

# Outcome of Augmented External Fixation of Unstable Distal Radius Fractures

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## ABSTRACT

**Background:** Well-reduced unstable distal radius fractures have the potential to undergo late displacement and/or collapse due to musculotendinous forces. To overcome this there is controversy as to which is the preferred treatment – minimally invasive like external fixation or invasive like open reduction and plating.

**Objective:** To determine the outcome of augmented external fixation of unstable distal radius fractures.

**Design:** Prospective study. **Setting:** Orthopedic surgery department of Independent Medical College, Punjab Medical College and University Medical College Faisalabad. **Period:** Between January 2009 and December 2010. **Methods:** In this case series study 46 patients with unstable distal radius fractures were followed for 1 year after operation using the technique of application of common 3.5mm AO external fixator using principle of ligamentotaxis for reduction and restoring length with addition of k-wires plus bone graft if needed.

All patients were evaluated according to the sum of demerit points system (Saito, 1983). **Results:** There were 20 male (43.48%) and 26 females (56.52%) with mean age  $48.54 \pm 16.36$ . According to the sum of demerit points (Saito, 1983), the latest follow-up functional end results were 'Excellent' in 45.66%, Good in 34.78%, Fair in 10.87% and Poor in 08.69%. As for the anatomical results at follow-up, the radial shortening <2mm in 37 (70.44%), from 2-4mm in 5 patients (10.87%) and >4mm in 4 (08.69%). The average radial tilt was 22° and palmar tilt was 6°. **Conclusions:** The application of common 3.5mm AO external fixator with addition of k-wires is simple, cost effective, quick, minimally invasive and prevents redisplacement of fracture fragments adequately. The risk of infection is small and there is little damage to the surrounding tissues.

**Key Words:** distal radius fracture, extra-articular fracture, intra-articular fracture, K-wire addition, unstable fracture, external fixation, redisplacement.

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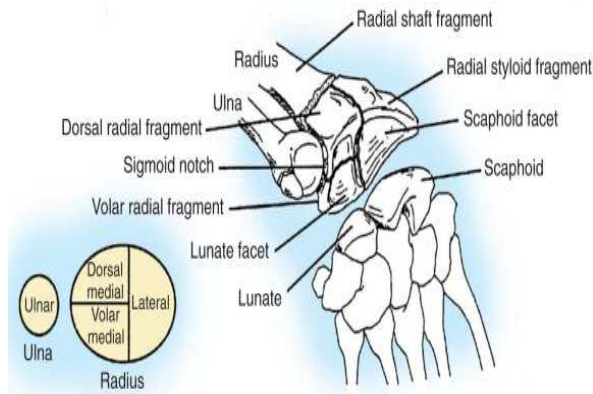
## INTRODUCTION

Fractures of the distal radius remain the most common fractures seen in the emergency room. Treatment modalities depends on many factors. These factors include the patient's age, bone quality, ability of the patient to tolerate the procedure, and the type of fracture<sup>1,2</sup>. Majority being treated conservatively with plaster cast following closed reduction with local anesthesia as originally described by Colles<sup>3</sup>. However, other distal radial fractures require surgical management and many treatment methods are available. These can be divided into minimally invasive as pins in plaster, external fixation<sup>4,5</sup>, percutaneous pinning with casting<sup>6</sup> and invasive like open reduction and internal fixation with a number of different implants

<sup>7,8</sup>. Fracture radius distal end include extra-articular, partially intra-articular and comminuted intra-articular Fig-1. The fracture of the distal radius presents a unique set of fixation issues. Distal fragments<sup>9</sup> are periarticular and usually extremely small Fig-2. Careful evaluation of radiographic results, even in those patients with acceptable clinical outcomes, has led to the observation that well-reduced fractures have the potential to undergo late displacement<sup>10</sup> due to musculotendinous forces acting across the wrist and/or collapse with loss of the initial articular congruity Fig- 3. Recognition of this potential for displacement has led to the evolution of this technique Fig-4. The technique of "Augmentation" of external fixation employs the use of the principle of ligamentotaxis in the management

