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Comparison between Two Methods of Fixation of Second and Third Metacarpal Shaft Fractures: A Meta-Analysis

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ABSTRACT

Background: Metacarpal bone fractures considered one of the common skeletal fractures, accounting for 36% of all hand and wrist fractures.

Patients and Methods: Only clinical studies of both methods used in the management of closed fractures of the second and third metacarpals were included in this review. It also included studies comparing open reduction and int. fixation with plate and screws Vs. percutaneous crossed K-wire fixation for metacarpal fractures. The Ten papers included in the systematic review and meta-analysis were retrospective cohort studies published between 2003 and 2019. The aim of this study is to evaluate the final results and postoperative complications for two methods of fixation within the treatment of fractures of Second and Third metacarpal bones: Fixation with plate and screws Vs. percutaneous crossed K-wire.

Results: No specifications used for the pattern of fracture, except for the fractures involving shaft of the second and the third metacarpals. All fractures needed to be operated due to deformity, angulations or rotation. No correlation could be done between types of fracture (i.e., spiral, oblique) and functional outcome. As all studies discussed the same indication for intervention, and on the other side, a correlation between type of fixation and functional outcome could be done.

Conclusion: No recommendation made that one fixation technique is superior to another, and the complications associated with ORIF or K-wire fixation in the management of metacarpal fractures are distinct.

Key Words: *Open reduction – Internal fixation – Percutaneous kirschner wires fixation – Fracture 2nd and 3rd metacarpals.*

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INTRODUCTION

The metacarpal bone fracture considered one of the common skeletal fractures **[1]**, Most of metacarpal shaft fractures can be repaired without surgery. Malrotation, angulation, shortening, a large number of fractures, as well as fractures accompanying soft tissue damage or bone loss are all indications for surgical intervention **[2]**.

Many factors influence the various treatment modalities available to allow returning to a normal lifestyle and work activities, also, most importantly, restoration of function, including the patient examination, the mode of injury, the fracture pattern, and the time of delay **[3]**.

For the diagnosis and treatment of metacarpal fractures, a complete understanding of anatomical distribution of the metacarpals is required. The 2nd and 3rd carpometacarpal joints (known to be the fixed hand unit) were found to have increased restriction of flexion-extension motions than the 4th and 5th carpometacarpal joints (11 degrees, 7 degrees to 20 degrees, 27 degrees, respectively), so, angulation will cause pronounced functional deficit in 2nd and 3rd metacarpals **[4]**.

Open reduction and internal fixation became popular after development of novel fixation procedures for metacarpal fractures, as the stable fixation aids in early mobilisation. Improved instruments and materials are further grounds for transitioning to open reduction and internal fixation **[5]**.

Extra-articular metacarpal fractures are fixed with percutaneous fixation with k-wires, a surgical method. It is less intrusive, more adaptable, and speedier when compared to other procedures **[6]**.

With the exception of some drawbacks caused by the invasive nature of the procedure, which resulted in adhesions, postoperative scar, infection, and the possibility for plate removal, open reduction and internal fixation (ORIF) with plate and screws provides stable fixation while also permitting early ambulation. There is no definitive treatment for metacarpal fractures because each method has benefits and drawbacks **[7]**.

PATIENTS AND METHODS

The Ten papers included in the systematic review and meta-analysis were retrospective cohort studies published between 2003 and 2019, with 318 patients included.

Criteria for contemplating studies for the review:

• *Type of studies:*

This systematic analysis included only clinical studies using open reduction and internal fixation using plate and screws versus percutaneous crossed Kirschner wires fixation for the management of second and third metacarpal bone fractures.

• *Types of interventions:*

This study compared two surgical techniques for management of second and third metacarpals fractures using plates and screws versus K-wires.

• Types of outcome measures:
- Range of motion.
- Hand grip.
- Patient satisfaction.
- Occurrence of complications such as: Malunion, non-union, stiffness, hematoma, infection and wound dehiscence.

• *Inclusion criteria:*
- Studies from any geographical location.
- English language papers.
- Study plan: Comparative (randomized or non-randomized), prospective or retro-spective studies.
- Target cases: Extra-articular fracture of the Second, and Third metacarpal shaft.
- Intervention: Open reduction and internal fixation using plate and screws versus fixation using percutaneous K-wires.

