ORIGINAL ARTICLE

A Novel 5-pin Fixation for Distal Radius Fractures and Its Functional Assessment

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Abstract

Background: Distal radius fractures are an extensively debated topic throughout decades. The treatment options include POP casting, plating, external fixation with or without ligamentotaxis, and *K*-wiring. This study was conducted to assess the functional outcome of a novel percutaneous 5-pin technique in distal radius fractures.

Materials and methods: This is a prospective observational study over 16 months from January 2019 to May 2020. Novel percutaneous 5-pin technique in a sequential configuration following a closed reduction was performed, followed by physiotherapy, and functional outcome was assessed at 6, 12, and 28 weeks following *K*-wire removal using Cooney's modification of Green and Obrien scoring and evaluated for functional status, pin loosening, tendon impalement, and nerve injury.

Results: All 20 patients were assessed. The mean age of patients was 47.15 years, 10 being females, with road traffic accidents being the major mode of injury. All patients were followed up for 6 months post-*K*-wire removal and 90% of patients had good to the excellent outcome and 10% of patients had fair to bad outcome with a functional range of supination and pronation movements. All fracture unions were satisfactory and four patients (20%) developed minor complications. None of them developed tendon impalement or nerve injuries.

Conclusion: The novel percutaneous 5-pin technique includes two additional ulnoradial wires which provide superior rotational stability and avoid the chance of late collapse and maintain radial height, unlike conventional *K*-wire techniques. Thus, avoiding the need for more invasive techniques and allows early mobilization of wrist and fingers preventing stiffness, resulting in an excellent outcome.

Keywords: 5-pin technique, Distal radius fractures, Green and Obrien scoring, *K*-wire.

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Introduction

Distal radius fractures are one of the most common injuries encountered in orthopedic practice. They make up 8–15% of all bony injuries in adults. Distal radius fracture has bimodal distribution affecting younger and older age groups accounting for high energy and low energy trauma, respectively. Distal radius fractures mostly occur due to the shearing force generated at the time of trauma as a result of a fall on an outstretched hand. Female preponderance is usually seen in the elder age group due to osteoporosis.

Zone of metaphyseal widening of the distal radius is prone to fractures due to the predominance of weaker cancellous bone comparing to the cortical bone. About 60 years ago, distal radius fractures were never considered for surgical fixation. By the continuing interest in the distal radius fractures and post-fracture biomechanics of the wrist, it was clinically proved that the correction of intra-articular step-off and radial shortening had improved patient functional outcome.[1,2]

Different types of treatment modalities are available like closed reduction and POP application, external fixation, internal fixation, and percutaneous pin fixation.[3] Out of all modalities of treatment percutaneous pin fixation will be the least morbid surgical treatment, accounting for the advantage of both non-operative and operative treatment. Even though management of fractures of the distal radius is an extensively discussed topic, there is still disagreement on classification[4] and management. None of the previous studies was addressing the supination force and DRUJ injury leading to late collapse.

In this study, we aimed to evaluate the novel concept of distal radius fracture management, with a 5-pin technique of *K*-wire fixation which is an emerging modality of management with inadequate evidences. In this method, we avoid the need for a Plaster of Paris slab (like in conventional *K*-wire fixation methods) in this study. Thus by giving early mobilization and adequate pin tract care, we greatly minimize the chances of wrist joint stiffness.[5] Advantages of this method are additional rotational stability,[6] low costs of implants, ease to perform, early mobilization, low learning curve, easy availability of the implants, and can be performed as a daycare surgery under regional anesthesia.

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Materials and Methods

This was a prospective observational study on the functional outcome of the 5-pin technique of *K*-wire fixation for distal radius fractures done between January 2019 and May 2020. After approval by the Institute Ethics Committee, all patients presented with distal radius fractures to the orthopedic OPD, and casualty was enrolled

by simple convenient sampling method after recording the clinical and X-ray findings.