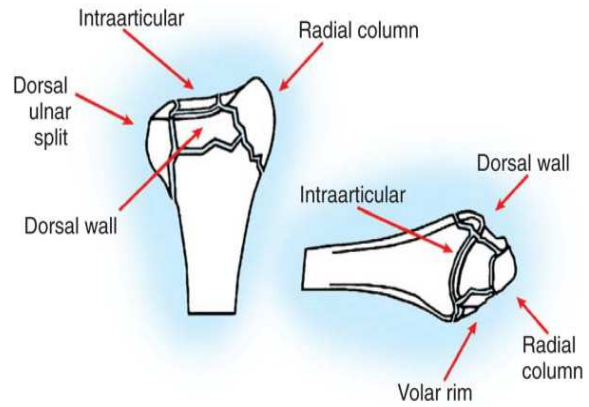
of unstable distal radius fractures with percutaneous Kirschner wire fixation of the major articular fragments<sup>11</sup> and, when necessary, supportive bone grafting to maintain adequate articular elevation. 46

**Figure-1**  
Distal radial anatomy Inset, Columnar classification of distal radius and ulna

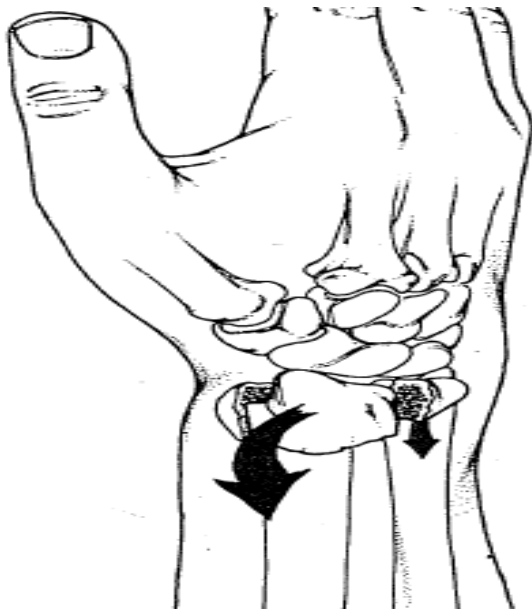


patients with unstable distal radius fractures were followed for 1 year after operation using this technique with overall 91.31 % satisfactory results.

**Figure-2**  
Distal Radial Fracture Elements



**Figure-3**  
Musculotendinous forces acting across the wrist tend to cause the Radial styloid fragment to displace laterally and the lunate fossa fragment to depress.



**Figure-4**  
Technique of "Augmentation" of external Fixation with additional pinning and if needed bone grafting



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## MATERIALS AND METHODS

In this study 56 consecutive patients with unstable distal radius fractures were selected from orthopaedic surgery department of Independent Medical College, Punjab Medical College and University Medical College Faisalabad between January 2009 and December 2010. 4 patients declined surgical treatment in spite of severely displaced fractures. Fifty-two patients with severely displaced and unstable fractures were operated at the beginning or after redisplacement that occurred during the conservative treatment of cast immobilization or after applying wooden sticks by bone setters. All patients had sustained unstable distal radius both intra-articular and extra-articular fractures consisting of a major radial styloid fragment, lunate fossa fragment and with or without significant dorsal and/or volar comminution. We followed the inclusion and exclusion criteria. The data was collected and all necessary arrangements were done for operation by augmented external fixation. Five (9.61%) of the patients underwent bone grafting and completed follow-up of 46 patients out of 52 for 1 year according to demerits points system (Saiot, 1983). Six (6) patients were not available for follow up. Four patients died later on due to associated co morbid medical conditions and two returned to foreign country for their job.

### INCLUSION CRITERIA

- ❖ All cases unilateral
- ❖ Unstable intra-articular and extra-articular distal radius
- ❖ Failure of conservative treatment
- ❖ Late cases of unsatisfactory deformity with poor functional results.

### EXCLUSION CRITERIA

- ❖ Bilateral fracture of distal radius
- ❖ Patients with long post-operative immobilization and general complications
- ❖ Low demand patients<sup>12</sup> who have fractures amenable to treatment by immobilization alone
- ❖ Fracture dislocation of the wrist.

