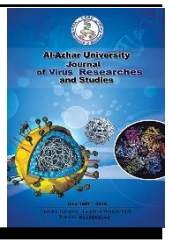
Al-Azhar University Journal
for Virus Research and Studies



Closed Reduction & Pinning of unstable Extraarticular fracture Distal Radius (How many K-wires needed?) Systematic Review

Akram Ahmed Answer Aly[1], Omar Abdelrahman Ahmed[1] and Ashraf Mohammed Abdellaziz[1]

[1]Department of Orthopedic Surgery, Faculty of Medicine for Girls, Al-Azhar University.

***E-mail: karamela.kimo@yahoo.com**

Abstract

Distal radius fractures represent 16% of all fractures of the body and as much as 72% of all forearm fractures. It's also known as wrist fracture, a breaking of the part of the radius bone which is close to the wrist**.** The aim of this study was to review recent trends and different modalities in management of extra articular distal end radius fractures and to conclude the optimal number of K-wires required for best fixation and best results clinically & radiologically. Online search using the Medline database on PubMed, Google scholar, Science direct, American and European Journals from 2010 to 2020; all the English language published studies were identified with the search keywords of, Extra articular distal end radius fracture, treatment of distal end radius, Closed Pinning, Number of K-wires. Among included 12 studies, 4 studies used 2 K-wires, 4 studies used 3 K-wires, 1 study used 4 K-wires and 3 studies used 5 K-wires. There was a better satisfaction rate, significant increase in grip strength and significant increase in DASH Volar tilt with 3 K-wires group more than 5 K-wires group. At the end we found that using 3 K-wires is perfect to maintain the reduction for the extraarticular distal end radius fractures radiologically in a cost-effective manner and high patient's satisfaction rate with least complications.

Keywords: Closed reduction; Pinning of unstable Extraarticular fracture Distal Radius, Number of K-wires.

1. Introduction

Distal radius fractures represent 16% of all fractures of the body and as much as 72% of all forearm fractures. In younger people, these fractures typically occur during sports or a motor vehicle collision. In older people, the most common cause is falling on an outstretched hand [1].

Various modalities of treatment for distal radius fracture are described and the four methods generally followed in treating these fractures are: Conservative treatment in plaster cast with or without manipulative reduction, Closed Pinning with K-wires to maintain reduction while in Plaster, External fixation (bridging or non-bridging), And Open reduction with internal fixation [2].

Closed reduction and cast immobilization may lead to collapse of the radius. Complications as malunion can occur when a fracture heals with improper alignment, articular incongruity, incorrect length, or a

combination of these elements and this could happen especially when fractures treated only with closed reduction and cast immobilization. Patients with symptomatic malunions of the distal radius usually present with restricted wrist range of motion (ROM), wrist pain, reduced grip strength; unsightly appearance; late neuropathy especially of the median nerve, with compression at the carpal tunnel [3].

Closed Pinning "Percutaneous K-wire fixation" provides additional stability and it's one of the earliest forms of internal fixation. After achieving anatomic reduction, the fracture is stabilized with K-wires. This technique is relatively simple and inexpensive. A number of techniques of percutaneous pin fixation have been described: These include pins placed through the radial styloid, two pins crossing into the radius, intrafocal pinning within the fracture site, ulnar to radial pinning without trans fixation of the distal radioulnar joint, one radial styloid pin and a second across the distal radioulnar joint and pins from the ulnar to the radius with trans fixation of the distal radioulnar joint. Kapandji intrafocal pinning is used to prevent displacement of fracture fragments proximally and dorsally thereby acting as a buttress. The pins are inserted into the fracture site both dorsally and radially and then levered up and directed into the proximal intact cortex [4].

The five-pin technique for fixation of distal radius fractures is a modification of the existing closed reduction and K-wire fixation technique. The technique involves closed reduction followed by internal fixation with 5 K-wires [5]. Percutaneous K-wires fixation method could have some disadvantages like the need for cast immobilization and the oblique orientation of pins which do not prevent the collapse that occurs at the fracture site, and we may encounter some complications as: Superficial Pinning site infection, Pin Migration and Nerve Injury [2].

The aim of this study was to review recent trends and different modalities in management of extra articular distal end radius fractures and to conclude the optimal number of K-wires required for best fixation and best results clinically & radiologically.

2. Material and Methods

Online search using the Medline database on PubMed, Google scholar, Science direct, American and European Journals from 2005 to 2021; all the English language published studies was identified with the search keywords of, Extra articular distal end radius fracture, treatment of distal end radius, Closed Pinning, Number of K-wires. Inclusions in this study was Humans, English studies, Extra-articular distal end radius, closed pinning, K-wires. Exclusions were non-human subjects. Non-English studies, Intra-articular distal end radius fractures, Different methods of fixation as cast or fixation with Plates and screws. Abstracts of articles identified using the search strategy were viewed, and articles that appear to fulfill the inclusion criteria were retrieved in full. Data on at least one of the outcome measures must be included in the study. The outcomes from included trials was combined using the Review Manager software and manually screened for eligibility to be included and then PRISMA flow chart was produced based on search results and the inclusion/exclusion criteria to make this study.

2.1 Data extraction

Data were extracted using a standardized data collection form that was developed according to the Cochrane guidelines [6].

The items collected included publication details, study type, numbers of patients, fracture types, the definition of displacement, the type of statistical analysis and details regarding treatment. For each study we determined which predictors of secondary displacement were found statistically significant (p <0.05).

Additionally, we assessed if the predictor was tested in a univariate or a multivariable analysis. For the meta-analysis, predictors and odds ratios or coefficients of predictors of secondary displacement were obtained and collected in a database.

2.2 Statistical analysis

Statistical analysis was conducted using the software Review Manager 4.2, which was provided by Cochrane Collaboration. The treatment effects were expressed as risk ratios (RR), with 95% confidence intervals (CI) for dichotomous outcomes and mean differences (MD) with 95% CI for continuous outcomes. Heterogeneity was tested using the Chi-square test with significance set at $p < 0.1$. The *I*-square test was also used to quantify the effect of heterogeneity within I2 of 50% or higher representing substantial heterogeneity. If there was no statistical evidence of heterogeneity, a fixed-effects model was used; otherwise, a random-effects model was adopted. If standard deviation was required to be calculated from raw data, SPSS 21.0 software was used.

