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Study of operative results of fracture distal end radius AO type 2R3C1 and C2 treated by external-fixator and k-wires in adults

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Abstract
The wrist joint is one of the most important joints in human body, essential to carry out day to day activities. Fractures of the distal end of the radius are amongst the most common fractures encountered in clinical orthopaedic practice. Learning how to anatomically fix these fractures, so that good functional outcome is obtained is very important. The principle of ligamentotaxis can help in reduction of certain fractures. However, some specific fractures require additional stability. This can be done with certain closed procedures like K-wires and External fixator in adults. In this prospective study, we studied 26 patients from July 2020 to October 2021 having AO type 2R3C1 and C2 treated with K-wires + External fixator. Patients were followed up for an average of 9 months and functional outcome was calculated using Green O'Brien and Gartland and Werley scoring system.

Keywords: Distal end radius, Kirschner wire, ligamentotaxis, external fixation

1. Introduction
Fracture of the distal end of radius is one of the most common fractures [1]. It commonly occurs in middle aged and elderly women. It also occurs in young men with high velocity injury though such cases are less in number [14]. The moulding of fracture fragments into alignment by traction force applied across the fracture through the surrounding soft tissue is known as ligamentotaxis. Anderson and O Neil [2] were first to maintain fracture reduction with an external fixator using the principle of ligamentotaxis. Multiple studies have documented the efficacy of this technique [3, 7, 8].

1.1 Measurements
- **Radial angulations:** Relative angle of distal radial articular surface on PA view to a line perpendicular to long axis of radius. Normal range is 13-30 degrees (avg.23 degrees). Loss indicates radial fracture with impaction or overlap of fragments.
- **Radial width:** Distance between longitudinal axis through the centre of radius and most lateral point of radial styloid process.
- **Radial length:** Measured on PA view, relates to length of radius to the ulna by the distance between to perpendicular lines to the long axis of radius: one joining tip of radial styloid and the other articular surface of the ulnar head. Normal is 11 to 12 mm. Range is from 8 to 18 mm
- **Palmar tilt:** Measured on lateral radiograph as angle created between articular surface of distal radius and a line perpendicular to the long axis of radius. The normal value is 11 -12 degrees.
- **Ulnar variance:** It is the distance between 2 axes which are perpendicular to longitudinal axis of radius: one tangential to distal articular surface of ulna and other from the medial articular corner of distal end radius. When the distal articular surface of ulna is distal to medial corner of radius [2], it is called- positive ulnar variance. When the distal articular surface of ulna is proximal to medial corner of radius it is called – negative ulnar variance. If relative ulnar length is varied by 2 to 2.5 mm, the load borne by ulna is increased from 5 to 40%.

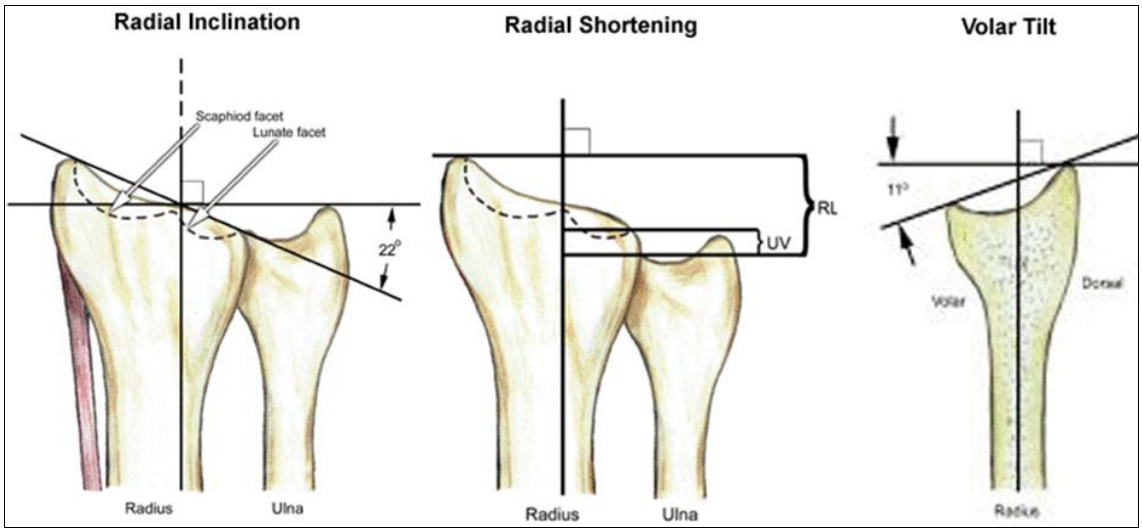

Fig 1: Images of Radial Inclination, Radial Shortening and Volar Tilt

2. Aims and Objectives

The purpose of this study is to evaluate and observe functional and radiological outcome in adults having fractures of distal end of radius of AO type C1 and C2 treated with closed reduction and external fixation using k- wires and external fixator in reference to following:

