

Closed reduction intermetacarpal Kirschner wire fixation in the treatment of unstable fractures of the base of the first metacarpal

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A.P.A. Greeven

T.D. Alta

R.E. Scholtens

P. de Heer

F.M. van der Linden

Abstract

The purpose of this study was to describe the results of extra-articular and intra-articular fractures, at the base of the first metacarpal, treated with closed reduction and percutaneous fixation with intermetacarpal Kirschner wires. Outcome was evaluated by experienced pain, functional outcome and radiographic indications for arthritis. In total, 25 patients with unstable fractures at the base of the first metacarpal underwent closed reduction and percutaneous fixation of the fracture. Prospectively collected data of 25 consecutive patients were evaluated retrospectively, assessing stability of fixation, operation time and the occurrence of fracture dislocation during and after treatment. All patients were assessed at 1, 3, 6 and 24 months. Follow-up included questionnaires: functional tests including Grip and Pinch measurement and Radiographic analysis for post-traumatic arthritis, using the modified Eaton-Littler classification. In total, 15 patients with extra-articular fractures and 10 patients with intra-articular fractures were treated with this technique. In the group of extra-articular fractures of 15 patients, only one patient had loss of Grip strength greater than 20% in comparison with the contra-lateral side (corrected for hand dominance). No clinically important difference was found for Pinch strength. One patient experienced functional limitations and was unable to return to a previous hobby. In the patients' group with intra-articular fractures, seven patients had a Bennett's fracture and three a Rolando's fracture. One patient with a Bennett's fracture had a loss of Pinch strength greater than 20% corrected for hand dominance. One of the three patients with a Rolando's fracture had Grip loss greater than 20%. None of the patients with intra-articular fractures experienced any functional limitations. The described fixation procedure results in a stable fixation of the fracture fragments, and no secondary dislocation of the fracture occurred. Fractures consolidated within 32 (26–50) days and no new fractures were observed. These results suggest that this technique can be safely used in the treatment of extra-articular fractures as well as intra-articular fractures at the base of the first metacarpal.

Level of Evidence: Therapeutic study, Level III

Introduction

Unstable first metacarpal base fractures are usually treated surgically; however, it is still debated whether closed or open reduction gives optimal results [20, 28, 31, 42, 43]. Various surgical procedures have been described, including intra-articular positioned osteosynthesis [29, 30, 32, 44-48]. In the late 1980's, a retrospective study described the treatment of fractures at the base of the first metacarpal bone with parallel extra-articular positioned Kirschner wires [11]. In the article by van Niekerk, two of the 23 included patients could not be treated with closed reduction and K-wire fixation, and open reduction and Kirschner wire fixation were necessary. The treatments of three other patients were not defined. During follow-up (6.25 years, range 1.5-9 years), nine patients reported slight complaints of which three patients reported these complaints to interfere with daily activities, hobby or sport. On the basis of these results, the authors advocated the closed reduction and fixation method, as open reduction and fixation would be more difficult.

Several other percutaneous fixations have been described placing the Kirschner wires through the base of the first metacarpal and into the trapezium [49, 50]. Intra-articular Kirschner wires give additional damage to the articular surface. This seems contradictory in the treatment of intra-articular fractures with the aim of anatomical reduction and preventing the development of post-traumatic arthritis.

As the reported results by van Niekerk are incomplete and nine out of 23 patients reported complaints, the current study evaluated the closed reduction and extra-articular fixation method to see if there is still medical evidence for its wide use in the Netherlands. The purpose of this study was to evaluate the clinical and radiological outcomes of the closed reduction and percutaneous fixation method described by van Niekerk in patients with intra- and extra-articular fractures of the base of the first metacarpal.

Materials and methods

The medical ethics committee of the Groene Hart Hospital approved this study. Prospectively collected data of patients presenting with unstable fractures of the base of the first metacarpal at our Accident and Emergency Department between 1998 and 2008 were retrospectively reviewed. The 1972 Green and O'Brien classification was used to describe all fractures (**Figure 1**) [51].