• *Exclusion criteria:*
- Published abstracts.
- Study with duplication of data.
- Papers in an exceedingly in a peer reviewed journal.

Search strategy for identification of studies:

A comprehensive search of the literature via electronic databases, including Pubmed/Medline, Cochrane, Web of Science and Google Scholar. An initial search was carried out using keywords: “metacarpal bone fracture”, “open reduction and internal fixation”, “percutaneous wiring” and “metacarpal bones fracture treatment”. Studies of various modalities were analysed and compared regarding the range of motion, hand grip, patient satisfaction and rate of complications. Hand surgeons also could be contacted to assist identifying other published and unpublished relevant studies.

• *Methods of the review:*

- *Locating and selecting studies:*

A copy of every paper included was obtained, and relevant data was abstracted by the primary reviewer for a quantitative overview. The odds were also ascertained. Just in case of discrepancies or when the data presented in this is unclear, abstraction by a second reviewer was sought to resolve this issue.

- *Data extraction:*

Two investigators independently evaluated each included study for results extraction including the primary author, publication year, sample size, the ultimate measures (fracture healing time, operation time, postoperative infection, the incidence of postoperative complications).

Statistical analysis:

Data were extracted to excel, reviewed, then entered to the Statistical Package for Social Science (IBM SPSS) version 20. The qualitative data were within the style of number and percentages while quantitative data were in the shape of mean, standard deviations and ranges.

The comparison between any two groups with qualitative data, were done using Chi-square test and/or Fisher exact test rather than Chi-square test when the count in any cell was less than 5.

The comparison done between quite two independent groups with quantitative data and parametric distribution used a technique ANOVA Test.

The confidence interval was set to 95% and also the margin of error allowed was set to five hundred percent. So, the *p*-value was considered significant because:

• $p>0.05$ represents no significant (NS).

• $p<0.05$ represent significance (S).

• $p<0.001$ represent high significance (HS).

RESULTS

The Ten papers included in the systematic review and meta-analysis were retrospective cohort studies published between 2003 and 2019. With 318 patients included, these studies were divided into two groups, the criteria of the studies used are stated in Table (1).

Only 4 papers were followed-up with time included.

Table (1): Criteria of the included papers (N=8).

Study	Publi-cation	Method	Number of patients	Follow-up
Galanakis et al. **[8]**	2003	K-wire	11	12 (120
Ozer et al. **[7]**	2008	ORIF	14	19 (12-219)
Westbrook et al. **[9]**	2008	ORIF	22	180 (100-240)
Takigami et al. **[10]**	2010	ORIF, K-wire	71	–
Sletten et al. **[11]**	2012	K-wire	32	128 (68-156)
Soni et al. **[12]**	2012	K-wire	20	
Khaled et al. **[13]**	2018	ORIF, K-wire	40	–
Lundin et al. **[14]**	2017	ORIF, K-wire	47	–
Dreyfuss et al. **[15]**	2019	ORIF, K-wire	59	–
Pandey et al. **[16]**	2019	K-wire	32	
Total	–	–	318	–

Table (2): Comparison between 10 Paper regarding Age.

Paper	Age		Test value	*p*-value	Sig.
	Mean ± SD	Range			
Galanakis et al. **[8]**	43±5.5	18-64	7.013	0.000	HS
Ozer et al. **[7]**	28±2.3	19-47			
Westbrook et al. **[9]**	25±1.9	14-79			
Takigami et al. **[10]**	40.5±20.5	–			
Sletten et al. **[11]**	30±9.7	19-50			
Soni et al. **[12]**	35±3.9	20-50			
Khaled et al. **[13]**	33.5±11.5	16-50			
Lundin et al. **[14]**	32.55±6.2	12.4-18.6			
Dreyfuss et al. **[15]**	28.45±8.9	18-57			
Pandey et al. **[16]**	29.34±9.8	16-40			

The Previous Table shows highly statistically significant difference between 10 Paper as regards the Age.

Table (3): Comparison between 6 Paper regarding Sex.

