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Assessment of Five Pin Technique versus Conventional Kirschner Wire Fixation for Management of Distal Radial Fractures

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ABSTRACT

Background: The ideal treatment for distal radius fracture should be a simple one with low complication and with the best functional outcome. Conventional Kirschner Wire Fixation is used for their management, and recently five pin technique has been introduced. **Objective**: The aim of the currents study is to compare the radiological outcome, the functional outcome, post-operative complication, and time of union of five pin technique with conventional k wire fixation in treatment of distal radius fractures.

Patietns and methods: A total of 48 patients who had fractured their distal radius were included in this randomized controlled clinical trial. Patients were divided into 2 groups with 24 patients in each group: Patients in *Group A* underwent five-pin techniques surgeries, and patients in *Group B* were operated via conventional k wire technique. At their follow up radiological evaluation was done using *Sarmiento score* (modified Lidstrom criteria), and *Cooney adaptation of the Green and O'Brien score* for clinical assessment.

Results: Loss of palmar tilt, radial shortening and loss of radial deviation were significant lower in 5 pin group, also the overall score was significantly better in 5 pin group. Pain and range of movement were significantly higher in 5 pin group, and total result score also was significantly higher in 5 pin group. The excellent overall score was associated with 5 pin score**. Conclusion**: Closed reduction and 5-pin configuration of K-wire fixation for distal radius fractures are excellent management options for distal radius fractures in terms of functional outcome, pain, range of movements, and stability than conventional k wire fixation after carefully selected distal radius fractures.

Keywords: Five Pin Technique, Kirschner Wire, Distal Radial Fractures.

INTRODUCTION

Distal radius fractures account for over 16 percent of all fractures treated in emergency rooms. High-energy upper-extremity injuries are more common in the younger age group, while high-energy traumas and insufficiency fractures are more common in the older age group, suggesting a bimodal distribution for distal radial fractures [(1)].

The radial styloid and scaphoid fossa are located in the radial column; the lunate fossa is located in the intermediate column; and the TFCC and the distal ulna are located in the ulnar column of the distal radius [(2)].

Any break in the distal radius must be no more than three centimeters proximal to the radiocarpal joint. They are usually closed. Due to the often-involved damage to neighboring ligaments and cartilage, these cases are considered difficult [(3)].

Despite the fact that DRF care has been talked about a lot, there is still significant disagreement on classification, treatment, and the association between functional as well as radiological outcomes [(4,5)].

There are numerous therapy options available. We opted for non-surgical treatment, which consisted of a closed reduction followed by immobilization with a Plaster of Paris (POP) cast. Surgical alternatives include internal plate fixation, external fixation, and percutaneous pin fixation [(6,7)].

For distal radius fractures, the American Academy of Orthopaedic Surgeons has established clinical practice guidelines. The American Academy of Orthopaedic Surgeons recommends surgical fixation for fractures with post-reduction radial shortening of more than 3 mm, dorsal tilt of more than 10°, or intra-articular displacement or step-off of more than 2 mm [(8)].Patients with three or more of dorsal angulation more than 20°, dorsal comminution, initial displacement greater than 1cm, initial radial shorting greater than 5 mm, associated ulnar fracture, have high rate of instability, and need for operative management [(9)].

The objective of the current study is to compare the radiological outcome, the functional outcome, post-operative complication, and time of union of five pin technique with conventional k wire fixation in treatment of distal radius fractures.

PATIENTS AND METHODS

A randomized controlled clinical trial was conducted at Orthopedic Departments of Zagazig University Hospital. A total of 48 patients with the diagnosis of distal radius fracture admitted for surgical management in the Department of Orthopedic Surgery, Zagazig University were included in our clinical trial.

Inclusion criteria:

- Patients older than 18 years of both sexes.
- All patients with extraarticular fracture will be included (AO type A2 and A3). In addition when the articular step-off is less than 2 mm, and the patient has an intra-articular fracture without considerable comminution (AO type B1).
- Failure to achieve acceptable reduction (>15° of dorsal angulation, <15° of radial tilt, or >2.0mm of

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radial shortening).
- Fracture not older than 2 weeks.