All skeletally matured patients with distal radius fractures, excluding Volar Barton fracture, pathological fracture, and distal ulna shaft fractures were included in the study after obtaining informed written consent. All patients underwent standard preoperative evaluation and classified as per Frykman.[7] All selected patients who were fulfilling the inclusion criteria then underwent closed reduction and 5-pin configuration of *K*-wire fixation.

Procedure

The closed reduction of fracture was attained with a patient in a supine position on arm table with abducted shoulder and elbow to 90°. The arm is held tightly to the table by the first assistant as the surgeon manipulates the fracture. Index fingers of both hands were placed on the distal fragment in the volar aspect while both thumbs were placed dorsally onto the proximal fragment. Fracture impaction was unlocked by gently supinating the distal fragment and then distracting in the long axis. As the fragment becomes disimpacted both thumbs were slid distally proximal fragment. The reduction was maintained by traction at the fingers by the second assistant and counter traction on the arm by the first assistant. Once the reduction was achieved the relation to the radial and ulnar styloid process was checked and confirmed by fluoroscopy.

All wires used in fixation are 1.8 mm *K*-wires. With the forearm in pronation, the first wire was a distal radioulnar wire (Fig. 1A), with a distal ulna entry point aiming to the subchondral part of the distal radius to maintain the radial length and prevents supination. The second wire was volar radial styloid wire (Fig. 1B) passed 45° oblique to the anatomical axis of the radius in both lateral and anteroposterior plane to catch the proximal radial cortex. The second wire stabilizes the lateral (radial) column. The third wire was the ulnar corner wire (Fig. 1C), with a dorsoulnar corner of the distal radius entry point to the radial side cortex of proximal radius to stabilize the middle (intermediate) column. The fourth wire was the Lister's tubercle wire (Fig. 1D), directed toward the anterior (volar) cortex of the proximal radius and helps in preventing the dorsal tilt of the distal fragment. The fifth wire (Fig. 1E), with an ulnar shaft entry point proximal to the level of the radial fracture, goes into the proximal radius in both cortices in the mid prone position and was used to prevent the deforming force by rotational movement, which is the main reason for the postoperative collapse.

Postoperatively splinting was done with static cock-up splint maintaining the functional position of the wrist, encouraging active finger movements. Patients were advised to remove the splint by themselves for 20 minutes each at least 5 times a day to mobilize all joints including shoulder, elbow, wrist, and fingers. Pin tract care was ensured with regular follow-up and pin tract dressing did every week.

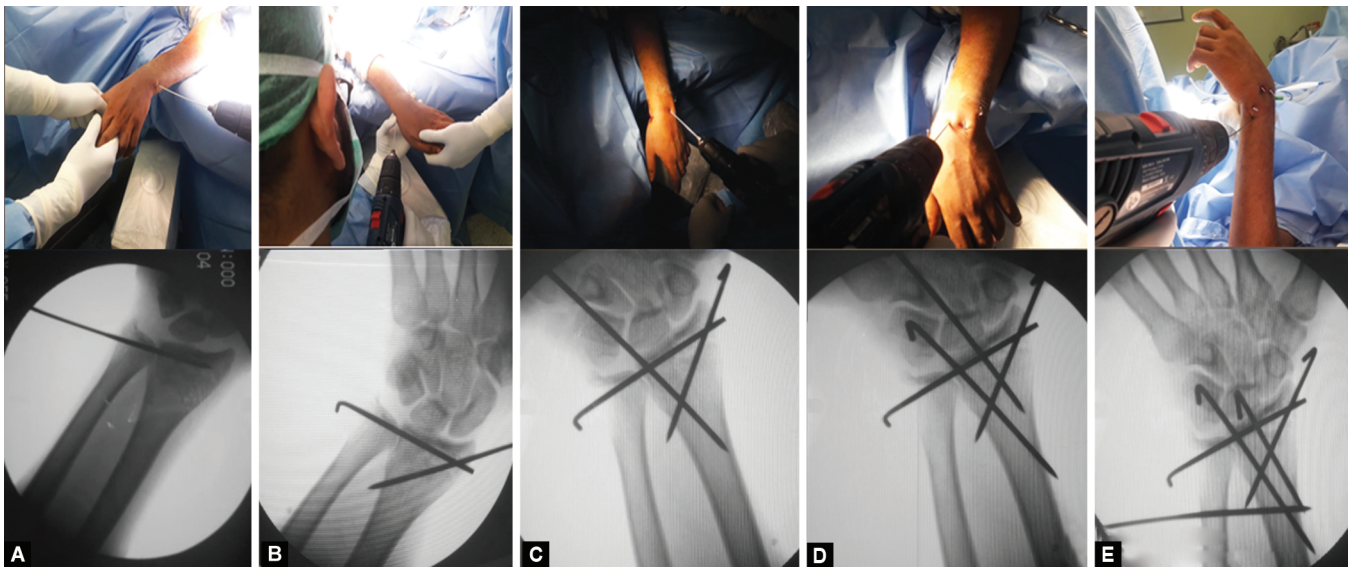
Distal and proximal radioulnar wires were removed at 4th or 6th week and forearm exercises started, all remaining radial pins were removed at 6th or 8th week after confirming fracture union with an anteroposterior and lateral radiograph.