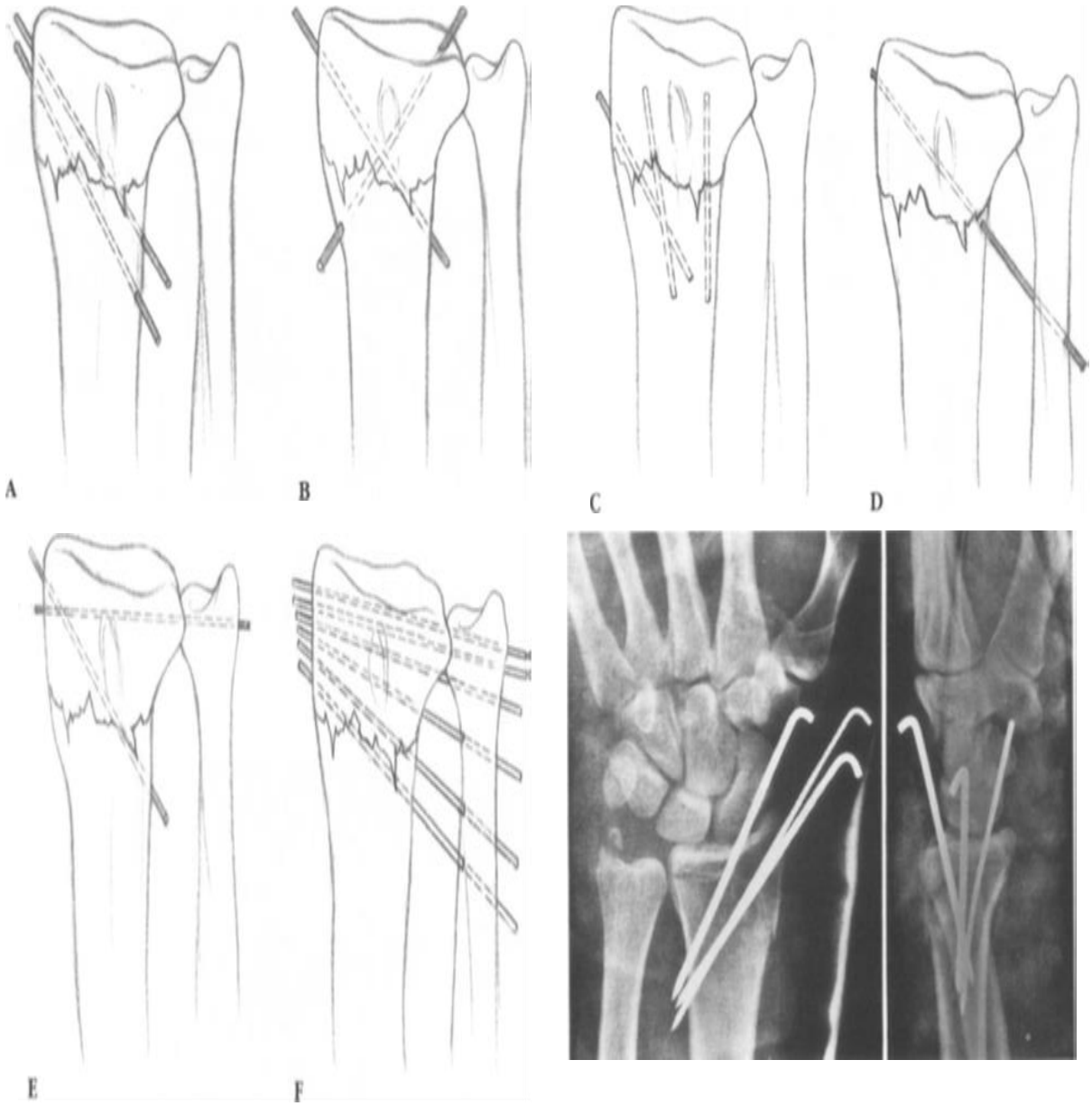


Figure 1: Methods of Percutaneous pinning.

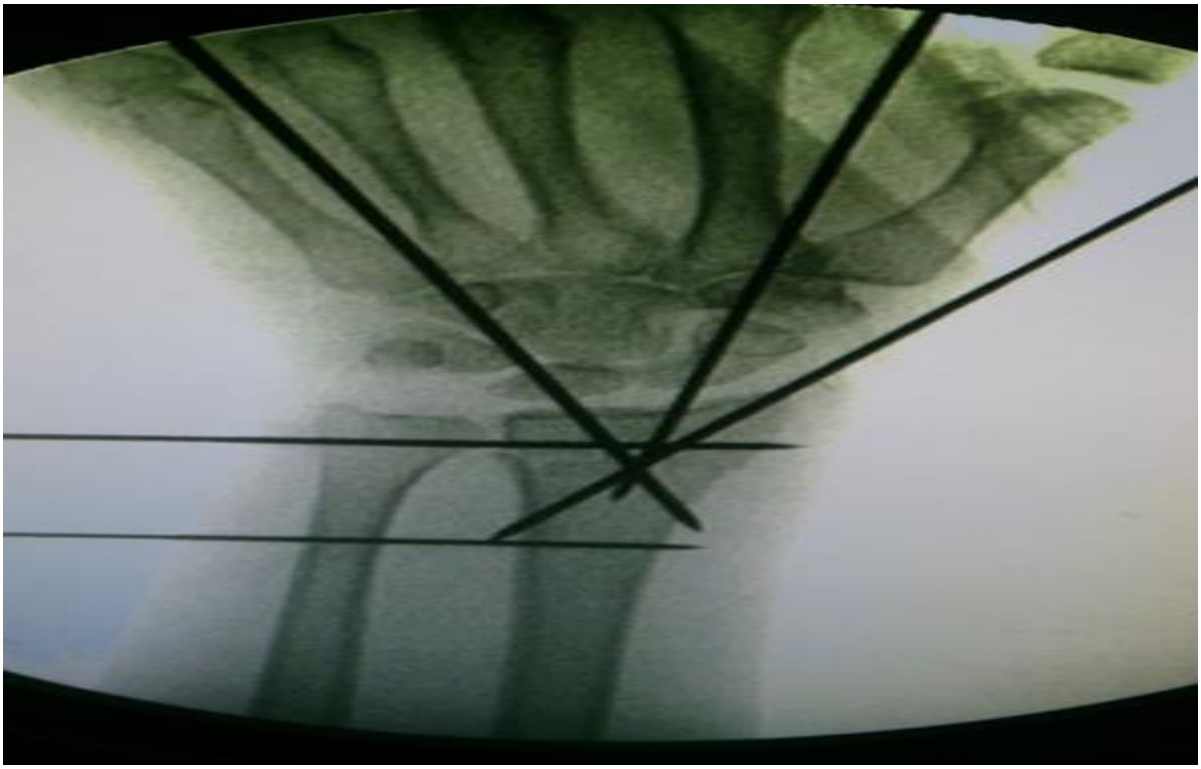


Figure 2: Fixation using five pin technique.

