash Scores. Bone union was achieved within 6 weeks in all patients. Nine cases of malunion were found, with a mean angular deformity of 8.33° (range, 5°-15°), of which 8 were patients treated with K-wires (mean 8.125°) and 1 with screws (10°). *Conclusion:* our results indicate that both procedures are effective in the treatment of displaced extra-articular metacarpal fractures. However, we believe K-wires represent the gold standard of treatment for displaced fractures of the metacarpal neck. Instead, screws are more effective for spiroid shaft fractures, while displaced fractures of the base may be treated with either screws or wires.

Key words: metacarpal fractures, internal fixation, intramedullary K-wire, screw fixation

Introduction

Even though metacarpal fractures are among the most common orthopaedic injuries (1), representing about 10% of all fractures (2), and the most frequent fractures of the hand, accounting for up to 40% (3), their treatment is subject to debate in the literature, ranging from non-surgical treatment in the majority of cases (4-9), also proposed for metacarpal neck fractures (10,11), to mini-invasive techniques with screws or K-wires(12, 13) and plating for shaft cases (14,15). Fractures of the metacarpal bone, generally due to accidental falls and direct blows (3,16), have an incidence estimated to be greater than 250 per 100,000 for persons between 15 and 24 years of age (3). They can involve the proximal base, the shaft, neck, or the head of the metacarpal bone. Depending on their location, stability, and fracture type, the indications for conservative or operative treatment can be different, with a variety of techniques possible: intramedullary K-wires or intraosseous wiring, interfragmentary or compression screws and hand plates (17). In particular, for spiral and comminuted fractures of the shaft, which are rotationally unstable with a tendency to shorten the metacarpal bone more than 3 mm, open reduction and internal fixation with interfragmentary screw fixation or plate fixation are indicated (18,19). Also head fractures, by definition intra-articular, require an open dorsal approach if the displacement is greater than 1-2 mm or involving more than 15% of the articular surface (17). In fact, they lead to post-traumatic arthritis and functional disability as a result of joint pain and loss of motion (20, 21). Conversely, metacarpal base fractures, the most stable due to both dorsal and palmar carpometacarpal, as well as interosseous ligaments, can be conservatively managed (22).

In this retrospective and comparative study, we report our experience in the treatment of unstable extra-articular fractures using two fixation methods: intramedullary Kirschner wires (K-wires) or interfragmentary screws. Then, we compare the two different techniques in order to determine which method provides a better functional and radiographic outcome, discussing possible complications of the two procedures, according to the level and type of fracture.

