Original Article

Prospective Randomised Study of Intra-Articular Fractures of the Distal Radius: Comparison Between External Fixation and Plate Fixation

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Abstract

Introduction: Intra-articular fractures of the distal radius represent high energy, complex, unstable injuries and the optimal method of treatment remains controversial. Materials and Methods: The aim of the paper is to compare the outcomes of external fixation (EF) with open reduction internal fixation (ORIF) with plates and screw fixation in the treatment of intra-articular fractures of the distal radius. Thirty-five patients were enlisted from December 2003 to September 2005 after a failure of initial conservative treatment. The patients were randomised into EF or ORIF groups. The patients were followed-up at 1 week, 3, 6, 12 and 24 months. Clinical and radiological outcomes were measured. They were scored using the Green and O'Brien or the Gartland and Wertley score. Results: Of the 35 patients, 5 defaulted the 6-month follow-up and were excluded. We found that the clinical and radiological outcomes for the 2 groups were not significantly different. Complication rates were also similar. Conclusion: There is no significant difference in the outcome of intra-articular distal radius fractures treated with either EF or ORIF.

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Key words: AO C fractures, Open reduction plate fixation, Randomised controlled trial, Unstable fracture of the distal radius

Introduction

Intra-articular fractures of the distal radius represent high energy, complex, unstable injuries and the optimal treatment remains controversial. Kreder et al[1] showed that external fixation provides more rapid return to function and superior functional outcome within 2 years compared to open reduction and plate fixation, provided intra-articular step and gap deformity are minimised. Westphal, Piatek, Schubert, Winckler[2], on the other hand, showed no differences between external fixation and ORIF.

Many surgeons prefer external fixation for AO C3 fractures as it becomes technically difficult to perform open reduction and internal fixation with increasingly comminuted fractures. However, with newer implants which are smaller and versatile, as well as fixed angle screws, there is a resurgence of ORIF.

The aim of our study was to compare the outcomes of external fixation with plate fixation of intra-articular fractures of the distal radius. This was part of a multi-centred prospective study comprising three centres (Hong Kong, Taiwan and Singapore). All surgeries were performed by a single surgeon. The protocol was approved by the hospital's ethics committee (Fig. 1).

Materials and Methods

All patients with AO type C fractures between December 2003 and September 2005 in our institution were treated with those with manipulation and reduction. Patients were randomised into either external fixation (EF) or open reduction and plate fixation (Table 1). Those with failure to achieve acceptable reduction or re-displacement within 2 weeks are enrolled into the study (Table 2).

These patients were randomised into either the external fixator (EF) or open reduction internal fixation (ORIF) (Table 1). Bone grafting, open reduction, K wiring and the use of fluoroscopy were used as the surgeon required. The plates used were 3.5mm AO T or oblique plates and a volar, dorsal or volar/dorsal approach was used. Data

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Table 1. Demographics of EF and ORIF Groups

Variable	Ext fixator n = 14	ORIF n = 16	*P* value
Gender (male:female)	9:5	9 :7	0.72
% males	64.29% males	56.25% males	
Age (range), y	45.3 (35-55)	41.8 (21-56)	0.75
Side (%) right sided injury	3 (21.4%) right sided injury	10 (62.5%) right sided injury	0.03
Dominance	12 right handed, 2 left handed (85.7% right handed)	15 right, 1 left handed (93.75% right handed)	0.59
Dominant side injured (%)	5 (35.71%)	9 (56.25%)	0.30
Comorbidities	14 (100%) nil	16 (100%) nil	-
Concomitant injury (%)	4 (28.6%)	4 (25%)	0.99
Energy level (high energy)	4 (28.6%)	8 (50%)	0.28

Table 2. Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
16 to 60 years	Premature menopause
AO C fractures	Drug/alcohol abuse
Failure of conservative treatment	Skeletal immaturity
Unacceptable reduction after at least one attempt at closed reduction	Severe open or delayed open fractures where ORIF is contraindicated
Surgical operation performed within 2 weeks after injury	Delay of >14 days after injury
Written consent by the patient	Isolated radial styloid or volar barton's Unco-operative patients