3. Results

Using the forementioned search strategy, 30 studies were identified. Following the title and abstract screening process, 14 studies remained. After a more detailed review on full-text 2 other studies were also extracted. Finally, a total of 12 studies were included in the analysis Figure 1. Among the included studies, 4 studies used 2 K-wires, 4 studies used 3 K-wires, 1 study used 4 K-wires and 3 studies used 5 K-wires. All studies involved in this study had used the same diameter and material of K-wires. This flow-diagram depicts the flow of information through the different phases of a systematic review or meta-analysis. It maps out the number of records identified, included and excluded, and the reasons for exclusions. The results of meta-analyses are often presented in a forest plot, where each study is shown with its effect size and the corresponding 95% confidence interval. The demographic characteristics of the patients in the 12 studies are present then Table (1). All the study was prospective studies. A total of 497 patients were included: 183 cases used 2 K-wires and 166 used 3 K-wires, only one study includes 54 cases used 4 K-wires, while 94 in three studies used 5 K-wires. Study characteristics and outcome were described in all 12 studies in Table (1). The most important outcome results of the different number of K-wires used was the satisfaction, for each study the excellent and good results considered as satisfactory results, from the results it was found that the most significant high satisfaction results in group 3 K-wires, followed by 5 K-wires, while both 2 and 4 K-wires considered as non-satisfactory results in compare to 3 and 5 K-wires Table (2). All the studies reported patient satisfaction data. The test for heterogeneity demonstrated that significant heterogeneity existed among these studies ($p < 0.001$), and a random-effects model was adopted. There was a significant difference between the 3 K-wires and 5 K-wires groups

regarding the patient's satisfaction, the 3 K-wires group show a high satisfaction more than the 5 K-wires group. Figure (2). Ten studies reported grip strength data. The test for heterogeneity demonstrated that significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in grip strength in the 3 K-wires group more than the 5 K-wires group. Table (3), Figure (3).

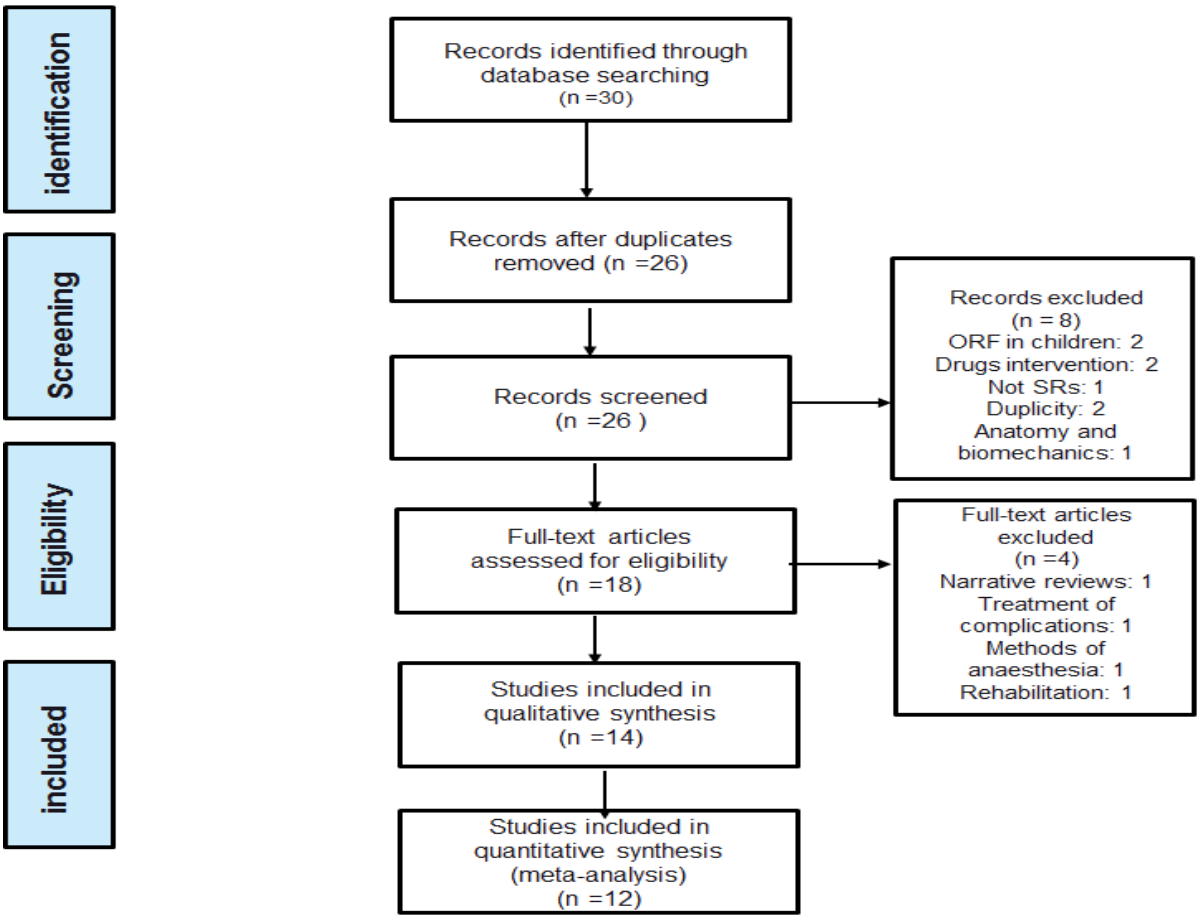


Figure 3**:** A PRISMA flowchart illustrating the selection of studies included in our systematic review.

Table (2): Comparison between different number of K-wires and final outcome (percent of satisfaction).

No. of K-wires	No. of studies	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2	4	71.05	6.06	3.03	61.41	80.69	63.30	77.70
3	4	84.68	6.36	3.18	74.56	94.79	79.00	93.70
4	1	71.8	.	.	.	.	71.8	71.8
5	3	80.83	1.04	0.60	78.25	83.42	80.00	82.00
Total	12	78.84	7.55	2.18	74.04	83.64	63.30	93.70

Table (1): Characteristics and methodological quality of the included studies.

No.	References	Sample size	No. of K-wires	Mean age	Male: female	Grip strength	DASH Volar tilt (°)	Supination (°)	Pronation (°)	dorsiflexion	Ulnar deviation (°)	Radial deviation	Radial inclination	Radial length	Palmar flexion	outcome (satisfactory)
1	Kurup (2007)	76	2	53.4	01:02.3	7.3	18.6									77.7
2	Kurup (2007)	19	3	50.4	01:02.1											84
3	Refai (2019)	30	2	55	01:02.3	8							14.6	8.33	64.8	63.3
4	Konde (2018)	30	2	62.16	01:01.5				64.8	69.9						70
5	El-Adawy (2021)	70	3	45	01:00.7	8.2	20.5	76			79	72.9		10.5	65	79
6	Gunay (2015)	45	3	62	01:04.0	9	20.45	77.2	76.7	74.2	23.6	17.96	21.2	11.93		82
7	Gunay (2015)	47	2	65	01:03.7	8.6	20.38	73.7	72.3	69.6	19.91	17.32	20.17	10.89		73.2
8	Das (2011)	32	3	41.4	01:00.8	10	20.5							9.2	66	93.7
9	Chen (2008)	54	4	52	01:01.2	11	20.1							8.1		71.8
10	Lohith (2017)	49	5	49.4	01:01.2	10	18									80.5
11	Jacob (2014)	15	5	62	01:01.5	8.5	19.5							7.9		80
12	Bhasme (2018)	30	5	45	01:00.7	8.7	18.8							7.4	60	82