Materials and methods

We prospectively examined 53 consecutive, closed, unstable metacarpal fractures in 49 adult patients, hospitalised at our Orthopaedic and Traumatological Clinic, between January 2008 and December 2010. All fractures were treated operatively using one of two fixation methods: percutaneous intramedullary K-wires or interfragmentary screw fixation. The choice between the two surgical techniques was based on the preferences and experience of the surgeons involved in the operations. Thus, the fractures were divided into two groups according to the fixation method used: *I) percutaneous intramedullary K-wire fixation group* (n=31) and *II) interfragmentary screw fixation group (n=22)*. The main indication for surgical treatment and inclusion in this study was displaced metacarpal fractures with a dorsal angulation of more than 30° or with a shortening of more than 3 mm. We excluded patients younger than 18 years. Also patients with open fractures or multiple traumas, associated fractures of shoulder, elbow, or wrist, with a history of diabetes, rheumatoid arthritis or gout, or with pre-existing neurological and functional deficits were excluded. The subjects participating in this study received a thorough explanation and gave informed consent. All patients were available for the review. They were 39 men and 10 women with a mean age of 37.46 years (range, 18-74 years) at the time of the surgery. The main characteristic of the patients and fractures are summarized in Table 1. The right hand was involved in 33 cases and the left one in 16 cases. The dominant hand was affected in 41 patients. Mechanism of injury included falls (30%), direct blows (32%) and traffic accidents (38%). Patients were operated after a mean period of 1.67 days (range, 1-5 days). We decided to classify the fractures according to the AO classification (23). The distribution of the fractures in the metacarpal bones assessed was as follows: the first metacarpal bone in 3 cases (3 A1 - 5.67%), the second in 5 cases (5 A1 - 9.43%), the third in 5 (3 A1; 2 A3 - 9.43%), the fourth in 5 (4 A1; 1 A3 - 9.43%) and the fifth in 35 (25 A1; 4 A2; 6 A3 - 66.04%). The incidence of fractures generally tends to increase toward the ulnar side of the hand. Between 53 fractures 41 were spiral (A1: 77.35%), 4 were oblique (A2: 7.54%), and 8 were transverse (A3: 15.09%). Further, according to the level of the fractures, there were 5 of type-1 (proximal: 9.43%), 26 of type-2 (shaft: 49.05%), and 22 of type-3 (distal: 41.51%). All of the fractures were closed. Overall, 31 fractures were fixed by intramedullary K-wires and 22 by inter-fragmentary screws. Thus, the 5 type-1 fractures were treated with K-wires in 4 cases (4 A1,) and with screws in 1 case (1 A1). The 26 type-2 fractures were fixed by K-wires in 6 cases (1 A1; 2 A2; 3 A3) and by screws in 20 (17 A1; 3 A3). Finally, the 22 type-3 fractures were treated with K-wires in 21 cases (18 A1; 1 A2; 2 A3) and with 2 screws in just one (1 A2) .

Surgical procedures

In all cases surgery was performed with the patient under peripheral anesthesia, with a pneumonic tourniquet and image intensification.

Table 1. Cases

Patients	Years gender	Metacarpal Side R, right; L, left	RX AO	Trauma-surgery interval (days)	Incision (dorsal d, medial, m)	Wires W, Screw S and number
1	69F	5L	2 A3	2	m	W 2
2	36M	5L	3 A3	1	m	W 2
3	49M	4R	2 A1	2	d	S3
4	20M	5R	3 A1	1	m	W 2
5	57M	5L	3 A1	3	m	W 2
6	23F	3R	2 A1	1	d	S2
7	33M	5R	3 A1	1	m	W 2
8	40F	5L	2 A1	1	d	S2
9	22M	1R	1A1	1	d	S1
10	41M	5L	2 A2	1	m	W2
11	37M	5R	2 A1	1	d	S2
12	18M	5R	3 A3	1	m	W 2
13	36M	5R	3 A2	1	m	W 2
14	18F	1L	1 A1	1	d	W 2
15	62M	2R 3R	2 A1 2 A3	2	d	S 2+2
16	52F	2R 3R	2 A1 2 A3	1	d	S 1+2
17	74F	5R	3 A1	1	m	W 2
18	53F	5R	1 A1	1	m	W 2
19	19M	5R	3 A1	1	m	W 2
20	29M	5L	2 A1	1	d	S1
21	31M	5R	3 A1	1	m	W 2
22	25M	5R	1 A1	1	m	W 2
23	26M	2R	2 A1	1	d	S3
24	21M	5L	3 A1	1	m	W 2
25	21M	2R	2 A1	1	d	S3
26	36M	5L	3 A1	1	m	W 2
27	44M	3L 4L	2 A1 2 A1	1	d d	S3 +1
28	54F	3R 4R	2 A1 2 A1	1	d d	S2 +2
29	29M	1R	1 A1	1	d	W 2
30	20M	2L	2 A1	1	d	S3
31	21M	5R	2 A3	1	m	W 2
32	39M	5L	2 A1	1	m	S3
33	71F	5L	2 A1	1	m	S2
34	26M	5R	3 A3	1	m	W 2