In total, 25 patients were operated for unstable fractures at the base of the first metacarpal. Under fluoroscopy, closed reduction was achieved by longitudinal traction, abduction and extension of the thumb in combination with pronation of the metacarpus. By keeping traction on the thumb, the reduction was maintained allowing two parallel 1.6 mm Kirschner wires to be placed. The K-wires were positioned approximately 2 cm apart, through the first metacarpal with a 90° angle and also through the second metacarpal (**Figure 2**).

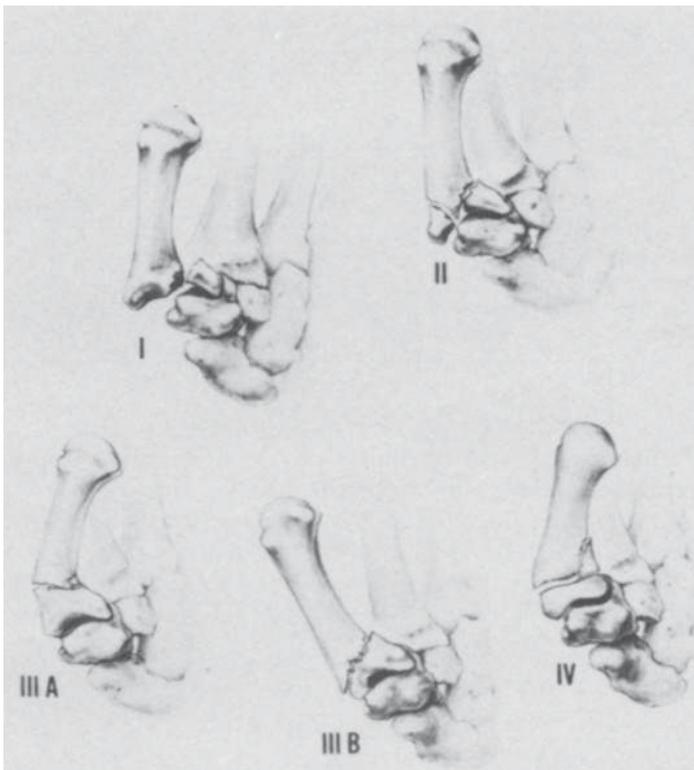


Figure 1. Classification of thumb fractures; Type I Bennett's fracture, Type II Rolando's fracture, Type IIIA Transverse extra-articular fracture, Type IIIB Oblique extra-articular fracture, Type IV Epiphyseal fracture. (Re-printed with kind permission from Elsevier Publisher® from "Fractures of the base of the first metacarpal bone: results of surgical treatment. J.L.M. van Niekerk, R. Ouwens; Injury, Vol 20, Issue 6, p 359-262 (Nov) 1989.)

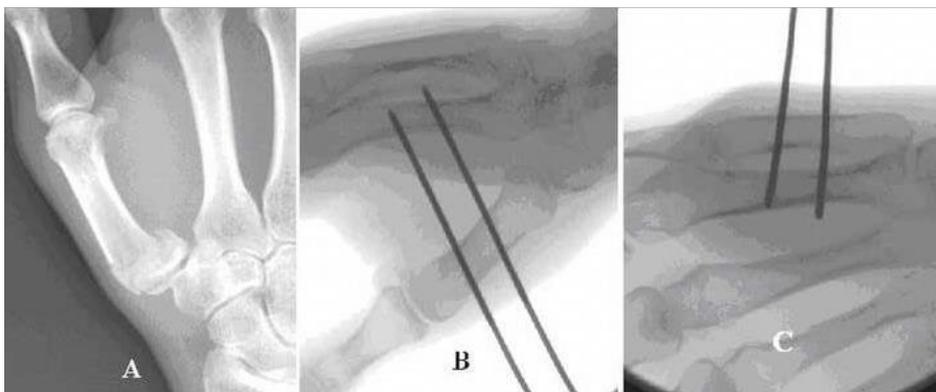


Figure 2. Extra-articular fracture and its surgical treatment. (A) Oblique view of the fracture. (B, C) Oblique views after treatment (same patient)

A maximal intra-articular step-off of 2 mm was accepted. Stability of the fixation was evaluated under fluoroscopy by moving the thumb. In patients where movement in the fracture was still possible, whilst maintaining adequate reduction, an additional cast was applied. Patients were operated by one of the staffs (trauma) surgeons and a surgical resident within 24 hours after trauma.