Table 3. Fracture Characteristics of EF And ORIF Groups

Variables	EF (range) n = 14	ORIF (range) n = 16	*P* value
Open or closed fractures	14 (100%) closed	16 (100%) closed	-
AO classification	13 (92.9%) C3 1 (7.1%) C2	13 (81.25%) C3 3 (18.75%) C2	0.60
Ulna styloid involvement	8 (57.1%) involvement	8 (50%) involvement	0.73
Time of removal of device (weeks)	Ave 7 weeks (range 6-8)	13.1 weeks (range 4-18 weeks); 2 not removed at 24 months	0.02
Bone grafting	5 (35.7%) bone grafted	2 (12.5%) bone grafted	0.20
K wires	12 (85.7%) K wired	7 (43.8%) K wired	0.03

was collected at presentation, 3, 6, 12 and at 24 months. X-rays were performed in the AP and lateral views 1 week postoperatively, at 3 months, 6 months, 12 months and 24 months and were assessed for degree of displacement and evidence of osteoarthritis.

The complications analysed include median neuropathy, finger stiffness, arthritis/OA grading, complex regional pain syndrome (CRPS) and tendon rupture. Knirk and Jupiter grading was used for the grading of radiocarpal arthritis following surgery.

There were 35 cases of AO C distal radial fractures in Tan Tock Seng Hospital (TTSH) between December 2001 and September 2003. Five patients defaulted 6-months follow-up and were excluded from the study. The 2 groups were compared based on demographics (age, gender, side of injury, hand dominance), fracture characteristics (AO C1, 2, or 3 and energy level of injury), need for adjuncts (bone grafting/K wiring as required) and overall complication rate (Table 3).

Analysis of covariance was applied to ascertain the difference in the Green and O'Brien scoring between groups. The sample size was able to detect an effect size of 0.75, with power and level of significance fixed at 80% and 5%, respectively; 16 subjects in a group will be required. In addition, various regression models were also employed to analyse the secondary outcomes. Analysed with Stata 9.0 (Stata Corp, Texas, USA), all statistical tests were conducted at 5% level of significance.