Continued

35	52M	5R	3 A1	4	m	W 2
36	46M	5R	3 A1	1	m	W 2
37	38M	4R	2 A3	1	d	S3
38	38M	5R	3 A1	1	m	W 2
39	24M	5R	3 A1	3	m	W 2
40	38M	5R	2 A2	2	m	W 2
41	39M	5R	3 A1	1	m	W 2
42	44M	5L	2 A1	1	m	W 2
43	35F	5R	3 A2	1	m	S2
44	44M	5R	3 A1	1	m	W 2
45	54M	5R	3 A1	1	m	W 2
46	27M	4R	2 A1	2	d	S2
47	32M	5L	3 A1	1	m	W 2
48	26M	5L	3 A1	1	m	W 2
49	47M	5R	2 A3	1	m	W 2

Percutaneous Intramedullary Nail

In the percutaneous intramedullary K-wire fixation group, the incision, only a few millimeters long, was made dorsally and proximally near the base for the first 4 metacarpal bones, from first to fourth fingers. Instead, for the 5th metacarpal, the incision was made medially near the ulnar side of the base of the 5th metacarpal, according to Foucher (24,25). 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 1.4 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 angulation of the first wire was 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.

Interfragmentary Screw Fixation

In the operations with titanium screws, a lazy curved incision was made dorsally at the metacarpal, with exposure and reduction of the fracture. This approach alone provided sufficient exposure of the fracture side and direct access of the fracture for its fixation in all cases. For fracture fixation, 2.0 mm-diameter bicortical interfragmentary screws (Synthes) were employed. These were emplaced after the fracture fragments had been gently compressed with a clamp (26). The reduction was aimed at obtaining perfect congruence of the fracture fragments. The direction of the screw was targeted to be as perpendicular as possible to the fracture line. Depending on the fracture configuration and size of the fragments, 1 to 3 screws were used to achieve stable fixation.

Postoperative management

Postoperatively, in both groups, hands were immobilized with a plaster splint for 3 weeks, and then the patients were encouraged to performed wrist and finger motion exercises. In the first group, the K-wires were removed six weeks after surgery in the operating room under conscious sedation after confirming complete bone union. In the second group, the metalwork was not removed until the last follow-up, as it did not cause discomfort and interference with tendon gliding and joint movement.

Clinical evaluation

At the follow-up, the clinical and radiological analyses were carried out by an independent investigator, the junior author C.B., not involved in the treatment of the patients. The following measures were used to evaluate the outcome: Mayo Wrist Score (27) for clinical objectivity and Disabilities of the Arm, Shoulder, and Hand (Dash) Score (28, 29) for subjective symptoms. The final result of the Mayo Wrist Score was expressed according to a numerical value: Excellent, between 90 and 100 points; Good 80-89; Moderate 65-79; and Poor <65 points. A Dash Score of 0 points reflects no disability, whereas a score of 100 points signifies maximum disability. The occurrence of deformity, pain, loss of strength and sensitivity were also considered.

Radiological evaluation

We performed preoperative postero-anterior, lateral, and oblique radiographs for all patients and used them to classify the injuries on the basis of fracture level and type, according to the AO classification (23). postero-anterior, lateral, and oblique radiographs were also taken post-operatively, as well as at 6 weeks after surgery and at last follow-up. Radiographic parameters included preoperative and last follow-up shortening, antero-posterior and lateral angulation, and presence of bridging bone callus on plain radiography.

Statistical analysis

The normality of distribution of follow-up, operation time, hospitalization days, Mayo Wrist and Dash Score in the two groups was evaluated with the Shapiro-Wilks test. The two groups were compared with the Student's t-test for operation time and with the Wilcoxon Rank Sum Test for Mayo Wrist Score and Dash Score.