Exclusion criteria:
- Patients of both sexes under the age of 18.
- Traumatic break caused by die punch
- Open and contaminated fractures - grade 2 and grade 3 of Gustillo and Anderson grading system.
- Fractures with neurovascular injury
- Pathological fractures.
- Patients who refused to participate in the study

Recruited patients who fulfilled the inclusion criteria were numbered sequentially then divided into two groups (each group 24 patients) according to simple randomization with patients of odd number underwent 5 pin technique and patients with even number underwent conventional k wire technique.

Group A were operated on via five pin technique.

Group B were operated on via conventional k wire technique

All participants were subjected to:

1. A thorough history of the patient's medical history and an orthopedic examination.
2. Radiologically: Measurements of the radial and ulnar bones, as well as the articular step-off and gap, will be taken in a posterior-anterior orientation.
3. All patients had full preoperative lab investigation before surgery including: Complete blood picture, Random blood sugar, Viral screen, Coagulation studies (PT/PTT) as well as Kidney and liver function tests.
4. Surgical technique: Patients lay supine with their shoulders abducted to 90 degrees, their elbows flexed to 90 degrees, their forearms pronated, and their wrists neutral. The skin of the forearm and hand was prepped with 10% povidone iodine solution. Wrist and hand were excluded from the operative field by surgical drapes. Closed reduction was performed by manual traction and countertraction to minimize a distal fragment; one must usually grasp it with two fingers across its width and then work to bring it into a more manageable position. First, the initial displacement must be amplified in order to separate the distal component from the shaft. To do this, it may be essential to decrease the amount of traction being applied and increase the degree of deformity.

In Group A (Fixation using five pin technique) ***fixation was done using 1.8 mm k wires:***

1. The first wire passed 45 degrees oblique to the radial axis laterally and anteriorly and posteriorly to catch the proximal radial cortex was used to create a volar radial styloid.

2. The second wire inserted at Lister's tubercle and pointing toward the anterior (volar) cortex of the proximal radius stabilizes the lateral (radial) axis and aids in preventing dorsal tilt of the distal piece.

3. The third wire was a distal radioulnar wire, with the entrance site in the ulna positioned distally to prevent supination and preserve radial length.

4. The fourth wire was the ulnar corner wire, having the middle (intermediate) column stabilized by a dorsoulnar corner of the distal radius entering the radial side cortex of the proximal radius.

Figure (1): Second, third and fourth wires.

5. The fifth wire in the mid-prone posture, a screw was inserted into the proximal radius in both cortices via an entry point in the ulnar shaft proximal to the level of the radial fracture. This was done to stop the deforming force via rotational movement, which was the primary cause of the collapse.

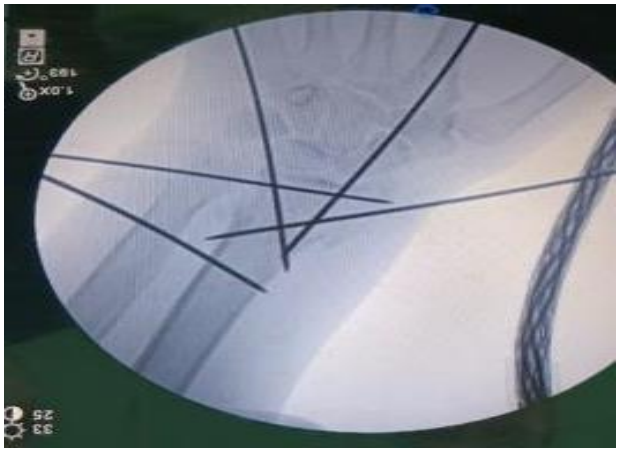

Figure (2): Fifth wire – proximal ulno radial.

In Group B (Fixation using conventional three k wire) ***fixation was done using 1.8 mm k wires:***

The first K-wire, guided by an image intensifier, was inserted from the dorsolateral side of the distal radius fragment through the fracture and into the proximal fragment. The second K-wire was threaded through the dorsolateral to dorsoventral split between the distal and proximal sections. Thirdly, a K-wire was moved dorsolaterally from the distal to the proximal segment.