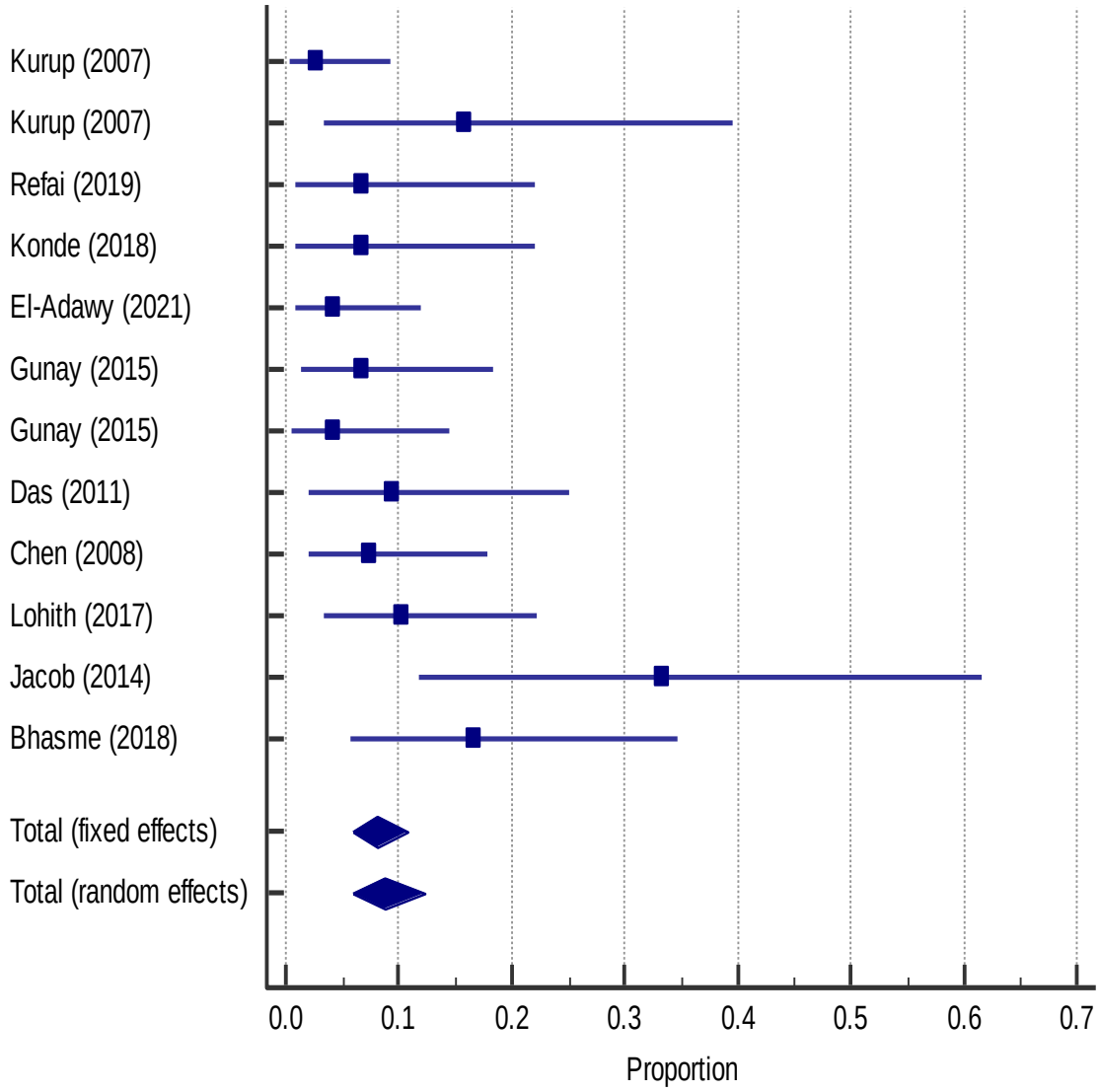


Figure 4**:** Forest plot for different studies weights for the examination of a studied articles percent of satisfaction of 12 randomized trials of unstable Extraarticular fracture Distal Radius management.

Table (3): Meta-analysis regarding Grip strength.

Study	Estimate	Standard Error	95% CI	z	P	Weight (%)	
						Fixed	Random
Kurup (2007)	7.300	2.000	3.380 to 11.220			19.75	19.75
Refai (2019)	8.000	2.000	4.080 to 11.920			19.75	19.75
El-Adawy (2021)	8.200	3.000	2.320 to 14.080			8.78	8.78
Gunay (2015)	9.000	3.000	3.120 to 14.880			8.78	8.78
Gunay (2015)	8.600	2.000	4.680 to 12.520			19.75	19.75
Das (2011)	10.000	3.000	4.120 to 15.880			8.78	8.78
Chen (2008)	11.000	4.000	3.160 to 18.840			4.94	4.94
Lohith (2017)	10.000	5.000	0.200 to 19.800			3.16	3.16
Jacob (2014)	8.500	5.000	-1.300 to 18.300			3.16	3.16
Bhasme (2018)	8.700	5.000	-1.100 to 18.500			3.16	3.16
Total (fixed effects)	8.510	0.889	6.768 to 10.252	9.575	<0.001	100.00	100.00
Total (random effects)	8.510	0.889	6.768 to 10.252	9.575	<0.001	100.00	100.00