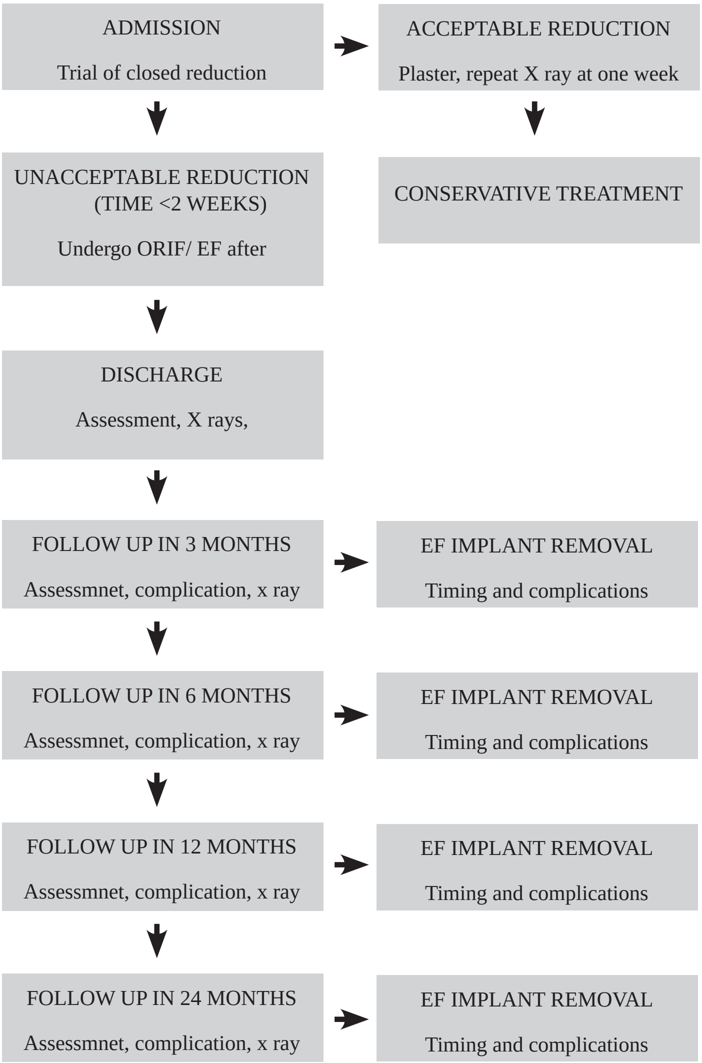

Fig. 1. Protocol

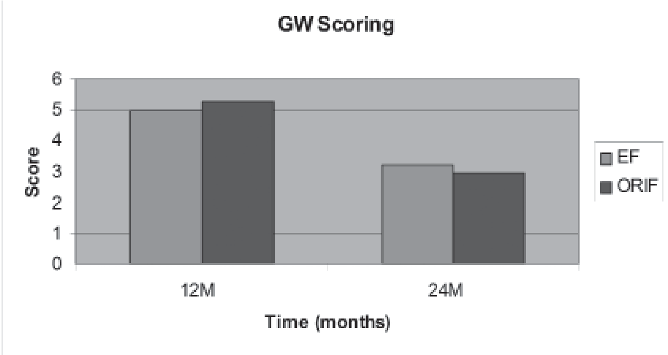

Fig. 2. Graph showing Gartland and Wertley scoring at 12 and 24 months. (P = 0.88 at 12 and 24 months)

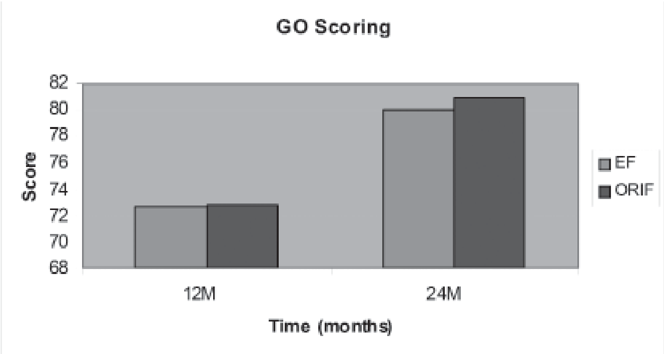

Fig. 3. Graph showing Green and O'Brien Scoring at 12 and 24 months. (P = 0.76 at 12 months, 0.85 at 24 months)

Results

Clinical Outcomes

ORIF appeared superior to EF at 12 and 24 months using the Gartland and Wertley scoring but this was not significant (P = 0.88, 0.88) (Fig. 2). The Green and O'Brien scoring was not significantly different for the 2 groups although the ORIF group is slightly superior. Over time, the GW scoring showed overall improvement for both groups (P = 0.04), however, this was not found to be so using the GO scoring (P = 0.10).

Range of Motion and Grip Strength (Table 4, 5 and 6)

The range of motion in the cohort of ORIF was not shown to be significantly different from the group undergoing external fixation. There was no difference in percentage grip strength of the injured hand compared to the normal hand in both groups at 6, 12 and 24 months.

Radiological Outcomes (Tables 7 & 8)

For radial height, radial shortening and radial tilt, there was no difference between the 2 groups. There was decreased radial tilt for the cohort over time (P = 0.03). Over time, increase in radial shortening and radial shift was seen for the 2 groups as a cohort (P < 0.01 for both). There was no statistical difference demonstrable between the 2 although it appeared that EF had increased in radial shift with time (P = 0.18 and 0.42 at 12 and 24 months, respectively). There was no loss or deterioration of radial height, palmar tilt, radiocarpal joint distance and step off over time (P > 0.05).

For the EF group, there was 1 patient with a 2mm step at 12 months on PA film. At 24 months, there were 3 patients with a 2mm step and 1 patient with a 1mm step (at 12 months P = 0.99). For the ORIF group, there was 1 patient with a 2mm gap on PA film. At 24 months, there were 3 patients with a 2mm step, 1 patient with a 1mm step, and 1 with a 3mm step on PA films (at 24 months, P = 0.89). Between 12 and 24 months, there was no significant increase in loss of reduction (P = 0.25).