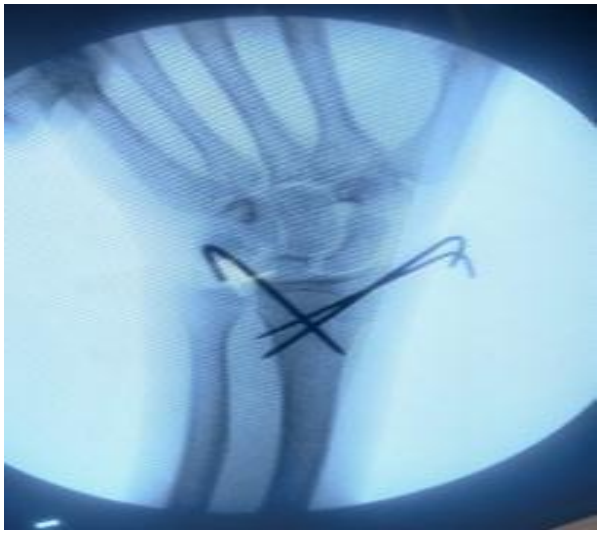

Figure (3): DRF after reduction and fixation with 2 k wires.

In both groups

After pin insertion:

- Alignment and steadiness were assessed using fluoroscopy.
- A passive flexion test of the fingers and wrist is performed to check for tendon tethering.
- A blade was used to cut off any ties to the skin.

Cut and bend K-wires:

In order to make removing K-wires simpler, they were bent at a right angle and then shortened beyond the skin. To prevent infection, K-wire was wrapped in a sterile covering that included sponge cushioning.

Splinting was executed with the wrist in its natural position, and aggressive finger movement is urged right from the start.

In Group A, patients were instructed to self-remove the splint for 15 minutes at a period, six times a day, and to perform tolerated range-of-motion exercises for the wrist, fingers, elbow, and shoulder (except forearm movements).

In Group B, patients were not allowed to remove the splint by themselves for all follow-up time.

Postoperative follow-up:

- Time of union in weeks.
- Radiological assessment: After each checkup, radiographs were collected from both the front and the side, and measures were recorded using the **Kreder *et al.*** [10] method. The posterior-anterior films were used to quantify the radial length, radial angle, articular step-off, and articular gap. On the lateral film, we checked for palmar tilt, articular step-off, and articular gap. For this study, we adjusted the Lidstrom criteria by including the Sarmiento radiological score [11]**.**
- Pain, functional status, range of motion, and grip strength are evaluated by the examiner using the Cooney adaptation of the Green and **O'Brien score** [12]. We give each of the four criteria 25 points out of a possible 100, for a grand total of 100. Using a scale from 90 to 100, good (80 to 89), average (65 to 79), and poor (65 and below).
- Postoperative complications were reported based on clinical findings with emphasis on loosening, pin tract infection, malunion, tendon injury, nerve injury, Complex reginal pain syndrome.

Ethical consent:

Zagazig University's Institutional Review Board (#6446/9-2020) approved the study. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 20 for Windows® (IBM SPSS Inc, Chicago, IL, USA). In order to convey the findings, tables and graphs were employed. Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) and Fisher's exact test to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean and standard deviation (SD). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value ≤ 0.05 was considered significant.

RESULTS

Table 1 summarizes demographic data of the 2 studies groups.

Table (1): Demographic data (age and sex distribution) between studied groups.

Variable			Five pin Group (N=24)	Conventional k wire Group (N=24)	T test	P-value
Age			39.87 ± 10.46	40.16 ± 10.08	0.098	0.922
Sex	Male	N	15	15		
		%	62.5%	62.5%		
	Female	N	9	9	0.0	1.0
		%	37.5%	37.5%		
Total		N	24	24		
		%	100.0%	100.0%		

* $P \leq 0.05$ indicates significance.

Fall was the major cause of injuries with no significant difference between groups. Also there was no significant difference regarding AO classification distribution (**Table 2**).

Table (2): Injury characters distribution between the 2 studied groups.

Variable			Groups		X^2	P-value*
			Five pin Group	Conventional k wire Group		
Mechanism of injury	Fall	N	14	13	0.085	0.77
		%	58.3%	54.2%		
	RTA	N	10	11		
		%	41.7%	45.8%		
AO classification	A2	N	9	9		
		%	37.5%	37.5%		
	A3	N	9	9	0.0	1.0
		%	37.5%	37.5%		
	B1	N	6	6		
		%	25.0%	25.0%		
Total		N	24	24		
		%	100.0%	100.0%		

RTA Road Traffic Accident. * $P \leq 0.05$ indicates significance.

Time of union showed no significant difference between the 2 studied groups (**Table 3**).