Results

The first analysis consisted of data observation, without comparison, to verify our treatments. All patients had satisfactory clinical and radiographic outcomes (Table 2). Then, the two groups were compared (Table 3). No statistically significant differences were found between the two groups related to all of the parameters considered in the statistical analy-

Table 2. Results

Patients	Follow-up (month)	Operation time (min	Ospitalization Days	Mayo Wrist score	DASH	Healing at 6 week	Malunions	Hardware removal
1	22	40	3	100	2.50	Yes	0	Yes
2	33	35	1	100	0.00	Yes	0	Yes
3	20	30	3	100	0.00	Yes	0	No
4	39	30	1	90	5.83	Yes	Vr 5°	Yes
5	27	30	3	90	10.00	Yes	Pr 10°	Yes
6	19	45	2	100	1.67	Yes	Pr 10°	No
7	36	30	1	100	0.00	Yes	0	Yes
8	55	45	1	100	0.00	Yes	0	No
9	35	25	1	100	0.83	Yes	0	No
10	34	50	1	100	0.83	Yes	0	Yes

Continued

11	35	20	1	100	1.67	Yes	0	No
12	22	45	1	100	2.50	Yes	Pr 5°	Yes
13	34	35	1	100	0.00	Yes	Pr 5°	Yes
14	31	25	1	100	5.00	Yes	0	Yes
15	27	40	3	90	0.83	Yes	0	No
16	34	45	2	85	10.83	Yes	0	No
17	29	45	1	100	0.00	Yes	0	Yes
18	31	70	4	100	1.67	Yes	0	Yes
19	28	35	1	100	0.00	Yes	0	Yes
20	30	35	2	100	2.50	Yes	0	No
21	22	25	2	100	0.00	Yes	0	Yes
22	21	30	1	90	7.50	Yes	0	Yes
23	21	45	1	100	0.00	Yes	0	No
24	22	20	1	90	8.33	Yes	0	Yes
25	18	50	1	100	2.50	Yes	0	No
26	29	60	5	85	9.17	Yes	0	Yes
27	26	45	4	100	1.67	Yes	0	No
28	36	45	1	85	15.83	Yes	0	No
29	37	45	1	100	0.00	Yes	0	Yes
30	22	60	2	100	0.00	Yes	0	No
31	28	50	2	100	5.83	Yes	0	Yes
32	38	45	2	100	8.33	Yes	0	No
33	36	50	2	100	4.17	Yes	0	No
34	18	60	1	100	2.50	Yes	0	Yes
35	21	45	4	100	2.50	Yes	0	Yes
36	25	45	1	85	18.33	Yes	R 5°	Yes
37	35	70	2	90	14.17	Yes	0	No
38	46	35	1	100	0.00	Yes	0	Yes
39	34	45	1	100	0.00	Yes	0	Yes
40	28	45	1	85	7.50	Yes	0	Yes
41	18	40	1	100	2.50	Yes	0	Yes
42	26	30	1	90	5.00	Yes	0	Yes
43	30	75	1	100	0.00	Yes	0	No
44	32	30	2	100	1.67	Yes	Pr 10°	Yes
45	20	55	1	100	0.83	Yes	0	No
46	19	60	2	100	1.67	Yes	0	No
47	23	25	1	90	9.17	Yes	Pr 10°	Yes
48	18	50	2	90	8.33	Yes	0	Yes
49	22	60	1	80	11.67	Yes	Pr 15°	Yes

(Ro=Rotation, Vr=Varus, Vl=Valgus, Pr=Procurvatus, R=Recurvatus)

Table 3. Summary of results

Groups	Intramedullary Nailing	Screw Fixation
Mean age, years	37.83 years	36.83 years
Fractured site	20 R, 11 L	17 R, 5 L
Gender	26 M, 5 F	13 M, 5 F
Type 1	4 (4 A1)	1 (1 A1)
Type 2	6 (1 A1; 2 A2; 3 A3;)	20 (17 A1; 3 A3)
Type 3	21 (18 A1; 1 A2; 2 A3;)	1 (1 A2)
Mean follow-up, months	27.61 (range 18 – 46)	29.78 (range 18 – 55)
Injury to surgery days	1.58 (range 1 – 4)	1.16 (range 1 – 2)
Hospitalization days	1.58 days (range 1-5 days)	1.83 (range 1- 4 days)
Operation time,minutes.	40.81 (range 25-70)	46.11(range 20-75 minutes)
Postoperative angulation °	8 patients	1 patient
Anteroposterior	0	1 (range, 0°-10°)
Lateral	8 (range, 5°-15°)	0
Postoperative shortening, mm	0 mm	0 mm
Mean MAYO	95.65 (range 80 - 100)	97.22 (range 85 - 100)
Mean DASH	4.17 (range 0.00 - 18.33)	3.7 (range 0.00 - 15.83)
Radiographic healing at 6 weeks	31	22
Malunions	8	1
Hardware removal, n	31	0