Fracture union was confirmed with a minimum of three cortical unions and trabecular continuity. Simultaneously, the radiograph was assessed for anatomical parameters of distal radius including radial inclination, radial height, and palmar tilt as per Sarmiento criteria, using the functions available on our computerized radiographical system. (Medsynaps, PACS, MGMC, and RI).

The physiotherapy protocol followed by the patients was counterchecked every 2 weeks for 6 weeks. Regular follow-up was done at 1½, 3, and 6 months after pin removal. During follow-up, the patient was evaluated for functional outcome using Cooney's modification of Green and Obrien scoring system,[8] and during each follow-up, patient pain status was assessed with visual analog scale[9] and at 6-month follow-up, Sarmiento modification of Lidstrom criteria[10] was used for anatomical scoring. Radiological parameters were assessed considering standard radial height as 12 mm, radial inclination as 24°, and palmar tilt as 11°, as there was no radiograph available of the opposite limb.

Statistical Analysis

The data were analyzed with Statistical Package for Social Sciences (SPSS) for Windows 26.0 (SPSS, Inc., Chicago, Illinois). Confidence intervals were set at 95% and p value <0.05 was interpreted as statistically significant. Descriptive statistics were used to calculate



Figs 1A to E: 5-pin technique procedure

Table 1: Comparing the ROM wrist with similar studies at end of follow-up

Studies	*Palmar flexion*	*Dorsiflexion*	*Supination*	*Pronation*
Gruber et al. (VLP)	63 ± 15	66 ± 17	82 ± 11	83 ± 14
Anakwe et al.[11] (VLP)	64	62	78	62
Wei et al.[12] (VLP)	63	66	68	68
Our study	77 ± 11.7	65 ± 5.49	72.5 ± 7.8	64.75 ± 7.51
Minimal for normal function (Sarmiento 1975)[13]	30	45	50	50

Table 2: Comparison of Green and Obrien scoring (showing significant improvement in functional outcome at 6-month follow-up)

Green and Obrien scoring	*Mean*	*F value*	*p value*
Green and Obrien at 6 weeks	51.00 ± 16.82	131.84	0.001 (S)
Green and Obrien at 3 months	69.00 ± 12.09		
Green and Obrien at 6 months	88.00 ± 8.17		

Table 3: Frykman type and Green and Obrien scoring at 6-month follow-up (no significant association was noted)

			Green and Obrien at 6 months				*Chi-square*	
		Total no	*75*	*80*	*90*	*100*	*value*	*p value*
Frykman type	II	1	0	0	1	0	21.57	0.2 (NS)
	III	1	0	0	0	1		
	IV	2	0	0	2	0		
	V	4	0	3	1	0		
	VI	3	1	1	1	0		
	VII	6	1	0	2	3		
	VIII	3	0	1	2	0		
Total		20	2	5	9	4		

numbers, percentages, mean, and standard deviations. Repeated measures ANOVA was applied to compare Green and Obrien scoring at 6 weeks, 3 months, and 6 months.