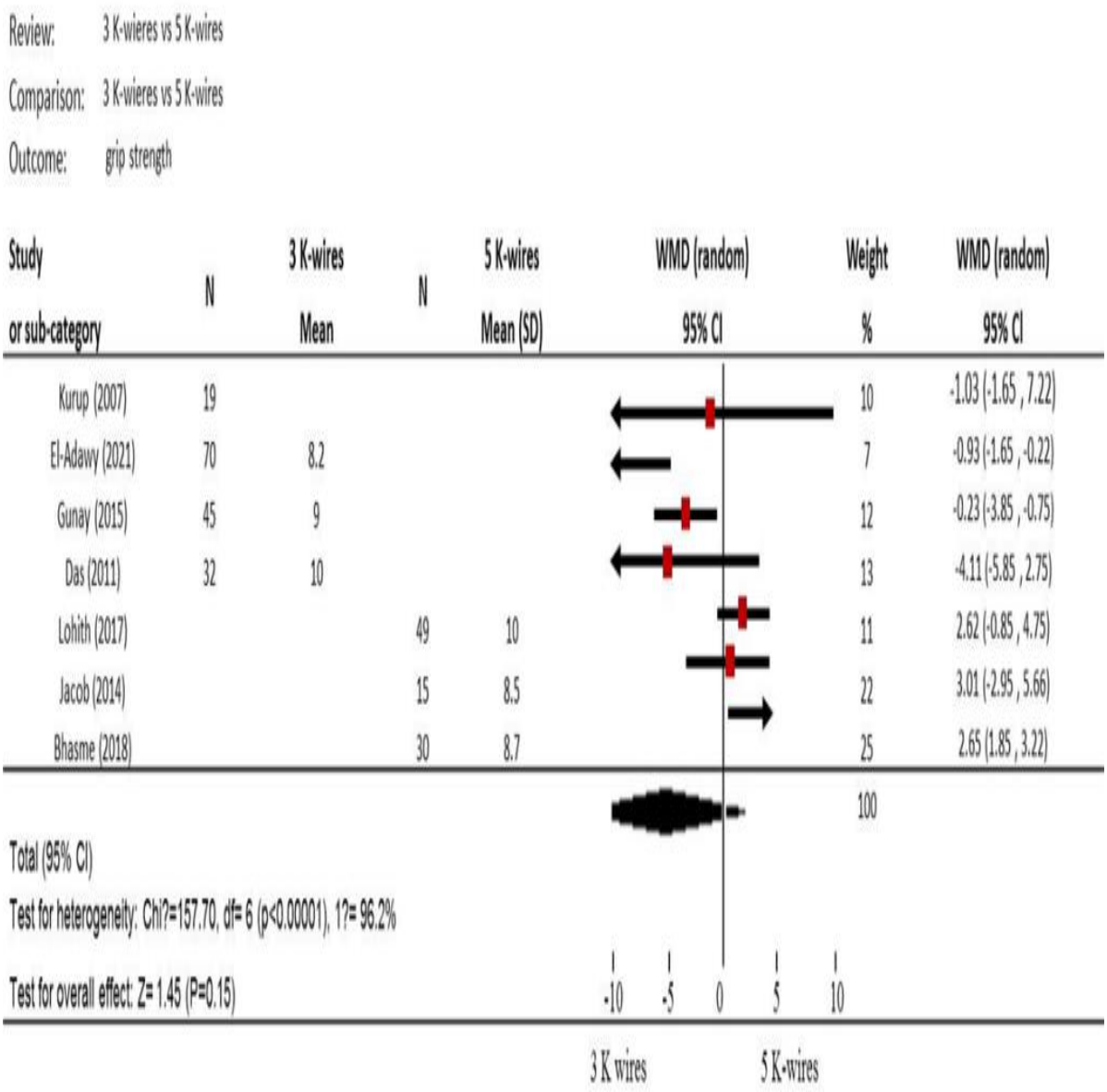


Figure 5**:** Percentage study weights for the examination of a studied articles of 3 K-wires and 5 K-wires regarding grip strength of unstable Extra-articular fracture Distal Radius management.

Table (4): Meta-analysis regarding Dash Volar tilt.

Study	Estimate	Standard Error	95% CI	Z	P	Weight (%)	
						Fixed	Random
Kurup (2007)	18.600	2.000	14.680 to 22.520			24.61	24.61
El-Adawy (2021)	20.500	3.000	14.620 to 26.380			10.94	10.94
Gunay (2015)	20.450	3.000	14.570 to 26.330			10.94	10.94
Gunay (2015)	20.380	2.000	16.460 to 24.300			24.61	24.61
Das (2011)	20.500	3.000	14.620 to 26.380			10.94	10.94
Chen (2008)	20.100	4.000	12.260 to 27.940			6.15	6.15
Lohith (2017)	18.000	5.000	8.200 to 27.800			3.94	3.94
Jacob (2014)	19.500	5.000	9.700 to 29.300			3.94	3.94
Bhasme (2018)	18.800	5.000	9.000 to 28.600			3.94	3.94
Total (fixed effects)	19.768	0.992	17.823 to 21.713	19.924	<0.001	100.00	100.00
Total (random effects)	19.768	0.992	17.823 to 21.713	19.924	<0.001	100.00	100.00

Nine studies reported DASH Volar tilt data. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in DASH Volar tilt in 3 K-wires group more than 5 K-wires group. Table (4), Fig (4) and (5). Eight studies reported Radial length. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in Radial length in 3 K-wires group more than 5 K-wires group. Table (5) and Figure (6). Four studies reported Palmar fixation. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in Palmar fixation with 3 K-wires group more than 5 K-wires group. Figure (7). The incidence of complication in the studied groups show that the lowest percent of complication was found in 3 K-wires group, on the other hand the 4 and 5 K-wires groups showed a significant increase in the incidence of complication which include Pin tract infection, Superficial radial nerve numbness and Nerve injury. On the other hand, the incidence of carpal tunnel syndrome and median nerve compression show insignificant difference between the four studied groups. Table (7).

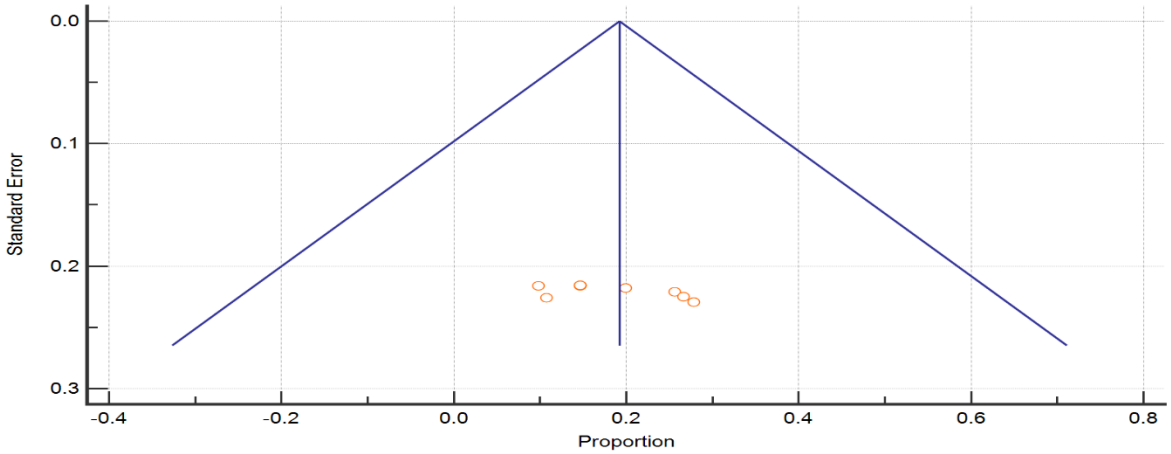


Figure 6: Symmetrical funnel plot for different studies weights for the examination of a studied articles percent of DASH Volar tilt of 9 randomized trials of unstable Extraarticular fracture Distal Radius management.