sis. Comparison of the follow-up time between the groups showed no statistically significant difference (p = 0.4734). Overall, the mean follow-up period was 28.4 months (range, 18-55 months), precisely: 27.61 months (median, 28 months; range, 18-46 months) in intramedullary K-wires group (Fig. 1), and 29.78 months (median, 30 months; range, 18-55 months) in the inter-fragmentary screw group (Fig. 2). The same comparison of the hospitalization days between the groups also did not reveal a statistically significant difference (p = 0.0882). The average hospitalization was 1.67 days (range, 1-5 days): 1.58 (median, 1 day; range, 1-5 days) in the percutaneous intramedullary K-wire group and 1.83 (median, 2 days; range, 1-4 days) in the inter-fragmentary screw group. There was also no statistically significant difference between the two groups regarding operating time (p = 0.1748). The average operating time was 42.75 minutes (range, 20-75): 40.81 minutes (median, 40; range, 25-70) in the percutaneous intramedullary K-wire group, and 46.11 minutes (median, 40; range, 20-75) in the inter-fragmentary screw group. Further, we also obtained no significant statistical correlations between the two groups in relation to Mayo Wrist Score (p = 0.3781), or Dash Score (p = 0.5988). The Mayo Scores revealed 43 excellent and 6 good results at the last follow-up, mean 96.22 points (range, 80-100 points). Thirty-one cases treated by wires had a mean Mayo Wrist Score of 95.65 points (median, 100 points; range, 80-100 points), and the 22 cases operated with screws had 97.22 points (median, 100 points; range, 85-100 points). The average Dash Score was 3.99 points (range, 0.00-18.33). In particular, the 31 patients receiving K-wires obtained a mean Dash Score of 4.17 points (median 2.5 points; range, 0.00-18.33 points), and the 22 patients with screws scored 3.7 points (median 1.67 points; range, 0.00-15.83 points).

Radiological evaluation revealed evidence of callus formation on all treated fractures at the follow-up of 6 weeks. However, there were 9 cases of malunion: 8 cases (n. 5; 6; 12; 13; 36; 44; 47; 49) with a mean angular deformity of 8.75° (range 5°-15°) on the sagit-

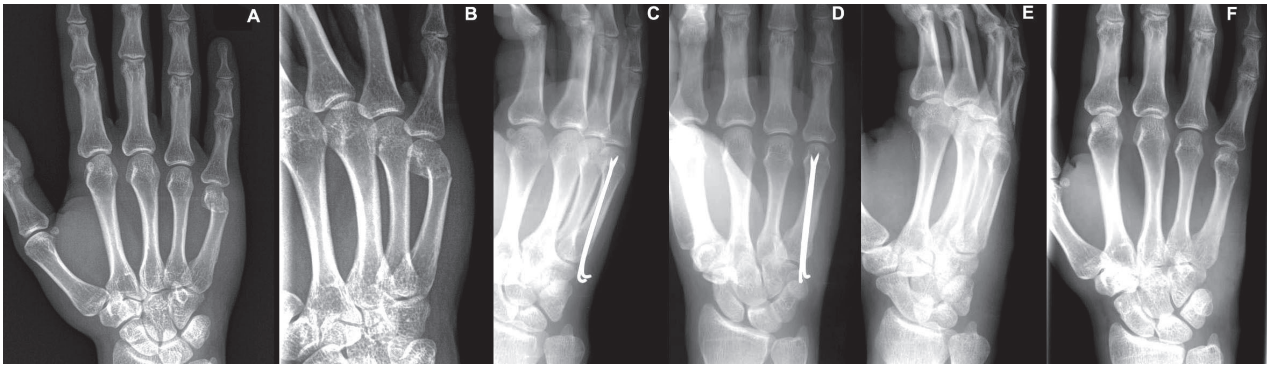

Figure 1. Case 7: A,B pre-operative X ray; C,D post-operative check-up; E,F follow-up 36