Paper	Sex				Test value	*p*-value	Sig.
	Male		Female				
	No.	%	No.	%			
Takigami et al. **[10]**	53	25.1	18	8.5	31.802	0.000	HS
Soni et al. **[12]**	10	4.7	10	4.7			
Khaled et al. **[13]**	27	12.8	13	6.2			
Lundin et al. **[14]**	34	16.1	13	6.2			
Dreyfuss et al. **[15]**	59	28.0	0	0.0			
Pandey et al. **[16]**	28	13.3	4	1.9			
Total	211	100.0	58	100.0	–	–	–

The Previous table shows highly statistically significant difference between 6 Paper as regards the Sex.

Table (4): Comparison between 10 Paper regarding KW Group and ORIF group. 370 operated fingers included.

	KW group		ORIF group		Test value	*p*-value	Sig.
	No.	%	No.	%			
Galanakis et al. **[8]**	11	5.1	0	0.0	123.873*	0.000	HS
Ozer et al. **[7]**	0	0.0	14	9.2			
Westbrook et al. **[9]**	0	0.0	22	14.4			
Takigami et al. **[10]**	39	18.0	39	25.5			
Sletten et al. **[11]**	32	14.7	0	0.0			
Soni et al. **[12]**	20	9.2	0	0.0			
Khaled et al. **[13]**	20	9.2	20	13.1			
Lundin et al. **[14]**	24	11.1	23	15.0			
Dreyfuss et al. **[15]**	39	18.0	35	22.9			
Pandey et al. **[16]**	32	14.7	0	0.0			
Total	217	100.0	153	100.0	–	–	–

The above table shows the highly statistically significant difference between 10 Paper regarding KW group and ORIF group.

Table (5): Distribution of the studied cases according to Pre-operative angulation in 8 Papers.

Study	Pre-operative angulation	
	Mean ± SD	Range
Galanakis et al. **[8]**	37	32-42
Ozer et al. **[7]**	14	0-82
Westbrook et al. **[9]**	29	16-62
Takigami et al. **[10]**	–	–
Sletten et al. **[11]**	35	1-69
Lundin et al. **[14]**	–	–
Khaled et al. **[13]**	–	–
Dreyfuss et al. **[15]**	–	–

Table (6): Comparison between 2 Paper regarding Fracture location.

K-wire	The fracture patterns							
	Transverse		Spiral		Oblique		Comminuted	
	No.	%	No.	%	No.	%	No.	%
Soni et al. **[12]**	8	33.3	4	50.0	8	100.00	0	0.0
Lundin et al. **[14]**	16	66.7	4	50.0	0	0.0	4	100
Total	24	100.	8	100	8	100	4	100
Test value	14.422							
p-value	0.002							
Sig.	HS							

The Previous table shows highly statistically significant difference between 3 Paper regarding Fracture location.

Table (7): Comparison between 2 Paper regarding Dominant extremity.

K-wire	Dominant extremity				Test value	*p*-value	Sig.
	Yes		No				
	No.	%	No.	%			
Soni et al. **[12]**	14	43.8	6	30.0	0.983*	0.321	NS
Pandey et al. **[16]**	18	56.3	14	70.0			
Total	32	100.0	20	100.0	–	–	–

The Previous table shows that there was no statistically significance found in 2 Papers as regards the Dominant extremity.

Table (8): Comparison between 4 Paper regarding Complication in K-Wire and ORIF.

	Complication				Test value	*p*-value	Sig.
	Yes		No				
	No.	%	No.	%			
K-wire:					–	–	–
- Galanakis et al. **[8]**	0	0.0	11	19.0	12.031	0.000	HS
- Sletten et al. **[11]**	11	37.9	21	36.2			
- Soni et al. **[12]**	3	10.3	17	29.3			
- Lundin et al. **[14]**	15	51.7	9	15.5			
Total	29	100.0	58	100.0	–	–	–
ORIF:					–	–	–
- Ozer et al. **[7]**	2	15.4	12	10.3	10.824	0.012	S
- Westbrook et al. **[9]**	6	46.2	16	13.7			
- Takigami et al. **[10]**	5	38.5	66	56.4			
- Lundin et al. **[14]**	0	0.0	23	19.7			
Total	13	100.0	117	100.0	–	–	–

The Previous table shows highly statistically significant difference between 4 Paper as regards the Complication in K-Wire, and there was statistically significant difference between 4 Paper as regards the Complication in ORIF.

Table (9): Comparison between 3 Paper regarding Time of union in K-Wire and ORIF.