## SURGICAL TECHNIQUE

All patients had either general endotracheal, axillary or Bier's block anesthesia. A "limited open surgical approach" was used for open reduction of fracture fragments to remove invasion of soft tissues and periosteum. The length or height was corrected by applying traction using the technique of ligamentotaxis. The 3.5 mm AO external fixator with at least two pins proximal and two pins distal to the fracture were applied. 1<sup>st</sup> proximal pin by giving small nick centered approximately 10 cm to the radial styloid over the dorsal aspect of the radius using the drill sleeve for drilling after centralizing the radius with drill sleeve and stabilizing it firmly this allows central insertion of the pin and avoids eccentric drill placement or multiple drill passes, which can result in significant weakening of the bone and pin loosening. Drilling with 2.5 mm drill bit was done for pin insertion. The radial sensory nerve track is not in the way so no chance of damage as its emergence from beneath the brachioradialis between the interval of the extensor carpi radialis longus and brachioradialis. The 2<sup>nd</sup> distal pin in the proximal segment was inserted within 2 cm from the fracture site. Distal pins insertion, likewise, was made under direct vision placing the proximal pin through the metaphyseal base of the index or middle metacarpal and the distal pin through the shaft of the index or middle metacarpal. If possible the 3<sup>rd</sup> distal pin was inserted in distal segment of the radius in case of extra-articular type under vision. This provides pin purchase in between six to ten cortices. Once pin insertion has been done, Traction was applied and initial reduction was obtained under vision through mini invasive approach. This initial reduction achieves restoration of overall length and radial tilt. The external fixation device itself was applied and at this point an additional traction was applied through the device, which can result in an increase up to 2 mm in the joint space of the radioscapholunate articulation. This traction applies tension across the dorsal and palmar radioscapholunate ligaments, keeping them taut during the period of immobilization (allowing

rapid return of flexion/extension on removal of the device). In case of radial styloid fragment when realigned to the shaft, a smooth 1.5mm K-wire was inserted percutaneously and obliquely from the tip of the radial styloid across the major fracture site and secured in the ulnar cortex of the shaft of proximal segment. The radial styloid thus secured acts as a buttress. To fix the lunate fossa fragment a free 1.5mm K-wire was inserted percutaneously under vision dorsally. It is used to elevate the lunate fossa articular fragment so that it is precisely congruent with the remainder of the distal radial articular surface, to stabilize this fragment in the reduced position. A third smooth K-wire was inserted percutaneously transversely from the radial aspect of the styloid fragment directly underneath the subchondral bone of the elevated "die-punch" fragment. Additional subchondral K-wires may be percutaneously added as needed depending on the degree of comminution. If a significant gap of 5mm or more was encountered, supportive bone grafting was done through a dorsal approach beneath the elevated fragments to ensure congruence of the radiocarpal and distal radioulnar joints. Once again all the pins of the fixator were retightened; the ends of the k-wires were bended beyond the skin. The wound was closed in layers. A bulky soft compression dressing was applied and therapy was initiated for active and passive digital range of motion. The dressing was changed on 3<sup>rd</sup> day. Functional and radiological evaluation after operation was done on 1<sup>st</sup> day, 12 weeks, 6 months and 1 year. The fixator was removed with in 6 to 12 weeks depending on radiological features of bone healing in out-patients department under analgesia. At this point the patient was advanced to a program of active, active assisted, and gentle passive wrist extension and flexion. After removal of all pins and full fracture healing as assessed by no tenderness from palpation at the fracture site an unrestricted

program of range of motion and strengthening can begin to increase grip power. Completed follow up for 1 year. All patients were evaluated according to the sum of demerit points system (Saito, 1983) Table-1. The radiological measurements were done as per Fig-5.

Table 1  
Demerit point system (Saito)

Subjective Evaluation		Points
Excellent	no pain, no disability, no limitation of motion	0
Good	occasional pain, no disability, slightly limitation of motion	2
Fair	occasional pain, no particular disability if careful, some limitation of motion, feeling of weakness in wrist, activities slightly restricted	4
Poor	pain, disability, limitation of motion, activities markedly restricted	6
Objective Evaluation		
I. Residual Deformity	out of the range of	
Ulnar variance	0 ± 2mm	1
Palmar tilt	11 ± 10°	1
Radial tilt	23 ± 10°	1
II. Range of Motion		
Dorsiflexion	< 45°	1
Palmarflexion	< 30°	1
Ulnarflexion	< 15°	1
Radialflexion	< 15°	1
Supination	< 50°	1
Pronation	< 50°	1
III. Grip Power		
Dominant hand	< the power of the opposite hand	1
	< 2/3 of the power of the opposite hand	2
Non-dominant hand	< 2/3 of the power of the opposite hand	1
	< 1/2 of the power of the opposite hand	2
IV. Arthritic Change		
None		0
Minimal	irregularity of the articular surface, sharpening of the articular margin	1
Moderate	narrowed joint space; osteophyte	2
Severe	marked osteophyte formation; ankylosis	3
Complication		
Nerve complication		1-2
Stiff fingers		1-2
Ruptured tendons		1-2
End Result		Point range
Excellent		0-3
Good		4-9
Fair		10-15
Poor		16-26