Patients were seen for follow-up after 1, 3, 6 and 24 months. At 1-month follow-up, radiographs were made to confirm consolidation. When callus formation was present, the K-wires were removed under local anaesthesia. In the absence of callus formation, the patient was re-examined with radiographs 1 or 2 weeks after the first evaluation.

At 3- and 6-month follow-up, wound healing and functional recovery were evaluated.

At 24-month follow-up, patients were asked to answer a questionnaire describing pain and function. To evaluate pain, a visual analogue scale, ranging from 0 cm (no pain) to 10 cm (worst imaginable pain), was used. In addition, patients were asked to report limitations in performing their daily work or hobbies. Function was evaluated by measuring Pinch and Grip-strength using the Jamar® Hydraulic Hand Dynamometer and Jamar® Hydraulic Pinch Gauge (Fabrication Enterprises Inc., New York, NY, USA).

To compare the Pinch and Grip strength between the injured and non-injured hand, a minimally clinically important difference (MCID) was set at a difference of 20%, compared with the contralateral side and adjusted for hand dominance as suggested by Crosby et al [35].

Radiographs were made to evaluate post-traumatic arthritis using the Van Niekerk and Owens modification of the Eaton and Littler classification: Stage I: no clear arthritic changes, Stage II: osteophytes smaller than 2 mm, Stage III: osteophytes larger than 2 mm or joint narrowing and Stage IV: joint space more or less disappeared [11, 37].

The Statistical Package for Social Sciences (SPSS) version 14.0 was used for all statistical analyses. A non-parametric Mann-Whitney test was used to compare the functional results between the injured and non-injured hand.

Results

Twenty-five consecutive patients with a mean age of 31 years (± 14 (SD), range 10–63 years), with 25 closed unstable first metacarpal base fractures were treated. Twenty-one patients were injured after a fall (**Table I**). All patients were male except one 10-year old girl, who was treated for an epiphyseal fracture. Of the 25 patients, 10 patients had an intra-articular fracture (e.g. seven Bennett's and three Rolando's fractures).

Five patients were lost to follow-up after 6 months. At 24-month follow-up, 20 patients were evaluated (80%), and in 17 patients control radiographs were made (68%). None of the patients reported a visual analogue score (VAS) higher than 4 (**Figure 3**). Patients described no loss or restriction of function. All patients returned to their former work. One patient, with an extra-articular fracture, was unable to carry out a previous hobby.

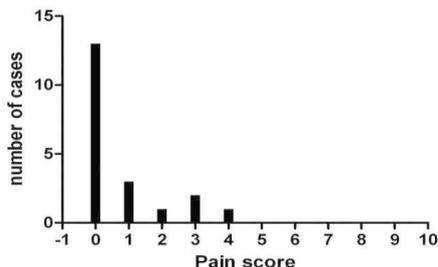


Figure 3. Pain rating (Visual Analogue Score). Pain scoring at 24-months follow-up.

Table I Patient Characteristics

	Sex	Age	Fracture side	Trauma Mechanism	Fracture Type	Operation time (min)	Cast Immobilisation	K-wire removal (days)	Complications
1	M	31	R	fighting	Extra Oblique	30	Yes	31	none
2	M	20	L	fall	Rolando Y	8	Yes	37	none
3	M	16	L	fall	Extra Transverse	25	Yes	28	none
4	M	16	R	fighting	Extra Transverse	20	No	29	none
5	M	63	R	fall	Extra Transverse	10	No	26	none
6	F	10	L	fall	Epiphyseal	32	Yes	32	none
7	M	34	R	fall	Extra Oblique	11	No	50 [#]	Pintract infection
8	M	41	R	fall	Rolando T	9	No	31	none
9	M	43	R	motorcycle accident	Extra Oblique	26	Yes	33	none
10	M	44	L	fall	Extra Transverse	10	Yes	29	none
11	M	46	L	fall	Bennett	20	No	35	none
12	M	17	R	fall	Extra Transverse	13	No	30	none
13	M	26	L	fall	Extra Oblique	7	Yes	38	none
14	M	35	R	fall *	Extra Transverse	113	Yes	41	none
15	M	24	L	fall	Extra Oblique	15	No	26	none
16	M	28	R	fall	Bennett	17	No	29	none
17	M	19	R	fall	Extra Oblique	45	No	30	Pintract infection
18	M	34	R	fighting	Extra Oblique	9	No	31	Pintract infection
19	M	52	R	fall	Extra Transverse	25	Yes	31	none
20	M	43	R	motorcycle accident *	Rolando T	190	Yes	37	none
21	M	49	L	fall	Bennett	20	Yes	28	none
22	M	18	R	fall	Bennett	5	No	30	none
23	M	16	L	fall	Bennett	11	Yes	32	none
24	M	18	L	fall	Bennett	8	No	30	none
25	M	39	L	fall	Bennett	6	No	30	none
		Age	31		Average operation time	27 min	32 days		
						Adjusted for Multi-trauma patients	17 min		