	Time of union		Test value	*p*-value	Sig.
	Mean ± SD	Range			
K-wire:			–	–	–
- Galanakis et al. **[8]**	NA	NA	252.253	0.000	HS
- Takigami et al. **[10]**	1.6±0.6	–			
- Sletten et al. **[11]**	NA	NA			
- Soni et al. **[12]**	10±2.5	8-12			
- Khaled et al. **[13]**	5.89±0.82	–			
- Dreyfuss et al. **[15]**	NA	NA			
ORIF:			–	–	–
- Ozer et al. **[7]**	NA	NA	26.002	0.000	HS
- Westbrook et al. **[9]**	NA	NA			
- Takigami et al. **[10]**	2.6±1.6	–			
- Khaled et al. **[13]**	4.56±0.86	–			
- Dreyfuss et al. **[15]**	NA	NA			

The Previous table shows highly statistically significant difference between 3 Paper as regards the Time of union in K-Wire and ORIF.

Table (10): Comparison between 2 group regarding Hand Grip in Khaled et al. **[13]** Paper.

	Khaled et al. **[13]**				Test value	*p*-value	Sig.
	KW group		ORIF group				
	No.	%	No.	%			
Hand Grip:							
Strong	13	65.0	14	70.0	0.37*	0.831	NS
Average	5	25.0	5	25.0			
Weak	2	10.0	1	5.0			

The Previous table shows that there was not statistically significance found between 2 group regarding Hand Grip in Khaled et al. **[13]** Paper.

Table (11): Comparison between 10 Paper regarding Dash Score.

	Dash score			
	ORIF		K-Wire	
Galanakis et al. **[8]**	–	–	N Av.	N Av.
Ozer et al. **[7]**	8.07±1.36	1-28	–	–
Westbrook et al. **[9]**	5±1.2	1-44	–	–
Takigami et al. **[10]**	N Av.	N Av.	N Av.	N Av.
Sletten et al. **[11]**	–	–	1±0.1	0-39
Soni et al. **[12]**	–	–	N Av.	N Av.
Khaled et al. **[13]**	N Av.	N Av.	N Av.	N Av.
Lundin et al. **[14]**	N Av.	N Av.	N Av.	N Av.
Dreyfuss et al. **[15]**	10.5±1.9	0-40	15.6±3.2	0-53
Pandey et al. **[16]**	–	–	N Av.	N Av
Test value	80.825		663.570	
p-value	0.000		0.000	
Sig.	HS		HS	

The Previous table shows the highly statistically significant difference between 3 Paper regarding Dash Score in ORIF group, and the highly statistically significant difference found between 2 Paper regarding Dash Score in K-wire group.

Table (12): Comparison between 3 Paper regarding DASH Score in KW group.

KW group	DASH score							
	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
Takigami et al. **[10]**	33	40.7	5	41.7	0	0.0	1	25.0
Khaled et al. **[13]**	16	19.8	2	16.7	1	100.0	1	25.0
Dreyfuss et al. **[15]**	32	39.5	5	41.7	0	0.0	2	50.0
Total	81	100.0	12	100.0	1	100.0	4	100.0
Test value				4.406*				
p-value				0.621				
Sig.				NS				

The Previous table shows that there was not statistically significance found in 3 Papers regarding DASH Score in KW Group.

Table (13): Comparison between 3 Paper regarding DASH Score in ORIF group.

ORIF group	DASH score							
	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
Takigami et al. **[10]**	29	39.2	5	41.7	0	0.0	5	71.4
Khaled et al. **[13]**	13	17.6	4	33.3	1	100.0	2	28.6
Dreyfuss et al. **[15]**	32	43.2	3	25.0	0	0.0	0	0.0
Total	74	100.0	12	100.0	1	100.0	7	100.0
Test value				10.587*				
p-value				0.102				
Sig.				NS				

The Previous table shows that there was no statistically significance in 3 Papers regarding DASH Score in ORIF Group.

Table (14): Distribution of the studied cases according to Type of Complication.