Results and Interpretation

Out of the 20 patients analyzed prospectively at our institute, the mean age of the patients at the time of presentation was 47.15 ± 17.1 with a range from 20 to 80 years. There was an equal gender distribution and RTA was the major mode of injury.

Most of the patients (55%) had dominant right hand involved. In our study, we have classified according to the Frykman classification (Table 1).

Functional outcome was assessed using Cooney's modification of the Green and Obrien scoring system (Table 2) along with an assessment of the range of movements and pain assessment by the visual analog scale at 6 weeks, 3 months, and 6 months following *K*-wire removal. Stability assessed by Sarmiento modification of Lidstrom scoring system for anatomical parameters and 90% ($n = 18$), showed good to excellent outcome. All the patients had acceptable anatomical criteria as per Sarmiento and Lafontaine et al.[14]

At the end of the study, mean supination at 6 months was 72.50 ± 7.86, mean pronation of 64.75 ± 7.51, mean palmar flexion of 77 ± 11.74, and mean dorsiflexion of 65.25 ± 5.49. The mean VAS score was 0.5 at the end of the study with a maximum score of 2. Mean radiological parameters were also assessed at the end of the study, mean radial inclination, mean radial height, and mean palmar tilt were found to be 23 ± 2, 10.24 ± 2, and 6.15 ± 5, respectively. None of them had pain affecting their daily activities or occupation at the 6-month follow-up.

None of the patients in our series developed any severe complications, two cases reported superficial pin tract infection which subsided with pin tract care and a short course of antibiotics. Two patients developed grade I CRPS, in which one patient had a head injury that affected the physiotherapy protocol. Both patients become better at the 6-month follow-up period with adequate analgesia and physiotherapy protocol. There was no significant association noted between the Frykman type and final outcome (Table 3).

Discussion

Distal radius fractures are a much-discussed topic from the early eighteenth century since Abraham Colles first described it. Throughout the centuries, many modalities have been discussed and most of them failed to prove their superiority over the existing ones. The main objective of the management is to provide adequate stability and to maintain intra-articular congruity. Recent studies done by Bhasme et al. and Vasudevan and Lohith in their series using closed reduction and 5-pin technique suggested that using the two additional radioulnar wires can prevent late radial collapse by giving adequate rotational stability. In our study, we found out that nearly 90% of patients had good to the excellent functional outcome as per Cooney's modification of the Green and Obrien scoring system (Table 1) (case illustration Fig. 2).

Majority of our patient was in their 4th decade of life, similar to the studies by Bhasme et al.[15] and Yamamoto et al.,[16] suggesting

Figs 2A and B: Case illustration (6 months follow-up)

high-velocity trauma proved by the majority falling under Frykman type VII and VIII similar to our study.

The functional outcome assessed using Green and Obrien scoring is comparable to the studies by Yamamoto et al.[16] (EX FIX), Drobetz et al.[17] (VLP), and Vidyadharan et al.[18] (6-pin) using the same scoring system.

Radiological parameters and anatomical parameters assessed on basis of Sarmiento modification of Lidstrom criteria are comparable to the studies by Gruber et al.[19] and Anand et al.[13] Mean range of motions attained at the end of the study were comparable to similar studies (Table 1).

Advantages of this method are additional rotational stability,[6] low costs of implants, ease to perform, and can be done as an emergency even in patients with comorbidities, very minimal risk of nerve damage, early mobilization, low learning curve, less scar and more cosmetic, easy availability of the implants, and moreover can be performed as a daycare surgery under local or regional anesthesia.

The main limitation is that a larger comparative study with a long-term follow-up will give more evidence to the current study. Randomized controlled studies including other modalities of management, for each fracture pattern in the future, can give an outline on the superiority of the 5-pin technique for distal radius fractures in the future.

Conclusion

Closed reduction and 5-pin configuration of *K*-wire fixation for distal radius fractures are cost-effective, safe, and excellent management options for distal radius fractures in terms of functional outcome, pain, range of movements, and stability.

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