Table (3): Time of union distribution between groups

Variable	Five pin Group	Conventional k wire Group	T test	P-value
Time of union	6.66 ± 0.63	6.90 ± 0.62	1.26	0.21

With less palmar tilt loss, less radial shortening, and less radial deviation, the five-pin group fared better and had a higher overall score (**Table 4**).

Table (4): Sarmiento radiological score (modified Lidstrom criteria) distribution between the 2 studied groups.

Variable			Five pin Group	Conventional k wire Group	t/ X^2 FISHER	P-value
Loss of palmar tilt			2.25 ± 0.54	5.58 ± 1.23	2.568	0.014*
Radial shortening			2.83 ± 0.51	5.16 ± 1.22	2.970	0.005*
Loss of radial deviation			3.66 ± 0.83	6.50 ± 0.54	2.851	0.007*
Total Sarmiento score	Poor	N	0	1		
		%	0.0%	4.2%		
	Fair	N	1	7		
		%	4.2%	29.2%	8.35	0.047*
	Good	N	10	9		
		%	41.7%	37.5%		
	Excellent	N	13	7		
		%	54.2%	29.2%		
Total		N	24	24		
		%	100.0%	100.0%		

Pain and range of movement were significantly higher in five pin group and total result score also was significantly higher in five pin group, the excellent overall score was associated with five pin score (**Table 5**).

Table (5): Modified Green O'Brien score for functional outcome distribution between the 2 studied groups.

Variable			Five pin Group	Conventional k wire Group	t/ X^2	P-value
Pain			20.2±4.03	17.91±3.26	2.163	0.036*
ROM*			23.33±2.40	19.79±3.75	3.891	0.00**
Hand grip			22.91±2.91	21.45±3.12	1.672	0.101
Activity			22.29±2.94	21.25±3.03	1.207	0.234
Total Results			89.16±8.03	80.41±9.77	3.389	0.001**
Modified Green O'Brien score	Poor	N	0	1	6.88	0.14
		%	0.0%	4.2%		
	Fair	N	1	6		
		%	4.2%	25.0%		
	Good	N	10	10		
		%	41.7%	41.7%		
	Excellent	N	13	7		
		%	54.2%	29.2%		
Total		N	24	24		
		%	100.0%	100.0%		

*ROM Range of Motion.

There was no significant difference found between groups regarding complications (Table 6).

Table (6): Distribution of complication in the 2 studied groups.

Variable			Groups		X^2	P-value
			Five pin Group	conventional k wire Group		
Pin tract infection	-VE	N	17	18	0.105	0.745
		%	70.8%	75.0%		
	+VE	N	7	6		
		%	29.2%	25.0%		
Extensor tendon	-VE	N	21	22	0.22	0.63
		%	87.5%	91.7%		
	+VE	N	3	2		
		%	12.5%	8.3%		
Late collapse and malunion	-VE	N	23	20	2.0	0.15
		%	95.8%	83.3%		
	+VE	N	1	4		
		%	4.2%	16.7%		
Total		N	24	24		
		%	100.0%	100.0%		

A-Pre-operative X-Ray

B- intra operative imaging after obtaining reduction and fixation

C- immediate postoperative Xray

D- Xray 6 weeks postoperative

D-6months post-operative

E- clinical assessment 6 months after

Figure (4): A 55 year old female, falling in outstretched hand, free medical history, Tenderness on LT wrist, Neurovascular intact, diagnosed: Closed fracture LT distal radius (AO type A3), managed: Closed reduction and internal fixation by 5 pin technique within 4 days, intraoperative: Under general anesthesia near anatomical reduction was obtained and fixation was done using 5 pin technique, He continued following up in the outpatient clinic to detect the union and final anatomical and functional outcome. Six-week post operative radiograph had demonstrated union and removal of k wires and slab was done. Follow up after six months the final x ray was done and radiographic parameters were measured to determine the radiological score, and clinical examination of the wrist was done to determine the clinical score.

DISCUSSION

K-wires have been suggested as a way to prevent the distal radius fracture from being dislodged again after it has been minimized. Two randomized controlled trials found that K-wires considerably improved reduction maintenance compared to manipulation under anesthesia and casting alone. In addition, K-wires have been proven to lessen the likelihood of re-displacement in fractures that experienced significant initial translation or had an inadequate reduction. It is common practice to treat distal radius fractures by performing a closed reduction and percutaneous pinning. The reliability of fixation is increased by "the five-pin approach", which combines the benefits of minimally invasiveness, like those of casting, with the stability of open reduction and plating [13].