**Figure-5A**  
**Radial inclination**



**Figure-5 B**  
**Radial length**



**Figure-5 C**  
**Ulnar variance**



**Figure-5 D**  
**Volar tilt**



Fig-5 Normal average distal radial angles. A, Radial inclination (RI; average 22 degrees). B, Radial length (RL; average 12 mm). C, Ulnar variance (UV; average 0 to -2 mm). D, Volar tilt (VT; average 11 degrees volar).

## RESULTS

There were 20 male (43.48%) and 26 females (56.52%). The age range 16 years to 70 years with mean age  $48.54 \pm 16.36$ . 26 cases of fracture due to fall. Twenty cases were due to road traffic accident. All cases were unilateral. 21 patients with dominant hand and 25 with non dominant hand. According to the sum of demerit points (Saito [13], 1983), the latest follow-up functional end results were excellent in 45.66% [Fig-7], good in 34.78% [Fig-6], Fair in 10.87% and poor in 08.69% [Table-2]. As for the anatomical results at follow-up, the radial shortening <2mm in 37 (70.44%), from 2-4mm in 5 patients (10.87%) and >4mm in 4 (08.69%). The average radial tilt was  $22^\circ$  and palmar tilt was  $6^\circ$ .

**Overall:** Forty-two (91.31%) patients had satisfactory results functionally and radiologically as they successfully achieved normalcy within 80% of normal and 4 (08.69%) had unsatisfactory results as failure to achieve 80% of normalcy. One was due to inadequate initial reduction and fixation with subsequent progressive collapse resulting in an incongruous painful wrist joint. One patient had reflex sympathetic dystrophy. Two patients with radial shortening >4 mm associated with diminished grip strength and ulnar-sided wrist pain. The grip power did not improve significantly in patients with the non dominant side. The functional results of the patients with radial shortening of 6 mm or more were poor. Less effect of minor residual deformity of dorsal angulation and radial tilt on functional outcome. Minor complications included 8 patients with superficial pin tract infection. All patients responded to oral antibiotics without need for pin removal. At the time of device removal 20 out of 230 fixator pins were loose enough to be removed by hand, but in no case did loose pins result in loss of fixation. There were no fractures through the pin sites or pin migration, no injuries of the radial

sensory nerve or tendons of the forearm, no cases of intrinsic contracture, and no deep infections. Most complications can be avoided by improving surgical technique and fixation devices. Careful selection of

cases with vigilance is an important factor for excellent outcome.

**Table-2**

**Functional results according to demerits point system (Saiot, 1983) not including resident deformity component of this system**

Grading	Number of patients	Percentage	Subjective demerits points	Range of motion demerits points	Grip power demerits points	Arthritic demerits points	Complicate-ions demerits points	Resulted score range
Excellent (0-3)	21	45.66%	0	1	1	0	0	From 0 to below 3
Good (4-9)	16	34.78%	2	2	1	0	0	From 5 to below 9
Fair (10-15)	5	10.87%	4	3	2	2	1(stiff finger)	From 12 to below 15
Poor (16-26)	4	08.69%	6	4	2	3	2(stiff fingers)	From 17 to below 26