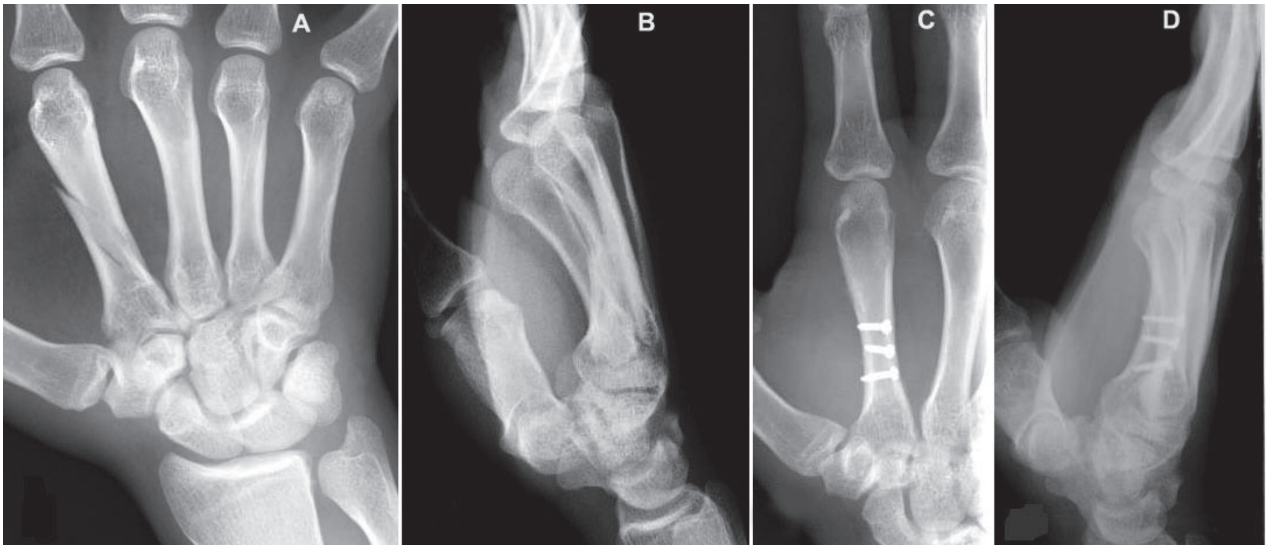

Figure 2. Case 23: A,B pre-operative X ray AP, LL; C,D follow-up X ray AP, LL at 21 months.

tal plane and one (n.4) case with an angular deformity of 5° in the coronal plane. In the percutaneous K-wire group, there were 8 cases of malunions (mean angular deformity: 8.125°): one type-2, A3 (n. 49) and six type-3, A1 (n. 4, 5, 36, 44, 47), A2 (n. 13), A3 (n. 12). Only one case, type-2, A1 (n. 6), was present in the screw group (10°). Considering the mean angular deformity, and the clinical and functional aspects of these patients, we did not suggest further surgery in any case. Overall, no immediate complication was seen in either group. None of the patients had a clinically detectable rotational deformity or stiffness, and they reported satisfaction with their resulting appearance. Grip strength was not impaired in comparison with the uninjured hand. There was no infection, hardware breakage, or hardware penetration into the joint in the two groups. Thus, all the patients who were employed at the time of the injury continued with their previous occupation.