- Adults (above 18 years)
- Type of fracture
- Clinical and radiological sign of union
- Range of motion
- Complications
- Functional outcome

3. Materials and Methods

3.1 Inclusion criteria

- Unstable fractures which fail to maintain reduction after initial attempt at closed reduction
- Skeletally mature patients having age more than 18 years.
- Fractures of AO type C1 and C2
- Patients with 6 months follow up
- Medically fit patients willing for surgery

3.2 Exclusion criteria

- Pathological fractures
- Patient lost to follow up
- Fractures of AO type A, B and C3.
- Associated fracture of same side of radius bone at higher level.

3.3 Implants used in surgery

1. K-wires: They are of various sizes
2. Schanz pins: 3.5 mm self-tapping threaded half pins for radius. 2.5 mm self-tapping threaded half pins for metacarpals.
3. Aesculap clamps.
4. T-handle.
5. Connecting rods: Available in sizes of small and long
6. Drill bit: 2.5mm for radius and 1.5 mm for metacarpals.

3.4 Surgical technique

- In each patient the fracture was assessed in AP & Lateral views on digital radiograph and need for CT scan was decided. After preoperative fitness, surgical intervention was planned for these patients.
- Operation was done under regional or general anaesthesia using tourniquet and proper aseptic precautions.

3.5 Pin insertion technique

Fig 2: Pin insertion technique with final image

Under fluoroscopic guidance, first of all primary reduction is achieved with traction and manipulation of fracture, which is then fixed with K-wires. After this, 2 schanz pins of 3.5mm are passed through radius and 2 schanz pins of 2.5mm are passed, one through 2nd and 3rd metacarpal neck and other through the base of 2nd and 3rd metacarpal. These schanz pins are then fixed with connecting rods via aesculap clamp with joint in appropriate distraction. The position is usually kept such that reduction is maintained. Regular pin tract dressing is then done and antibiotics started post-operatively. Elbow joint and MCP joints are kept free to mobilize.

4. Observation and Results

In our study, we have included 26 patients having distal end of radius fracture treated with k-wires and external fixators from July 2020 to October 2021. The patients were followed up for an average period of 9 months between a period ranging from 6 months to 1 year.

4.1 Patient Demographics and characteristics

- After applying Inclusion and Exclusion criteria, Of the 26 patients, 20 patients were females and 6 were males, with the mean age of 50 years (26-71).
- There were 18 patients who had injury to right side, rest of 8 patients having injury to left side. Most of the patients were right hand dominant.
- Incidence of self-fall was more as compared to domestic fall down. This is due to the fact that there are more elder patients in our study.

Table 1: Movements of wrist joint at final follow up

	Normal range	Our study range	Our study avg.
Supination	70-90	60-90	74
Pronation	70-85	70-85	78
Palmer flexion	70-90	45-90	75
Dorsiflexion	65-90	30-90	80
Radial deviation	15-25	13-20	17
Ulnar deviation	30-40	25-35	30

Table 2: Evaluation according to Gartland and Werley score

Score	No. of patients	Percentage
Excellent	18	69.23%
Good	6	23.07%
Fair	2	7.6%
Poor	0	0
Total	26	100

Table 3: Evaluation according to Green O'Brien Score

Results	Patients
Excellent (90-100)	16
Good (80-89)	8
Fair (65-79)	2
Poor(<65)	0

In our study, we have had 5 patients who have had complications. We have had 1 patient with superficial infection that resolved with regular wound care and antibiotics. We also had 2 patients each who had residual dorsal tilt and grip weakness at the end of final follow up. These complications can be attributed to the technique of external fixation like excessive distraction, irritation of tendons or excessive palmar flexion/ulnar deviation while trying to fix the fracture [5, 6]. We managed them with regular physiotherapy and grip strengthening exercises. In our study, we have not encountered any complications such as Sudeck's osteodystrophy which have been reported occasionally [4]. In our study