*= multi-trauma patient

Technique

The average operation time was 27 minutes (range 5–190 minutes). Of the 25 patients, two patients had multiple fractures and injuries and operation time for the procedure of the metacarpal fracture was not documented individually. Average operation time corrected for these two multi-trauma patients was 17 minutes (range 5–45 minutes). The type of fracture did not influence the duration of the operation (**Table I**).

Twelve patients received additional cast immobilisation after fixation because of instability of the fracture after testing with fluoroscopy. None of the fractures showed dislocation at 1-month follow-up. K-wires were removed after a mean of 32 days (range 28–50 days). No new fractures were observed during follow-up.

Step-off

All intra-articular fractures were treated with closed reduction and percutaneous fixation. A 2mm step-off was accepted during surgery. No secondary dislocation occurred. Fluoroscopy images were not saved digitally and fluoroscopy images of most of these patients were untraceable. Consequently, the exact accepted step-off of the fracture during surgery cannot be reported, other than smaller than 2 mm.

Function

Functional testing with the Jamar® Dynamometer showed no significant difference in Pinch or Grip strength between the injured and non-injured hand of each patient (**Figure 4**). Reported pain did not influence the functional outcome. The difference in Pinch and Grip strength adjusted for hand dominance showed that 90% of patients in the extra-articular group and 71% of patients in the intra-articular group had no clinically important difference (**Tables II and III**).

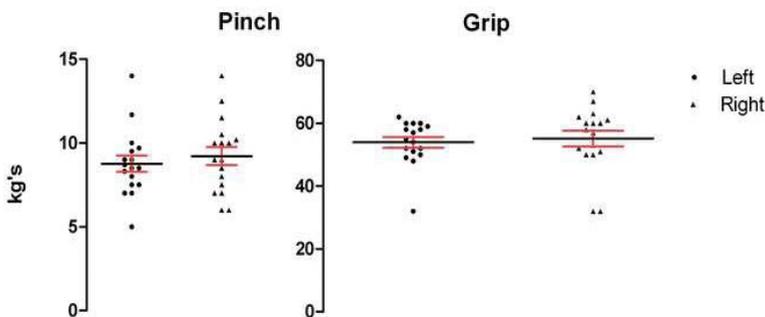


Figure 4. Functional results at 24-months follow-up

Extra-articular fractures

In the group of 15 patients with extra-articular fractures (**Table II**), all patients returned to their previous work. One patient was unable to carry out a previous hobby. In one patient, the Grip

strength of the injured hand showed a loss of 25.7% in comparison with the contra-lateral side. This patient did not experience any loss of function and reported a subjective force of 8 out of 10. None of the patients with extra-articular fractures showed arthrotic changes on radiographs (modified Eaton and Littler classification: Stage I: no clear arthrotic changes).

Intra-articular fractures

In the group of patients with intra-articular fractures, seven patients had a Bennett’s fracture and three patients had a Rolando’s fracture. All patients were able to return to their work and hobbies (Table III).

In the group of patients with Bennett’s fractures, one patient had a loss of Pinch strength of 22.2% in comparison with the contra-lateral side. The patient did not experience any pain or functional limitations and reported a subjective force of 9 out of 10. In one patient with a Bennett’s fracture, the radiographs showed osteophytes smaller than 2mm (modified Eaton and Littler classification Stage II). This patient reported a VAS score of 3.