Discussion

Treatment of displaced extra-articular fractures of the metacarpals is much debated in the literature. Most cases could be managed with conservative methods after closed reductions (4-9), and the indications for accurate open reduction and internal fixation are few, probably less than 5% of all hand fractures (30). However, when an unacceptable reduction persists or in cases of displaced intra-articular fractures, multiple fractures, open fractures with associated soft tissue damage and bone loss, surgical intervention is mandatory. Among the various surgical options, intramedullary K-wire osteosynthesis of the metacarpal bones is preferable because of the simplicity of the technique, limited operating room time, and minimum soft-tissue dissection and scarring (31). Further, the closed approach guarantees good consolidation, although malunion may occur in unstable displaced fractures, mostly concerning rotation and metacarpal shortening. In an experimental study on cadavers, Strauch et al. (32) showed that every 2 mm of metacarpal shortening gave rise to an average of 7° of extensor lag at the metacarpo-phalangeal joint. The angle of metacarpal neck fractures exceeding 30° causes a reduction in grip strength. In fact, Ali (33) found that angles >30° decrease muscle strength of the flexor digiti minimi and finger motion. Low et al. (34) demonstrated fracture angulation >30° and shortening >3 mm resulted in a decrease of flexion force in extrinsic tendons. Based on the biomechanical evidence reported, a metacarpal neck fracture is defined unstable and requires open reduction and internal fixation when it is shortened more than 3 mm or angulated more than >30° (35), although the indications in the literature vary greatly (36-44). Plating guarantees good reduction of the unstable displaced metacarpal neck and shaft fractures in these cases, as well as early mobilization of fingers during post-operative course (45), and is very frequently used today (14,16), although its ultimate role remains unclear (46). In the past, many authors have reported successful results in a series of metacarpal fractures treated with screws or plating (47-51). However, the drawbacks of this approach may include subcutaneous and tendon irritation – even tendon rupture – but mainly finger stiffness or nonunion (53, 54). These are difficult to solve, and often there is need for hardware removal (54, 55).

Fujitani et al. (35) conducted a comparative study between intramedullary nail and low-profile plate fixation for unstable neck fractures and found that the range of finger motion in the intramedullary fixation group was considerably better than in the plate group. In fact, open reduction and internal fixation by plate and screws may generate additional fibrosis around the metacarpal joint. Thus today, many surgeons prefer K-wires, not only for metacarpal neck fractures, especially the fifth (13,56-61), but also for shaft fractures (13,59,61). Intramedullary K-wire osteosynthesis was initially preferred (62-64) because of the simplicity of the method and because it imposes the least amount of strain on the sliding tissue. However, some authors object (65) that anterograde insertion of a K-wire to the metacarpal shaft may be difficult due to the poor control of the tip and the angle of introduction. To overcome this problem, we recommend the use of angled K-wires (66,67). In the last decade, antegrade intramedullary nailing, like Bouquet osteosynthesis, which was originally described by Foucher (25,26) in 1975, is mainly preferred (56-58,61) by surgeons and has gained popularity as it is minimally invasive and relatively simple (68). Since Foucher's paper, several articles have described variations of the technique, reporting excellent results (69-79). Other authors have reported good results with retrograde treatment (60) since 1957, when the military surgeon Lord (80) described this technique for fixation of displaced metacarpal fractures. More recently, Lee et al. (81) reported good clinical and radiographic outcomes with a low rate of complications by using a retrograde intramedullary multiple K-wire fixation technique without dorsal skin incision and arthrosis in the metacarpophalangeal joint associated with cartilage damage. Winter et al. (82) investigated also patient satisfaction, reporting 94% of patients satisfied or very satisfied. In the literature, wires are considered safe with regard to complications, although there is a possibility of K-wire migration. Some cases have been mentioned in which there has been distal perforation of the metacarpal head and infections, especially when K-wires were not sunk into the skin (83).