5. Discussion

- Fracture of distal end of radius is one of the most common fractures of the body [14].
- The use of external fixators in the treatment of distal radius fractures is common [9, 11].
- In comparative studies, bridging external fixators achieved consistently better anatomical results than re-manipulation and cast management [12].
- In displaced fractures of distal radius, reduction is easy to achieve but difficult to maintain due to intraosseous crushing. There is a void at the fracture site which can heal only after collapse. This collapse is kept in place using external fixator.
- The addition of K wires to an external fixation construct helps to increase rigidity. This may be required if fracture reduction cannot be obtained by ligamentotaxis with the fixator alone, or if an excessive, non-physiological position of the wrist is needed for fracture reduction [13].
- With the presence of dual fixation, either the fixation or K wires can be removed early if needed.
- Micic *et al.* [21] reported a statistically significant difference in particular congruity in a group of patients treated with K wire and external fixator as compared to external fixator alone leading to better functional outcomes in the K wire group. Our study confirms these findings.
- The most important factor affecting the functional outcome was radial height followed by palmer tilt.
- K-wire insertion contributed significantly in the correction of palmer tilt after distal end of radius fracture and improves the stabilization effect of external fixation.
- In our study we have radial height of 10 mm which is within normal range of acceptable criteria. Restoration of radial shortening and palmer tilt appears to be the major factor in regaining normal wrist function after fracture.
- Charles Lin *et al.* [19] reported a palmar flexion of 45 degrees and dorsiflexion of 35 degrees in the group of patient treated with external fixator and k wires. Our study reported an average palmar flexion of 75 degrees and dorsiflexion of 80 degrees which is better than Lin *et al.* and comparable to Fardeen Sherriff *et al.* [20] and Micic *et al.* [21].
- The difference in results can be attributed to the fact that Lin *et al.* [19] studied fixation in AO C3 type fractures and hence inferior results were obtained while rest of the studies included all AO subtypes of Distal end of Radius.
- K-wire insertion and external fixation of distal end of radius fractures have better stability for extra articular distal end of radius fractures [15].

Table 4: Comparison of our studies to other studies

Study	Charles Lin *et al.* (2004) [19]	Fardeen sheriff *et al.* (2017) [20]	Micic *et al.* (2019) [21]	Our study
No. of cases	36	15	20	26
Mean age	62.3(23-89)	34(20-50)	46.6	50(29-71)
Type of procedure	k-wire + External fixator	k-wire + External fixator	k-wire + External fixator	k-wire + External fixator
Palmer flexion(degrees)	42	67	68	75
Dorsiflexion (degrees)	35	69	69	80
Supination (degrees)	83	69	78	74
Pronation (degrees)	64	68	78	78
Radial deviation (degrees)	16	14	14	17
Ulnar deviation (degrees)	21	22	25	30
Loss of Radial length (mm) average	0.3	1.67+/-0.89	2.32 +/- 2.23	1.76
Radial inclination	25	19	18	20
Palmer tilt	3	8	1.52+/-5.72	5
Complication	N=11(33%)	N=4(23.5%)	N=10(30%)	N=6(23%)

Table 5: Functional outcome

Study	Charles lin *et al.* (2004) [19]	Fardeen sheriff *et al.* (2017) [20]	Micic *et al.* (2019) [21]	Our study
Scoring system	Gartland and Werley	Gartland and Werley	NYOH	Gartland and Werley
Functional outcome	Excellent to good - 91.60% Fair to poor - 8.4%	Excellent to good - 86% Fair to poor - 14%	Excellent to Good- 95% Fair to Poor- 5%	Excellent to good - 92.30% Fair to poor - 7.6%

6. Clinical cases

Fig 3: Pre-operative, post operative X-ray with functional outcome of a 52/female with AO type C-1 Distal end radius fracture

Fig 4: Pre operative; post operative and functional images of 26 years old male patient having AO type C2 Distal End Radius Fracture

7. Conclusion

- The use of external fixator and placement of intramedullary Kirschner wires can avoid displacement of fracture and helps achieve anatomical union, resulting in better functional outcome.
- It is an effective method of treating unstable extra-articular and complex intra-articular fractures of the distal end of radius.
- The small external fixator is a simple device which is easy and safe to use even under regional anaesthesia with the distinct advantage of superior mechanical efficiency and capacity of fracture adjustment during healing period and unimpeded access to wounds in cases of open fractures.
- The shorter period of surgery without the use of tourniquet and minimal exposure are its distinct advantage over plate fixation. It can be performed in emergency with minimum instrumentation and expertise.
- Complications like infections are rare because of this being a closed procedure.
- Wrist and finger stiffness are usually not seen with appropriate physiotherapy.
- External fixator can not be used in coronal shear fracture like AO Type-B.

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