Of the patients with Rolando’s fracture, one patient showed a difference in Grip strength of 38.5%. The patient reported a subjective force of 8 out of 10 and a VAS score of 1.

Table II Extra-articular fractures at 24 months follow-up

Age	Fracture	Hand dominance	Difference % Pinch	Difference % Grip	Pain (VAS)	Force (subjective)	Work return	Hobby return	Pinch L (kg)	Pinch R (kg)	Grip L (kg)	Grip R (kg)	Arthritis Eaton-Littler Class.	
17	19	Extra Obli	R	4,9%	5,0%	3	7	Yes	Yes	9,7	10,2#	60	63#	1
18	34	Extra Obli	R	*	*	0	4	Yes	No	*	*	*	*	*
19	52	Extra Trans	*	*	*	*	*	Yes	Yes	*	*	*	*	*
12	17	Extra Trans	R	5,9%	-18,0%	0	10	Yes	Yes	9	8,5#	49	60#	1
13	26	Extra Obli	R	6,8%	-25,7%	0	8	Yes	Yes	11,7#	12,5	52#	70	1
14	35	Extra Trans	R	16,7%	4,8%	0	10	Yes	Yes	7,5	9#	59	62#	1
15	24	Extra Obli	*	*	*	*	*	Yes	Yes	*	*	*	*	*
3	16	Extra Trans	R	*	*	0	8	Yes	Yes	*	*	*	*	*
4	16	Extra Trans	R	0,0%	3,8%	0	10	Yes	Yes	7,5	7,5#	51	53#	1
5	63	Extra Trans	R	0%	24%	0	10	Yes	Yes	10	10#	48	50#	1
6	10	Epifysiolyse	L	-16,7%	0%	0	8	Yes	Yes	5#	6	32#	32	1
7	34	Extra Obli	*	*	*	*	*	Yes	Yes	*	*	*	*	*
1	31	Extra Obli	R	17,4%	0%	0	10	Yes	Yes	8,5	11,5#	60	60#	1
9	43	Extra Obli	R	5%	6,9%	0	8	Yes	Yes	9,5	10#	54	58#	1
10	44	Extra Trans	R	5,9%	8,5%	1	10	Yes	Yes	8,5#	8	58#	61	1
31									Average:		8,7	9,3	52	57

*= lost to follow-up

Table III Intra-articular fractures and Difference in Pinch and Grip

Age	Fracture	Hand dominance	Work Return	Hobby Return	Pain (VAS)	Force (subjective)	Pinch (kg)		Grip (kg)		Difference % Pinch	Difference % Grip	Arthritis Eaton-Littler Class.	
							L	R	L	R				
21	Bennett	L	Yes	Yes	4	10	7,0#	6,0	58#	50	14,3%	13,8%	1	
22	Bennett	*	Yes	Yes	*	*	*	*	*	*	*	*	*	
23	Bennett	R	Yes	Yes	0	9	7,0#	9,0	57#	60	-22,2%	5,0%	1	
24	Bennett	*	Yes	Yes	*	*	*	*	*	*	*	*	*	
25	Bennett	L	Yes	Yes	1	7	8,0#	7,0	62#	52	12,5%	16,1%	1	
11	Bennett	L	Yes	Yes	3	10	9,0#	10	55#	57	-10,0%	-3,5%	2	
16	Bennett	R	Yes	Yes	2	10	8,7	10,5#	50	51#	17,1%	2,0%	1	
2	Rolando Y	R	Yes	Yes	0	9	*	*	*	*	*	*	*	
8	Rolando T	L	Yes	Yes	0	10	14	14#	60	67#	0,0%	10,4%	1	
20	Rolando T	R	Yes	Yes	1	8	8,3	7,0#	52	32#	-15,6%	-38,5%	1	
32	Average:							8,9	9,1	56	53			

* = lost to follow-up

Complications

In three patients, pin-tract infections occurred requiring treatment with oral antibiotics. In one of these patients, K-wire removal was delayed (50 days) compared to the average (32 days) of all 25 patients (**Table I**). One patient complained of a cosmetic deformity of the thumb. Neither clinical examination nor radiographic imaging showed an objective deformity (**Table I**); the patient was referred to another hospital for a second opinion.