As regard demographic data, there was not statistically difference between studied groups regarding to age and sex.

The mean age in ***Group A*** was 39.8 and in ***Group B*** 40.1 years, which is comparable with studies of **Bhasme *et al.*** [14]; mean age 45 years, **Vasudevan and Leith** [15]**;** mean age 49.4 years, **Vipin *et al.*** [16] mean age 47.1 years, **Hegazy *et al.*** [17]; mean age 48.3 years and differ from **Solanki, Mahendra *et al.*** [18] patients ranged in age from 50 to 80, with 56 years being the median age.

In our study the incidence of distal radius fractures was higher in males (62.5%) in both groups which is similar to studies of **Bhasme *et al.*** [14], **Hegazy *et al.*** [17] and **Solanki *et al.*** [18] This could be because men are more likely to engage in physically demanding activities such as hiking, biking, and driving. While **Vasudevan and Lohith** [15], reported in their study higher incidence in female (57.1%) and this difference may be due to different lifestyles of studied population.

There was no statistically significant variation between groups with respect to the causes of injuries.

The most common cause of injury in both groups was a fall onto an outstretched hand; in *Group A*, this accounted for 58.3 percent of all cases, while in *Group B*, it accounted for 47.3 percent (54.2 percent) like **Chattopadhyay *et al.*** [19] as they reported that majority of the patients (69.8%) sustained the injury due to fall. On the other hand, **Vasudevan and Lohith** [15] and **Vipin *et al.*** [16] found in their studies that road traffic accident was the most common cause of distal radius fractures.

Regarding inclusion criteria, distal radius fractures AO class A2-A3-B1were included in our study, with no significant difference between the studied groups.

According to the AO categorization, 9 instances were A2, 9 were A3, and 6 were B1 in our study. While in **Vasudevan and Lohith** [15], among the cases classified by the AO, 94 were A2, 106 were A3, 46 were B1, 62 were B2, 112 were C1, 72 were C2, and 4 were C3, and in the study of **Chattopadhyay *et al.*** [19], a total of 31 of the cases were classified as Type A, 17 as Type B, and 5 as Type C. Also, **Sinha *et al.*** [13] showed that 12 (60%) were A2 fractures, 4 (20%) were A3 fractures, 2 (10%) were B1 fractures, and 2 (10%) were C1 fractures.

Regarding inclusion criteria, time lapse from distal radius fractures to surgical treatment was not older than 2 weeks in both groups.

Like in the study of **Bhasme *et al.*** [14]**,** most of cases operated in first 2 weeks as of those patients, 16 had surgery in less than a week, 9 in 1-2 weeks, and 5 in 3-4 weeks. Also, **Hegazy *et al.*** [17], 22 (55%) patients were less than 1 week, 13 (32.5%) patients were within 1 to 2 weeks, and only 5 (12.5%) patients were within 1 to 3 weeks.

Time of union was distributed as 6.66 (SD 0.63) and 6.90 (SD 0.62) days, respectively with no significant difference between studied groups.

Like in the study of **Vasudevan and Lohith** [15]**,** at 6 weeks, all but 12 of the fractures had healed radiographically. While in the study of, **Sinha *et al.*** [13], There was a 100% success rate for fracture healing between 12 and 16 weeks, with 3 fractures (15%) healing in 10 weeks, 15 (75%) in 12 weeks, and 2 (10%) in 14 weeks.

The radiological outcomes of our investigation showed that *Group A* fared better than *Group B*, with *Group A* having much lower rates of loss of palmar tilt, radial shortening, and loss of radial deviation and a much higher total score A.

In *Group A*, 13 patients had an excellent radiological outcome according to the Sarmiento (modified Lindstrom) criteria, while 10 patients had a good outcome and 1 had a poor one. In *Group B*, 7 patients had an excellent radiological outcome, 9 had a good one, 7 had a fair one, and 1 had a poor one. Which like to **Solanki *et al.*** [18] the radiological results were classified as excellent for 11, decent for 18, and mediocre for 1. Furthermore, **Vipin *et al.*** [16] 90% (n =18) reported good to outstanding stability as measured by the Sarmiento adaptation of the Lidstrom scoring system for radiological parameters.