Type of complications	ORIF (36 fracture)	K-wire (65 fracture)
delayed union	O	O
Non-union	O	O
failure of fixation	0	0
stiffness/tenolysis	5	1
CRPS	0	0
Infection	2	8
Pain	1	5
Skin irritation	NA	4
Cosmetic deformity	NA	0
New fracture	0	3
Developed tendon irritation.	0	0
Rotational or angular displacement	0	0
Wound complication		2

DISCUSSION

Metacarpal fractures represent one of the most common skeletal fractures, accounting for 36% of all hand and wrist fractures. Most of the metacarpal fractures occur in their shaft. The shaft fractures may be managed conservatively by splinting only or by surgical intervention Indications for surgical intervention are malrotation, angulation, shortening, involvement of adjacent metacarpals, moreover, soft tissue injuries or bone loss **[5]**, Open reduction and internal fixation (ORIF) with screws or plates may be the first choice in displaced metacarpal shaft fractures for better alignment and fixation, on the other hand, closed reduction and percutaneous fixation with K-wires provides stable fixation with less dissection and ensuing fibrosis. Many studies defined the merits of internal fixation while others mentioned that percutaneous K-wires are usually enough. This meta-analysis study, states ways of management of metacarpal shaft fractures, their prevalence, complications and best practice.

Ten studies were included in this meta-analysis study with a total of 318 patients operated upon (370 operated fingers) published between 2003 and 2019. Complication rates are higher in K-wire and ORIF treated patients, according to information from the available literature, which reported on a total of 318 patients who had a metacarpal fracture (29 vs. 13 percent respectively).

No information about the type of fractures, were provided in these studies, concerning the second and therefore third metacarpal. The rational for management of these fractures surgically was either instability, angulation, or deformity. Putting in mind, that those studies did not mention the type of fracture; there was no way to relate fracture type (spiral, oblique) to the functional outcomes. Thus, the only variable in those studies that affected the functional outcome was the way of management whether open reduction and internal fixation or percutaneous K-wire.

Takigami et al. **[10]** found that fixation utilizing the low-profile plates and screw technique for metacarpal and phalangeal fractures is effective and dependable in comparison to K-wire fixation. In accordance, to the fact that the healing time in the plates group was shorter, it was widely assumed that low profile plates fixation considered to be one of the most effective strategies for returning to a normal quality of living.

In addition, Dreyfuss et al. **[15]** found that fixation of metacarpal shaft fractures with plate and screws produced better results than wire fixation in terms of stability, early ambulation, and low plate profile and reducing the extensor tendon adhesions. If pin fixation is decided, secondary rotation can be prevented by using a locking intramedullary nail, multiple nails, or buddy tapping to neighbouring digit.

ORIF was more technically demanding and costly than K-Wires, according to Lundin et al. **[14]**. Moreover, K-wires fixation, provided a wider active range of motion, less liability for infection, less pain during rehabilitation, and required fewer post-operative follow-up visits. As a result, the K-wire was chosen for this study only due to its lower cost. Equivalently, Pandey et al. **[16]** favored the use of K-wire in fracture fixation over plates because fixation by plates has inherent problems such as soft tissue damage, surgical scarring, and implant impingement, Pandey et al. **[16]** preferred the use of K-wire for fracture fixation over plating.

In a prospective comparison study of plates and intramedullary nail for the metacarpal fractures, Ozer et al. **[7]** found no changes in the functional outcome and range of motion. The intramedullary nail group had more cases of loss of reduction, penetration of metacarpo-phalangeal joint, and secondary procedures for nail removal. They did not have to follow true randomization, which means that fracture treatment is influenced by the surgeon's preference, which can affect the outcome.

Although the general functional outcome was reported to be good for both techniques, the data in Takigami et al., (2010) **[10]** shows one ORIF-

treated patient with a DASH score of 38. Such a DASH score is likely to be associated with loss of function. Unfortunately, no further specifications are made, and no explanation is given for this finding by the authors. Similarly, one K-wire patient also scored a relative high DASH score of 38. The authors suggest a plausible reason by explaining the patient had encountered additional injuries to the upper limb, not related to the operated hand, but therefore possibly resulting in a biased DASH score.

Conclusion:

Based on the reported results there is no evidence to suggest one fixation technique over another. The reported complications however for ORIF and K-wire fixation in the treatment of metacarpal fractures are unmistakably different for the two types of fixation.

ORIF was associated with a considerable number of functional restricting complications whereas K-wire fixation resulted frequently in pain that treated conservatively. The significance of these reported findings suggests ORIF to be more preferable surgical technique in comparison to K-wire fixation in the treatment of metacarpal fractures.

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