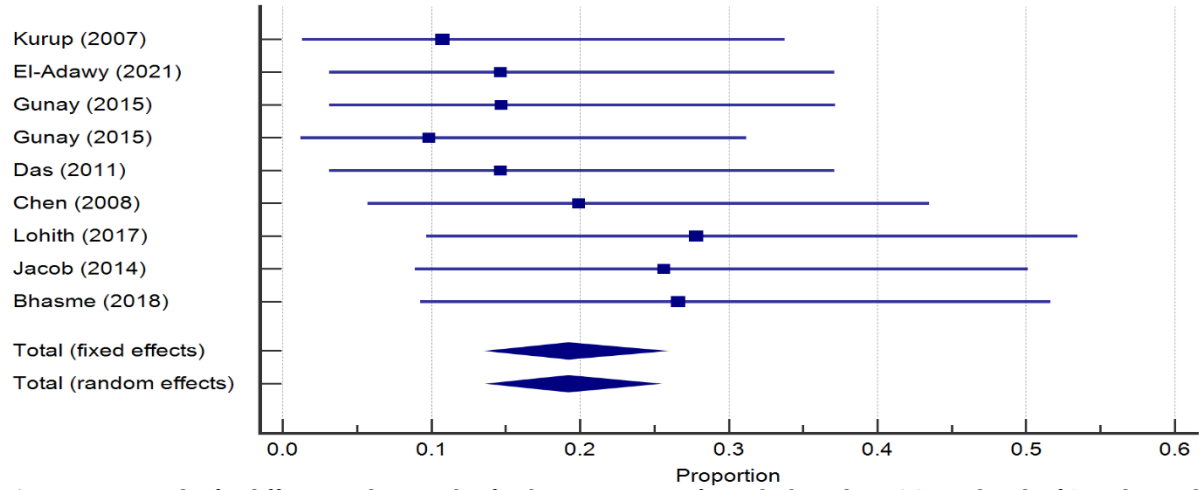


Figure 7: Forest plot for different studies weights for the examination of a studied articles DASH Volar tilt of 9 randomized trials of unstable Extraarticular fracture Distal Radius management.

Table (5): Meta-analysis regarding Radial Length.

Study	Estimate	Standard Error	95% CI	z	P	Weight (%)	
						Fixed	Random
Refai (2007)	8.330	2.000	4.410 to 12.250			25.62	25.62
El-Adawy (2021)	10.500	3.000	4.620 to 16.380			11.39	11.39
Gunay (2015)	11.930	3.000	6.050 to 17.810			11.39	11.39
Gunay (2015)	10.890	2.000	6.970 to 14.810			25.62	25.62
Das (2011)	9.200	3.000	3.320 to 15.080			11.39	11.39
Chen (2008)	8.100	4.000	0.260 to 15.940			6.40	6.40
Jacob (2014)	7.900	5.000	-1.900 to 17.700			4.10	4.10
Bhasme (2018)	7.400	5.000	-2.400 to 17.200			4.10	4.10
Total (fixed effects)	9.671	1.012	7.687 to 11.656	9.554	<0.001	100.00	100.00
Total (random effects)	9.671	1.012	7.687 to 11.656	9.554	<0.001	100.00	100.00

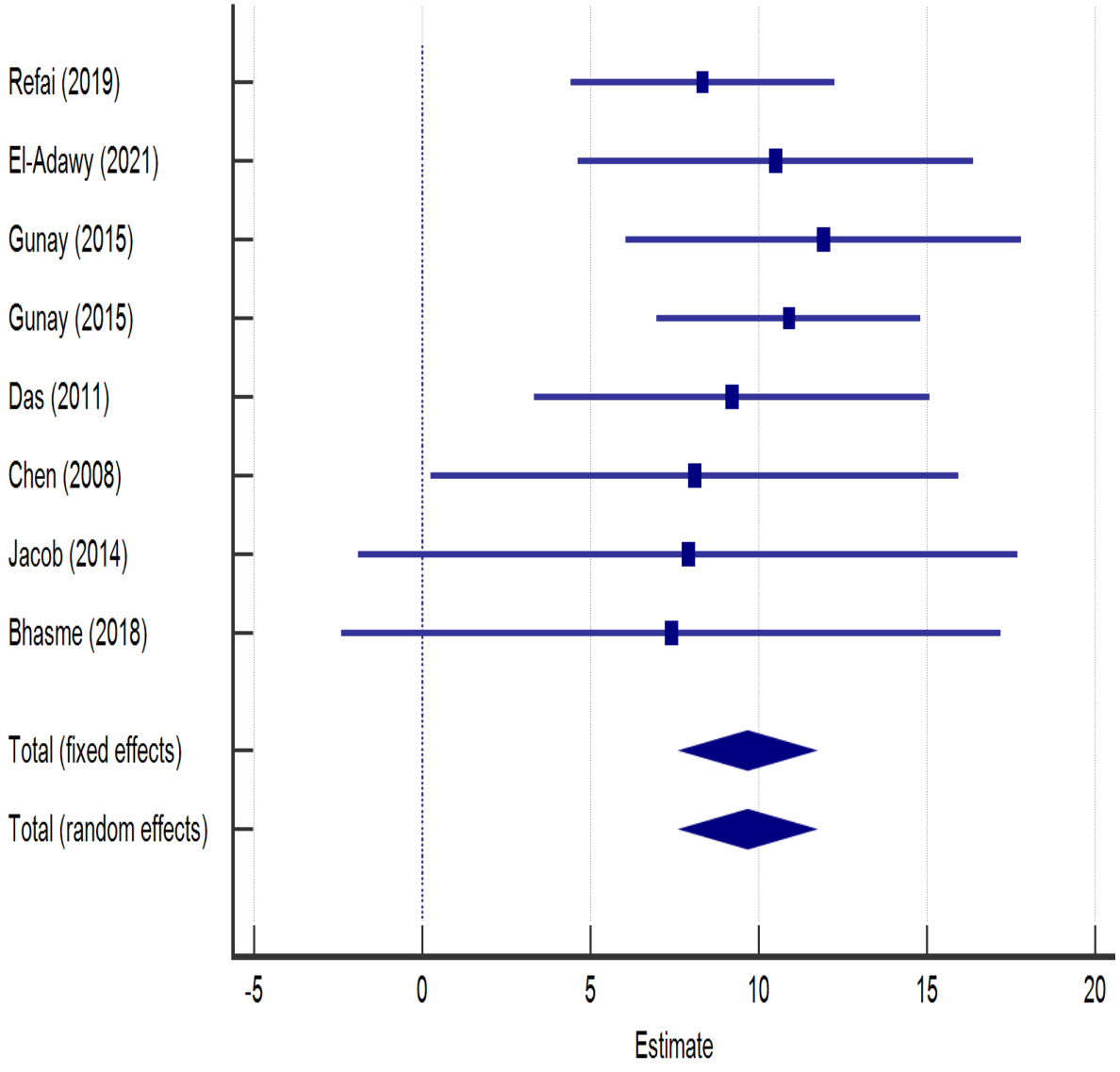


Figure 8: Forest plot for different studies weights for the examination of a studied articles Radial length of 8 randomized trials of unstable Extraarticular fracture Distal Radius management.