At 12 months, the EF group had 33.33% (4 of 12) showing mild stiffness at 12 months while 27.27% (3 of 11) of the

Table 4. ROM and Percentage Power Compared to Normal Hand at 6 Months

	EF (range)	ORIF (range)	*P* value
Volar flexion	46.07 (30-65)	46.0 (20-75)	0.90
Dorsiflexion	48.93 (30-70)	56.56 (30-80)	0.08
Supination	80.0 (45-90)	79.69 (55-90)	0.88
Pronation	75.71 (55-110)	70.0 (30-105)	0.32
Ulna deviation	22.86 (15-40)	24.06 (15-30)	0.72
Radial deviation	13 (2-30)	14.06 (5-25)	0.49
Percentage grip strength (percentage)	74.77 (40-125)	71.49 (42-108)	0.79

Table 5. ROM and Percentage Power Compared to Normal Hand at 12 Months

	EF (range)	ORIF (range)	*P* value
Volar flexion (degrees)	45.83 (30-60)	46.82 (25-65)	0.95
Dorsiflexion (degrees)	51.08 (40-65)	55 (25-75)	0.31
Supination (degrees)	80.83 (55-90)	82.27 (65-90)	0.68
Pronation (degrees)	75.83 (60-85)	68.18 (0-85)	0.59
Ulna deviation (degrees)	24.58 (15-45)	20.45 (15-30)	0.23
Radial deviation (degrees)	12.5 (5-20)	14.09 (10-20)	0.29
Percentage grip strength (percentage)	79.43 (47-102)	80.76 (55-112)	0.79

Table 6. ROM and Percentage Power Compared to Normal Hand at 24 Months

	EF (range)	ORIF (range)	*P* value
Volar flexion (degrees)	51.82 (35-65)	49.09 (30-60)	0.59
Dorsiflexion (degrees)	55 (40-70)	59.55 (40-70)	0.17
Supination (degrees)	80 (55-90)	85.45 (75-100)	0.21
Pronation (degrees)	75.91 (65-85)	71.82 (60-80)	0.23
Ulna deviation (degrees)	25 (20-30)	24.55 (20-40)	0.45
Radial deviation (degrees)	15.91 (5-25)	15 (5-25)	0.72
Percentage grip strength (percentage)	95.7 (70.2-161.5)	89.34 (64.5-118.7)	0.78

Table 7. Summary of Radiological Outcomes at 12 Months

	EF (range)	ORIF (range)	*P* value
Radial height (mm)	11.72 (6-16)	13.04 (9-17)	0.27
Radial shortening (mm)	-0.273 (-2-4)	0.273 (-2-3)	0.17
Radial tilt (degree)	24.55 (14-31)	25.08 (20-30)	0.83
Radial shift (degree)	16.45 (14-21)	17.29 (15-21)	0.18
Palmar tilt (degree)	1.455 (-22-12)	1.723 (-14-20)	0.93
RCJ distance (mm)	2 (2-2)	1.83 (1-3)	0.15
Articular step off (mm)	0.36 (0-2)	0.72 (0-3)	0.99

Table 8. Summary of Radiological Outcomes at 24 Months

	EF (range)	ORIF (range)	*P* value
Radial height (mm)	12.68 (6.5-17)	12.63 (8-15)	0.98
Radial shortening (mm)	0.273 (-2-3)	0.64 (-1-2)	0.58
Radial tilt (degree)	24.5 (15-36)	24.0 (16-32)	0.82
Radial shift (degree)	17.32 (13-28)	17.32 (15-20)	0.42
Palmar tilt (degree)	3.64 (-16 -16)	4.72 (-7-9)	0.90
RCJ distance (mm)	1.82 (1-3)	1.55 (0-2)	0.99
Articular step off (mm)	0.64 (0-2)	0.80 (0-3)	0.89

ORIF group exhibited this (P = 0.99). At 24 months, stiffness was seen in 16.7% (2 of 12) in the EF group and 25% (3 of 12) in the ORIF group (P = 0.99) (Tables 7 and 8).