Using the Modified Green O'brien score to evaluate functional outcomes, we found that *Group A* greatly outperformed *Group B* in terms of Pain and range of movement, and that *Group B* also strongly outperformed *Group A* in terms of the Total Result Score A.

According to Cooney modification of the Green and O'Brien score is the mean of Pain score was 20.2 in Group A versus 17.91 in Group B. The mean range of movement score was 23.33 in Group A versus 19.79 in Group B. The mean Hand grip score was 22.91 in Group A versus 21.45 in Group B. The mean activity score was 22.29 in Group A versus 21.25 in

Group B. The mean total score was 89.16 in Group A versus 80.41in Group B.

A Method for Analyzing Clinical Results in Group A, 13 (54.2%) patients were rated as excellent on the Cooney modification of Green and O'Brien's scale, 10 (41.7%) patients were rated as good, and 1 (4.2%) patient was rated as fair. In group B, 7 (29.2%) patients were rated as excellent, 10 (41.7%) patients were rated as good, 6 (25%) patients were rated as fair, and 1 (4.2%) patient was rated as poor (4.2%). Which is comparable to **Vasudevan and Lohith [15],** 12 patients died at one year due to unrelated causes, and 20 were lost to follow-up, for a final number of 464 patients. Of these, 444 (95.7%) had excellent outcomes, 18 (3.9%) had good outcomes, and 2 (0.4%) had fair outcomes. And in **Vipin *et al.* [16]** discovered that around 90% of patients had satisfactory to excellent functional result using a modified version of the Green and Obrien scale. Furthermore, in the study of **Solanki *et al.* [18]**, 30 patients were evaluated for their functional result using the Obrien scoring system, which yielded a score of 90 or 100 for 11 patients, 80 or 89 for 18, and 80 for one patient.

On the other hand, in the study of **Bhasme *et al.* [14]**, **Hegazy *et al.* [17]** and **Bhasme *et al.* [14]** were using Quick DASH scoring for clinical assessment of Kirschner wire fixation.

Our study found that the five-pin approach was substantially related to excellent and good outcomes in Group A, possibly because it allows for early mobilization, provides the much-desired fragment-specific fixation, and adds rotational stability. No statistically significant difference was seen between groups with respect to the occurrence of complications following surgery.

We found that 7 (29.2%) patients in Group A and 6 (25%) patients in Group B developed a superficial pin tract infection, which was treated successfully with pin tract care and a short course of oral antibiotics until the pins were removed. Three (12.5%) patients in Group A experienced extensor tendon tethering and 2 (5%) patients. Following pin removal, tethering of the extensor tendons resolved in both study groups. One patient in Group A (4.2% of total) and 4 patients in Group B (16.7% of total) experienced late collapse and malunion. Both the deformity and the fracture collapse contributed to a worse functional outcome, even though they did not cause it directly which supported by the study of **Bhasme *et al.* [14]**, **Vipin *et al.* [16]**, **Hegazy *et al.* [17]** and **Bhasme *et al.* [14]** problems such as extensor tendon tethering, deformity, and fracture collapse were seen as consequences.

In the study of **Vipin *et al.* [16]**, none of the patients in their series developed any severe complications, two cases reported superficial pin tract infection. Furthermore, **Hegazy *et al.* [17]**, revealed that regarding the complications in the study participants, 18 (45%) didn't have any complications, 4 (10%) had deformity, 4 (10%) had extensor tendon tethering, 9 (22.5%) superficial pin tract infection, and 5 (12.5%) patients had deformity and superficial pin tract infection. And in the study of **Bhasme *et al.* [14]**, less significant problems such as extensor tendon tethering, superficial pin tract infection occurred most frequently (30%), and malunion and late fracture collapse (25%).

On the others hand, **Vasudevan and Lohith [15],** validated 52 instances of superficial pin tract infection, 2 instances of extensor carpi ulnaris tendon impingement, and 12 cases of sensory branch radial nerve discomfort, all of which improved after wire removal.

CONCLUSION

Closed reduction and 5-pin configuration of K-wire fixation for distal radius fractures are excellent management options for distal radius fractures in terms of functional outcome, pain, range of movements, and stability than conventional k wire fixation after carefully selected distal radius fractures.

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