**Figure-6 A**  
**Pre-operative X-Ray**



**Figure-6 C**  
**After 1 Year X-Ray AP View**



**Figure-6 B**  
**Follow UP X-Ray**



**Figure-6 D**  
**After 1 Year X-Ray lateral View**



**Figure-6 E**  
After 1 Year grip plus flexion



**Figure-6 F**  
After 1 Year Extension



**Figure-6**  
Good Functional and Radiological Result at the end of 1 year

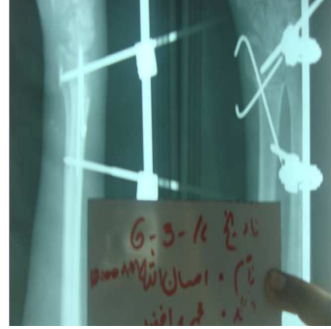
**Figure-7 A**  
Pre-operative X-Ray



**Figure-7 B**  
Pre-operative X-Ray lateral View



**Figure-7 C**  
Follow UP X-Ray



**Figure-7 D**  
After 1 Year x-ray AP view



**Figure-7 E**  
After 1 year x-ray Lateral view



**Figure-7 F**  
After 1 year neutral position



**Figure-7 G**  
**After 1 year flexion**



**Figure-7 H**  
**After 1 year extension**



**Figure-7**  
**Excellent Functional and Radiological Result of unstable fracture radius distal end right side after 1 year**

## **DISCUSSION**

The treatment of distal radial fractures is constantly changing. Though most reports of the results for conservative treatment of minimally displaced and stable fractures of distal end of radius have shown good outcome<sup>14</sup>. The traditional plate and screw approach is not the answer for unstable distal radius fractures. Often the distal fragments are periarticular and extremely small. The proximity to a tight network of tendons and retinacular sheaths precludes the use of bulky plates. Usually distal fragments are too thin to provide adequate thread purchase for bone screws. The mere creation of holes for bone screws in distal fragments can result in iatrogenic comminution. Tri Med fragment specific approach<sup>15</sup> is technically demanding procedure it needs specific training course before trying it. Though optimal fixation is achieved with implants that are specifically designed for each fracture fragment. The rationale for augmentation of external fixation is to resist forces created by muscle- tendon units

traversing the wrist which tend to cause a lateral/ rotational displacement of the radial styloid fragment and impaction of the lunate fossa fragment of initially well-reduced fractures despite support of only external fixation device. Simple addition of K-wires is adequate to resist these forces. This has been borne out clinically with a high rate of satisfactory results and specifically with an extremely high radiographic rating. Our ability to adequately manage the challenge of the unstable distal radius fracture lies in our ability to restore anatomy while limiting our treatment-related complications. Our experience has demonstrated that a limited open surgical approach combined with pins of adequate size can avoid bending and breakage and provide appropriate bone purchase. An external fixation device that allows pin insertion before fracture reduction while providing adequate stability and clear fracture visualization in all planes simplifies the surgical technique and therefore minimizes potential device-related complications. Once fixed in place with a K-wire, the major radial styloid fragment acts as a buttress for the lunate fossa fragment and for the smaller periarticular fragments of dorsal and/or anterior comminution<sup>16</sup>. Restoration of the radial length supports proximal carpal row so unloads lunate facet. Use of a K-wire as a "joystick" to elevate a depressed lunate fossa fragment is effective in restoring a congruent transition from scaphoid fossa to lunate fossa of the distal radial articular surface. Several studies clearly showed that restoration of the radial length is the most important factor in achieving a good end result<sup>17</sup>. Need to elevate the lunate fossa 5 mm or more after radial styloid reduction and fixation has demonstrated a void of metaphyseal bone. This requires a supportive bone graft behind the transverse subarticular Kirschner wire. Addition of this limited internal fixation and bone graft in appropriate cases has provided superior overall results, and has demonstrated maintenance of articular congruity by radiographic assessment. Our results are comparable with William H who reported 92% satisfactory results. A number of studies have shown favorable results following external fixation of distal radial fractures<sup>18,19</sup>. The importance of immediate postoperative hand rehabilitation and patient education in activities of daily living and in pin-site care cannot be overlooked. This procedure yields



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comparable results to other costly procedures. The other recent techniques<sup>20</sup> need lots of expertise, experience and expensive equipments and implants which are not available at every center. This procedure can be performed by majority of orthopaedic surgeons even in small peripheral centers.

## CONCLUSION

The application of common 3.5mm AO external fixator with addition of k-wires is quick simple, minimally invasive, and prevents redisplacement of fracture fragments adequately. This technique is effective in restoration of the radial length which is the most important factor in achieving a good end result. The chance of infection is small and less damage occurs in the surrounding tissue compared to open reduction with internal fixation. The patients are very happy with low cost and surgery at door step.

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