Lost to follow-up

In total, five patients (20%) were lost to follow-up at 24 months, three of these patients had an extra-articular fracture. Two patients had returned to work and hobbies at previous follow-up. One patient was unable to carry out a previous hobby. This was the patient who was referred to another hospital for a second opinion. One other patient had been successfully treated with antibiotics for a pin-tract infection. Two patients with extra-articular fractures were interviewed on the telephone because they were unable to visit the hospital for clinical examination at 24 months. Both patients did not report any pain, but one experienced loss of force (**Table II**).

Two patients with intra-articular fractures were lost to follow-up at 24 months. Both patients had returned to work and hobby during earlier follow-up. One other patient did not visit the hospital at 24-month follow-up and was interviewed on the telephone reporting no pain and a subjective force of 9 out of 10.

Discussion

The purpose of this study was to evaluate if extra-articular as well as intra-articular fractures could be treated successfully with Van Niekerk's closed reduction and percutaneous fixation [11].

The described technique gave adequate fixation of the fracture in all 25 patients. No dislocations of the fractures occurred during treatment. All patients with intra-articular fractures returned to their former work and hobby. Only one patient, with an extra-articular fracture, was unable to return to a previous hobby.

Ninety percent of the patients with extra-articular fractures had no clinically important difference in Pinch or Grip strength. The difference in Pinch and Grip strength showed that 71% of patients with an intra-articular fracture did not have a clinically important difference.

The treatment of articular fractures and fracture dislocations at the base of the first metacarpal are challenging [47]. Previous authors have stated that the quality of the reduction is correlated with the development of arthritis, although it had developed in almost all cases, even after exact reduction [20]. The amount of anatomic incongruity that can be accepted is still debated. Several authors accept an intra-articular step-off of 2mm [43, 52]. Other authors will not accept any displacement and choose open reduction and internal fixation to achieve

this. Extensive dissection for open reduction can result in further damaging of the already injured hand [37].

Percutaneous techniques cause less damage to the surrounding soft tissues and are associated with less infections and ligament damage [34, 52, 53]. Huang and Fernandez stated that in most cases Bennett's fractures can be treated with closed reduction with Kirschner wire fixation [46]. Other authors reported good results in treating Rolando's fractures with external fixators [54]. Niempoog and Waitayawinyu reported very good results when an external fixator was applied in combination with Kirschner wires [55]. The position of these Kirschner wires is similar to the intermetacarpal Kirschner wires in the current technique.

In this study, all patients with an intra-articular fracture (Bennett's and Rolando's fracture) returned to their work and hobbies, and only one patient showed modified Eaton and Littler classification Stage II on radiographs. In three patients, pin-tract infections occurred which were successfully treated with oral antibiotics. All pin-tract infections occurred in patients with extra-articular fractures. Fracture consolidation took longer than average in one of these patients. If this was caused by the infection is unknown. In all three cases no additional casting was applied. Maybe cast immobilisation protects pin tracts from becoming infected.

A limitation of this study is the 20% loss to follow-up at 24 months. Secondly, the study is a case series and consequently there is no control group. Although the data is prospectively collected, analysis is done retrospectively. All unstable fractures at the base of the first metacarpal were treated similarly. Within the intra-articular group, seven Bennett fractures and three Rolando fractures were treated. Another limitation is that the exact accepted intra-articular step-off after fixation was not exactly known per patient, other than smaller than 2 mm.

In addition, no standardised questionnaire was used. And for optimal evaluation of radiographic arthritis longer follow-up could be beneficial [37].

For future studies it could be interesting to focus on larger groups of patients with similar fractures. It would also be valuable to compare this closed technique with open reduction and internal fixation.

In this study we show that closed reduction intermetacarpal Kirschner wire fixation can be safely used in the treatment of extra-articular fractures at the base of the first metacarpal. Intra-articular fractures at the base of the first metacarpal can be treated with this technique provided there is a maximal intra-articular step-off of 2 mm after closed reduction and percutaneous fixation.