Complications

A. Median Neuropathy

At 12 months, the EF group had 0% (0 of 12) incidence of median neuropathy at 12 months while the ORIF had 9.09% (1 of 11) incidence grade I median neuropathy (P =0.48). At 24 months, median neuropathy was seen in 8.33% (1 of 12) of the EF group and 0% (0 of 12) in the ORIF group (P = 0.99). There were OA changes on the x-rays of 33.3% (4/12) of the EF group and 33.3% (4/12) of the ORIF group (P = 0.99).

B. Arthritis

For the EF group at 12 months, there were 3 patients with grade 1 arthritis and 1 with grade 3 arthritis. Three patients had grade 1 changes on x-rays. At 24 months, 1 additional patient had developed grade 1 arthritic pain. There were a total of 4 patients with grade 1 arthritis on x-rays.

For the ORIF group, at 12 months, there was 1 patient with grade 1 arthritic pain and 1 patient with grade 3 pain. X-rays revealed 2 grade 1 OA changes for the 2 patients. At 24 months, 2 additional people developed pain (1 grade 1 and 1 grade 3). There were a total of 4 patients whose x-rays revealed grade 1 OA changes.

C. Other complications

There was no incidence of complex regional pain syndrome (reflex sympathetic dystrophy), tendon rupture or radial neuritis at any time during the 2-year follow-up.

No pin site infection, breakage of implant. Fractures at a pin site, late collapse and re-displacement were also not seen. There was no statistical difference between the EF and ORIF groups for all complications measured.

Discussion

Comminuted intra-articular fractures of the distal radius are difficult to manage. A variety of methods of treatment have been used with success.[3] External fixation alone has not proven to be sufficient. External fixation with K wiring has been used with some degree of success.[4] Open reduction with internal fixation, either via a volar, dorsal or a combined approach is used. External fixation has the advantage of minimal soft tissue disruption, and is usually used with K wires and bone grafting supplementation. Arthroscopic assisted reduction and stabilisation with K wires and external fixation have the advantage of direct visualisation of the articular surface and concomitant assessment of the ligaments. Open reduction and internal fixation is technically demanding and should not be done unless the surgeon is sufficiently skilled in the technique. External fixation is often insufficient alone and often requires reduction with adjuncts such as bone grafting or K wiring in many cases.[5] In recent years, there has been a surge of interest in open reduction and internal fixation for comminuted distal radius fractures. With better and smaller implants, with locking screws, even comminuted fractures with dorsal metaphyseal instability can be fixed with a volar plate.

Despite the use of various methods of treatment of intra-articular fractures, the optimum method of treatment has not been determined. A local paper by BK Chan et al[6] and a paper by McKenna J[7] on the use of external fixator in the treatment of unstable intra-articular fractures of the distal radius showed that external fixator yielded good results. However, external fixation alone is insufficient to address articular congruity. External fixation with K wiring was compared to ORIF by a few authors. Kreder found the use of EF superior.[1] Grewel (dorsal)[8] and Margaliot[9] found no difference in the 2 methods. In the latter case, the external fixation group had a higher rate of complications.

Kreder et al[1] had conducted a randomised controlled trial of indirect reduction and percutaneous fixation versus ORIF for displaced intra-articular fractures of the distal radius. During the 2-year follow-up, patients who had indirect reduction and percutaneous fixation had a more rapid return to function and were found to have a better functional outcome, provided articular step and gap deformity was minimised. Grewel et al[8] had found no differences using the Disabilities of the Arm, Shoulder and Hand outcome scores for open reduction internal fixation with dorsal plating or mini-open reduction, percutaneous fixation and external fixation. They recommend external fixation over open reduction and internal fixation for the fixation of intra-articular distal radius fractures since the dorsal plate group showed a higher complication rate, tourniquet time and pain at 1 year when compared to the EF group.

Arora and Malik[10] on the contrary, concluded that EF was insufficient. They had applied the external fixator to patients who sustained comminuted displaced intra-articular fractures. EF was able to maintain reduction in those cases but was not able to restore articular congruity in many cases. They recommend that EF be supplemented with additional procedures such as bone grafting or K wiring or arthroscopy for restoration of articular congruity.