We find it best to aim at uniform treatment of extra-articular metacarpal fractures, both metaphyseal and diaphyseal, with two types of techniques, which we believe are relatively non-invasive: no open reduction with wires for metaphyseal or transverse shaft fractures, and open reduction with screws for spiroid shaft ones. The comparison of the data found in this study indicates that neither of the two procedures provides better outcomes as both have resulted effective in maintaining fracture restoration. Cases have also been reported of good results with screws applied without opening the fracture (12). In our experience, open reduction with limited exposure is necessary for correct positioning of the screws perpendicularly to the fracture plane. Both types of treatment, with screws or wires, involve immobilization for three weeks which, has not lead to joint stiffness. We had no cases of K-wire migration, in particular into the joint, or nonunion or stiffness. As the cases of malunions presented a mean angular deformity less than 9° without any serious rotational deformity, none of them required further operation. However, malunion has been reported (854) to be the main concern in terms of complications with any management technique, and although overall results of metacarpal fractures are very good, no technique is failsafe. We therefore believe that antegrade and medial access according to Foucher for such fractures does not lead to reduced sensitivity. Antegrade access, which we always used in our cases, seems to be more reliable because retrograde pinning may cause more restriction of metacarpo-phalangeal joint motion due to scarred adhesions of the extensor hood (25,26,56-58,61).

The limited number of patients for each group, their lack of randomization, and the range of different fracture types and level make the comparison (between surgical procedures) difficult. Further, the selection between the two surgical techniques and implants was based on the preferences and experience of the surgeons involved in the operations. Finally, the radiographic measurement and the fracture angulation was difficult to determine in the lateral view due to overlapping of the metacarpal bones, which could have affected the data to a small degree.

In conclusion, according to our results and those reported by Friedrich and Vedder (85), we believe that treating transverse or slightly oblique metacarpal shaft fractures with percutaneous intramedullary K-wires constitutes an attractive option, limiting damage to the periosteum, although cases of slight malunion may occur. In fact, we treated 6 patients with type-2 fractures (1A1; 2 A2; 3 A3) by K-wires obtaining a mean Mayo Wrist Score of 92.50 points (range, 80-100 points) and a mean Dash Score of 5.55 points (range, 0.83-11.67 points). However, for spiroid shaft fractures, we believe screws are more effective. There were 16 patients with the this type of fracture (17 A1; 3 A3) treated by screws, and they achieved a mean Mayo Wrist Score of 96.87 points (range, 85-100 points) and a mean Dash Score of 4.11 points (range, 0.00-15.83 points). Further, intramedullary K-wire fixation represents the gold standard, as confirmed by recent review (86), for displaced unstable metacarpal neck fractures, in particular for boxer's fractures. Hence, in our series, the patients with type-3 fractures were treated by K-wires in 21 cases (18 A1; 1 A2; 2 A3;), reporting a mean Mayo Wrist Score of 96.19 points (range, 85-100 points) and a mean Dash Score of 3.88 points (range, 0-9.17 points), while the only case treated by screws (fracture A2) obtained a Mayo Wrist Score of 100 points and a Dash Score of 0 points. Instead, displaced fractures of the base may be treated with either wires or screws, whereas condylar fractures need an intra-articularly placed interfragmentary screw fixation (87). There were 4 patients with type-1 fractures (4 A1) treated by K-wires, resulting in a mean Mayo Wrist Score of 97.5 points (range, 90-100 points) and a mean Dash Score of 3.54 points (range, 0-7.5 points), while only one patient treated by screws obtained a Mayo Wrist Score of 100 and a Dash Score of 0.83 points.

Finally, concerning the comparison between intramedullary nail and plate fixation for unstable neck fracture treatment, we think percutaneous intramedullary K-wires are to be preferred, since plating may lead to complications due to periosteal detachment and scarcity of soft tissue. In addition, exposing the tendons may lead to metacarpo-phalangeal joint stiffness. We think intramedullary K-wire fixation of metacarpal shaft fractures should be compared with nailing of long bone fractures, such as in cases of femur and tibia shaft fractures, in which plating of transverse shaft fractures is now rarely used.

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