Table (6): Meta-analysis regarding Palmar fixation.

Study	Estimate	Standard Error	95% CI	z	P	Weight (%)	
						Fixed	Random
Refai (2019)	64.800	2.000	60.880 to 68.720			48.81	48.81
El-Adawy (2021)	65.000	3.000	59.120 to 70.880			21.69	21.69
Das (2011)	66.000	3.000	60.120 to 71.880			21.69	21.69
Bhasme (2018)	60.000	5.000	50.200 to 69.800			7.81	7.81
Total (fixed effects)	64.729	1.397	61.990 to 67.467	46.326	<0.001	100.00	100.00
Total (random effects)	64.729	1.397	61.990 to 67.467	46.326	<0.001	100.00	100.00

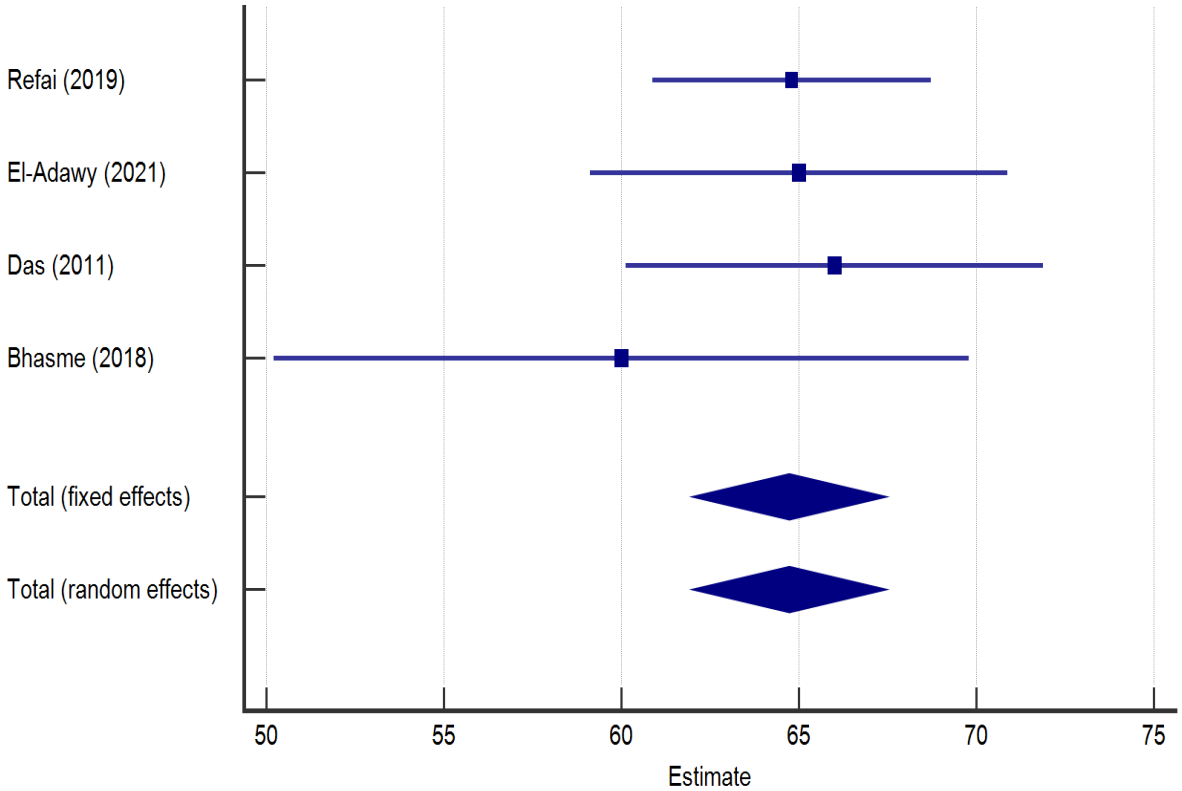


Figure 9: Forest plot for different studies weights for the examination of a studied articles Palmar fixation of 4 randomized trials of unstable Extraarticular fracture Distal Radius management.

Table (7): incidence of complications in different groups of K-wires.

Type of post operative complications	Percent of complication				P value
	2 wires	3 wires	4 wires	5 wires	
Pin tract infection	22.0%	12.0%	28.0%	26.0%	0.021*
loss of reduction	18.0%	9.0%	16.0%	21.0%	0.033*
Carpal tunnel syndrome	5.0%	0.0%	3.0%	8.0%	0.098 N.S.
Superficial radial nerve numbness	5.0%	4.0%	12.0%	14.0%	0.011*
Median nerve compression	0.0%	2.0%	4.0%	6.0%	0.074 N.S.
Nerve injury	0.0%	0.0%	2.0%	6.0%	0.033*

4. Discussion

Fractures of the distal radius are the most common of all orthopedic injuries accounting for nearly 16% of all fractures presenting in the Emergency Department [**7].** Despite the development of different fixation devices for distal radius fractures, Kirschner (K)-wire fixation still plays an important role in the treatment of both stable and unstable fractures of the distal radius. It's a less invasive procedure that prevents soft tissue damage [8]. The results of our study showed that A total of 497 patients were included 183 patients used 2 K-wires and 166 used 3 K-wires, only one study includes 54 cases used 4 K-wires, while 94 in three studies used 5 K-wires. Study characteristics were described in all 12 studies. Also it was found that the most important outcome results of the different number of K-wires used was the satisfaction, for each study the excellent and good results considered as a satisfactory results, from the results it was found that the most significant high satisfaction results in group 3 K-wires, followed by 5 K-wires, while both 2 and 4 K-wires considered as non-satisfactory results in compare to 3 and 5 K-wires. Regarding patients' satisfaction, all the studies reported patient's satisfaction data. The test for heterogeneity demonstrated that significant heterogeneity existed among these studies ($p < 0.001$), and a random-effects model was adopted. There was a significant difference between the 3 K-wires and 5 K-wires groups regarding the patient's satisfaction, the 3 K-wires group show a high satisfaction more than the 5 K-wires group [**9].** Regarding grip strength, it was found that ten studies reported grip strength data. The test for heterogeneity demonstrated that significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in grip strength in 3 K-wires group more than the 5 K-wires group [**10].** Regarding Dash Volar tilt, it was found that nine studies reported Dash Volar tilt data. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in DASH Volar tilt in 3 K-wires group more than 5 K-wires group. Regarding Radial Length, it was found that eight studies reported Radial Length data. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in Radial length in 3 K-wires group more than 5 K-wires group. Regarding Palmar fixation, it was found that four studies reported palmar fixation data. The test for heterogeneity demonstrated that a significant heterogeneity existed among these studies ($p < 0.01$), and a random-effects model was adopted. There was a significant increase in palmar fixation in 3 K-wires group more than 5 K-wires group. Regarding Complications, the incidence of complication in the studied groups show that the lowest percent of complications was found in 3 K-wires group, on the other hand the 4 and 5 K-wires groups showed a significant increase in the incidence of complication which include Pin tract infection, loss of reduction, Superficial radial nerve numbness and Nerve injury. In agreement with our results, Gunay et al., [**11]** study Which modality is the best choice in distal radius fractures treated with two different Kirschner wire fixation and immobilization techniques, they found that significant cortical and cancellous comminution in the distal radius on the dorsal and on the radial side may lead to late collapse due to resorption of the crushed bone. Therefore, an additional dorsal third K-wire was used to reduce the risk of collapse and regain better radiologic results. The use of the third K-wire reduced loss of radial length by about 1mm in Group I who managed by 3 K-wires