Margaliot et al[9] had performed a meta-analysis on outcomes of external fixators versus plate osteosynthesis for unstable DR fractures. They concluded that there was no evidence to support that the use of ORIF is superior to EF. However, there were significantly higher rates of postoperative neuritis, infections, pin loosening and hardware failure for the external fixator groups. Tendon rupture and tenosynovities were more commonly seen in the ORIF group.

There is no difference between EF and ORIF in DR AO C3 fractures in some series. Westphal et al[2] performed a retrospective comparative study and found no differences between EF and ORIF outcomes. A paper by Kapoor et al[11] in 2000 reported a randomised controlled trial on displaced intra-articular fractures of the DR. He concluded that ORIF provided the best anatomical restoration with patients least likely to develop arthritis. However ORIF should be avoided in severely comminuted fractures as fixation may not be stable with poorer functional results. EF is seen to maintain radial length best due to sustained countertraction utilising the principle of ligamentotaxis. EF provides the best results in severely comminuted fractures. Complications are minimal with meticulous pin insertion and pin site care.

Rogachefsky et al[12] used open reduction with a combination of EF and ORIF for severely comminuted AO C fractures and found that this provides satisfactory function and can restore radiological parameters, maintain reduction. Our study shows there is no difference between the 2 modes. However, we are limited by our small sample size.

The outcome of comminuted distal radius fractures treated with volar locking plates is promising. This removes the risks associated with dorsal locking plates, for example, adhesions, tendon rupture and prominence. There is a current trend towards the use of internal fixation. Newer plates such as the locking plates provide stable fixation, and make double plating unnecessary as well as reduces the use of external fixation. This study was performed before the widespread use of volar angled stable plate fixation. Surgical techniques may be difficult to randomise since individual surgeons have a personal preference due to equipment familiarity and training.

Articular Congruity

At 12 months, 2 patients had a 1mm step while 1 patient had a 2mm step on PA films. At 24 months, 3 patients in the EF group had a 2mm of step and 1 patient with a 1mm step.

In the ORIF group at 12 months, 1 patient had a 1mm step, 2 patients had a 2mm step and 1 patient had a 3mm step. At 24 months, the same number of patients with the same degree of step was seen for the ORIF group.

Supplementary methods were used in some cases to improve anatomical result. Bone grafting was taken from iliac crest in some patients to fill defects and stabilise the fracture site. K wire fixation was used to stabilise fragments. In the EF group, 3 patients had bone grafting performed in addition to EF. Nine patients of the 14 had K wires inserted for stabilisation. Average time of removal of EF was 7.09 weeks (range 6 to 8 weeks). In the ORIF group, 2 patients underwent bone grafting and 5 patients of 11 had additional K wiring. The mean time of removal of K wires was 12.9 weeks (range 5 to 16 weeks).

The most common complication seen in this group of patients is finger stiffness at both 12 and 24 months review. Stiffness appeared to be more severe in the EF group at 12 months, but at 24 months, the group with the ORIF had more stiffness. This may be related to the earlier time period for removal of the external fixator in the EF group. We have tried to engage all patients in early hand occupational therapy to retain range of movement of joints. There were no complications such as radial nerve neuritis and wound infection in the followed-up patients.

Limitations of our study include small numbers. We used a variety of non-locking plates. They were assessed for DRUJ instability but not correlated to outcome. Variations in technique in the ORIF group in terms of dorsal, volar or dorsal/volar plating were present. We did not analyse other issues related to workman's compensation.

Conclusion

We did not find any significant difference between EF and ORIF for primary and secondary outcomes. There was overall improvement in volar flexion, dorsiflexion and supination from 6 months to 24 months but not for pronation, ulna, radial deviation and percentage power over time. Over time, progression in radial shortening and radial shift was seen for the 2 groups as a cohort. There was no difference demonstrable between the 2 although it appeared that EF had increased in radial shift with time. There was no loss or deterioration of radial height, palmar tilt, radiocarpal joint distance and step off over time.

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