compared to Group II who managed by 2 K-wires. Therefore, the better functional results in Group I patients can be considered to be due to not only early movement but also to the lower reduction loss of radial length [**12].** In radius fracture management, a satisfactory functional outcome is unlikely unless a good anatomical result is achieved. Most authors estimate loss of radial length as the most important radiologic parameter influencing the functional outcome, and it seems that any technique maintaining the radial length may attain better functional results. However, loss of radial length has been reported in various forms in the literature [**13].** Many studies have shown that the number or position of K-wires does not influence radial inclination. In the present study, although radial inclination was better in Group I, there were no statistically significant differences between the groups in loss of radial inclination at follow-up [**14].** Also, in Gunay study they found that the grip strength was minimally higher in Group I compared to Group II, but this was not statistically significant as previously reported in other studies. A meta-analysis study has demonstrated that external fixation may lead to greater recovery of grip strength, especially compared to fixation with locking volar plates. Since this treatment protocol resembles a kind of external fixation with K-wires and supporting devices, grip strength measurements may have showed higher scores in both groups [**11].** Loss of reduction usually happens after 2 weeks of casting despite a perfect initial anatomic reduction. Gartland and Werley obtained a 68.3% satisfactory result, and Sarmiento et al. reported an 82% satisfactory result treated with the casting technique [**15].** Spira and Weigl. Reported a 51.4% unsatisfactory result with reduction and use of cast in the treatment of comminuted fracture of distal radius with articular involvement. Closed reduction and percutaneous pinning hold the fracture in an appropriate anatomic alignment [**16].** Clancey reported a 96.4% satisfactory result in 30 patients treated with percutaneous pinning if the articular surface of the radius was not comminuted into more than two fragments. However, the tenting effect is not strong enough in comminuted fracture, which often results in subsiding and dorsal angulation [**17].** From results we found that, using only 2 K-wires may lead to collapse of the fracture or losing of radial length, also many patients complained with weak grip strength. However using 3 K-wires showed better results radiologically and clinically with better patient's satisfaction rate, perfect grip strength and perfect Dash Volar tilt.

Meanwhile using 4 or 5 K-wires can provide more rotational stability to the fracture and lead to better results radiologically, but patients may have some complications as adding more K-wires will increase the risk of superficial pin tract infections, Nerve injury or tendon tethering.

5. Conclusion

At the end we found that using 3 K-wires is perfect to get the best reduction for the extraarticular distal end radius fractures radiologically in a cost-effective manner and high patient's satisfaction rate with least complications.

Funding Sources: There was no support for this study from any governmental, private, or non-profit organization.
Conflicts of interest: No competing interests.

References

1. Bucholz RW, Heckman JD, Court-Brown CM et al. Rockwood and Green's Fractures in Adults 7th edn Philadelphia, PA: Lippincott Williams & Wilkins; 2010.

2. Allain J, le Guilloux P, Le Mouel S, et al. Trans-styloid fixation ofof the distal radius. A prospective randomized fractures comparison between 6- and 1-week postoperative immobilizationin 60 fractures. ActaOrthopScand 1999; 70:119ae:123.

3. Prommersberger KJ, Pillukat T, Mühldorfer M, et al. Malunion of the distal radius. Arch Orthop Trauma Surg. 2012; 132(5): 693-702.

4. Rosenthal AH, Chung KC. Intrafocal pinning of distal radius a simplified approach. Ann PlastSurg 2002; 48:593:599.

5. Virendra K, Vishwanath G, Mrityunjaya N. Functional outcome analysis of fixation of distal radius fractures using 'five pin technique'. International Journal of Contemporary Medical Research 2018; 5(9): 114-I18.

6. Özkan S, Westenberg RF, Helliwell LA, et al. Distal Radius Fractures: Evaluation of Closed Reduction and Percutaneous Kirschner Wire Pinning. J Hand Microsurg. 2018; 10(3):134-138.

7. Narendra J, Premsagar C, Rakesh K, et al. Prospective study on outcome in management of distal radius fracture by closed reduction and percutaneous 5 K-wire fixation. Int J Orthop Sci 2021; 7(3):572-577.

8. Higgins and Green. Cochrane guidelines for data collection and results of scientific studies, 2011.

9. Naidu SH, Capo JT, Moulton M, et al. Percutaneous pinning of distal radius fractures: a biomechanical study. J Hand Surg Am 1997; 22:252-7.

10. Venkatesh R, Maranna G, Kumar R. A Comparative Study between Closed Reduction and Cast Application Versus Percutaneous K- Wire Fixation for Extra-Articular Fracture Distal end of Radius. Journal of clinical and diagnostic research: JCDR, 2016. 10. RC05RC09.10.7860/JCDR/2016/182 66.7220.

11. Gunay C, Oken F, Yavuz O, et al. Which modality is the best choice in distal radius fractures treated with two different Kirschner wire fixation and immobilization techniques? Turkish Journal of Trauma and Emergency Surgery. 2015; 21. 10.5505/tjtes.2015.55938.

12. Liberati A, Altman D, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009;6(7): e1000100.

13. Hung K, Chen J; Feng, I, et al. Efficacy and airway complications of Parker Flex-Tip tubes and standard endotracheal tubes during airway manipulation, European Journal of Anaesthesiology: August 2021 - Volume 38 - Issue 8 - p 813-824.

14. Song J, Yu A, Li Z. Comparison of conservative and operative treatment for distal radius fracture: a meta-analysis of randomized controlled

trials. International Journal of Clinical and Experimental Medicine. 2015; 8(10):17023-17035.

15. Kennedy C, Kennedy MT, Niall D, et al. Radiological outcomes of distal radius extra-articular fragility fractures treated with extra-focal kirschner wires. Injury 2010; 41:639-42.

16. Azzopardi T, Ehrendorfer S, Coulton T, et al. Unstable extra-articular fractures of the distal radius: a prospective, randomised study of immobilisation in a cast versus supplementary percutaneous pinning. J Bone Joint Surg Br 2005; 87:837-40.

17. Tronci, V, Campochiaro G, Gazzotti G. Distal radius articular fractures: A comparison between ORIF with angular stability plate and percutaneous Kirschner wires. Acta bio-medica: Atenei Parmensis. 2013; 84: 38-43.