ANALYSIS OF FUNCTIONAL AND ANATOMICAL OUTCOME OF MANAGEMENT OF UNSTABLE EXTRA-ARTICULAR DISTAL RADIUS FRACTURE WITH PLASTER IMMOBILIZATION AND WITH EXTERNAL FIXATION

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CERTIFICATE

This is to certify that **Dr.N.KARTHIKEYAN**, post graduate student (2005 - 2008) in the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur has done this dissertation on **`ANALYSIS OF FUNCTIONAL AND ANATOMICAL OUTCOME OF MANAGEMENT OF UNSTABLE EXTRA-ARTICULAR DISTAL RADIUS FRACTURE WITH PLASTER IMMOBILIZATION AND WITH EXTERNAL FIXATION '** under my guidance and supervision in partial fulfillment of the regulation laid down by the Tamil Nadu Dr. M.G.R Medical University, Chennai for MS (Orthopaedics) degree examination to be held on March 2008.

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I dedicate this work to my loving daughter, wife and my parents.

CONTENTS

INTRODUCTION

Fractures of the distal radius are one of the most common fractures seen in an emergency department. Nearly two centuries after Sir Abraham Colles described a fracture distal radius in 1814, still there is no consensus regarding the description, management and assessment of the outcomes of fracture distal radius.

Fracture of the distal radius being a common fracture and closed in most cases, has long been treated by closed reduction and cast application. Although cast does provide support, it will not completely maintain a reduction. Hence, in a majority of cases, satisfactory reduction will reangle or redisplace in an immobilizing cast resulting in a poor functional outcome.

Displaced fractures of distal radius are considered unstable when alignment can not be maintained in a forearm plaster after closed reduction, but this definition applies retrospectively. Previous studies have attempted to identify risk factors for instability from which we can predict instability at the initial presentation.

Various methods of preventing or minimizing the loss of reduction of unstable fractures of distal radius have been described. These include

- Percutaneous pinning
- Immobilization with pins incorporated in the plaster
- External skeletal fixation
- Limited open reduction with or without bone grafting or bone graft substitutes and
- Extensive open reduction an internal fixation.

For an unstable extra articular fracture of distal radius percutaneous pinning has been recommended as a simple way of providing additional stability to immobilization in cast. Percutaneous pinning has all the disadvantages of external fixator like inability to achieve direct reduction, immobilization of radio carpal joint and pin tract infections. It also lacks some of the advantages of external fixators like adjustability, known strength and reusability for a specific patient.

External fixation for distal radius fracture relies on the principle of **Ligamentotaxis** in which, a distraction force applied to the carpus aligns the fragments by means of intact ligaments. Distraction assisted reduction and maintenance of distal radius fracture is a widely used and reliable treatment method.

AIM

The aim of this study is to analyze and compare the functional and anatomical outcome of management of unstable extraarticular fracture of distal radius by closed reduction and cast immobilization with closed reduction and external fixation.

REVIEW OF LITERATURE

HISTORIAL ASPECTS

In the year 1814, Sir Abraham Colles, a surgeon from Ireland described the most common fracture pattern affecting the distal radius before the invention of X rays. Ponteau, a French surgeon is said to have described the same fracture earlier.

Other surgeons notably Smith and Barton also described fractures of distal radius in the nineteenth century. After the introduction of radiography, Hutchinson described radial styloid fracture and named it as Chauffeur's fracture.

Initially surgeons treated distal radius fractures with casts and splints.

Anderson and O'Neil described external fixator for distal radius fractures in 1944. They were the pioneers in using external fixators for management of distal radius fractures. They produced excellent results in most of their patients.

In 1951, Gartland and Werley published their Demerit Point System of functional evaluation of outcome of distal radius fracture.

In 1959, Lindstrom published his study on the end results of the fractures of distal radius in the Journal of Acta Orthopaedica Scandinavia.

In 1967, Frykman introduced his classification.

Cole and Obletz described an alternative method utilizing pins and plaster.

In 1965, Ellis described volar buttress plate for Barton's fractures.

In 1985, Diego L. Fernandez introduced his system of distal radius fracture classification.

In 1980s and 1990s, articles about open fixation with or without external neutralization were published.

DEMOGRAPHY

Incidence

The distal radius fracture is the most common forearm fracture. McMurthy et al reported that distal radius fractures account for one sixth of all fractures seen in any emergency department.

Age

A bimodal age distribution has been documented. Peaks occur at ages between 5-14 years and at ages between 60-69 years. The first peak is due to increased **physical activity** seen in adolescents and second peak is due to **osteoporosis** of old age.

The majority of the fracture in the elderly are extra articular, whereas the incidence of intra articular fractures are much higher in the young.

Sex

Most distal radial fractures occur in postmenopausal women. So in elders, the male to female ratio is 1: 4. However in adolescent boys and girls the ratio is 3: 1 because of their level of sports involvement.

Risk Factors

Decreased bone mineral density, female gender and early menopause have all been shown to be risk factors for fractures of distal radius.

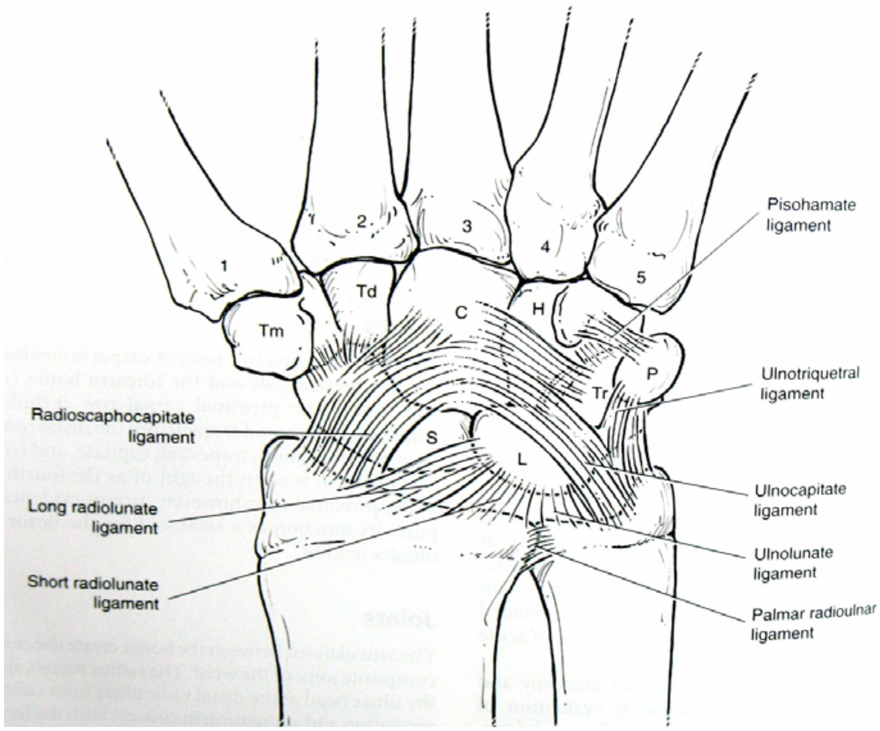
ANATOMY

The distal radius functions as an articular plateau upon which the carpus rests and from which the radially based supporting ligaments of the wrist arise. The hand and radius as a unit articulate with and rotate about the ulnar head via the sigmoid notch of the radius.

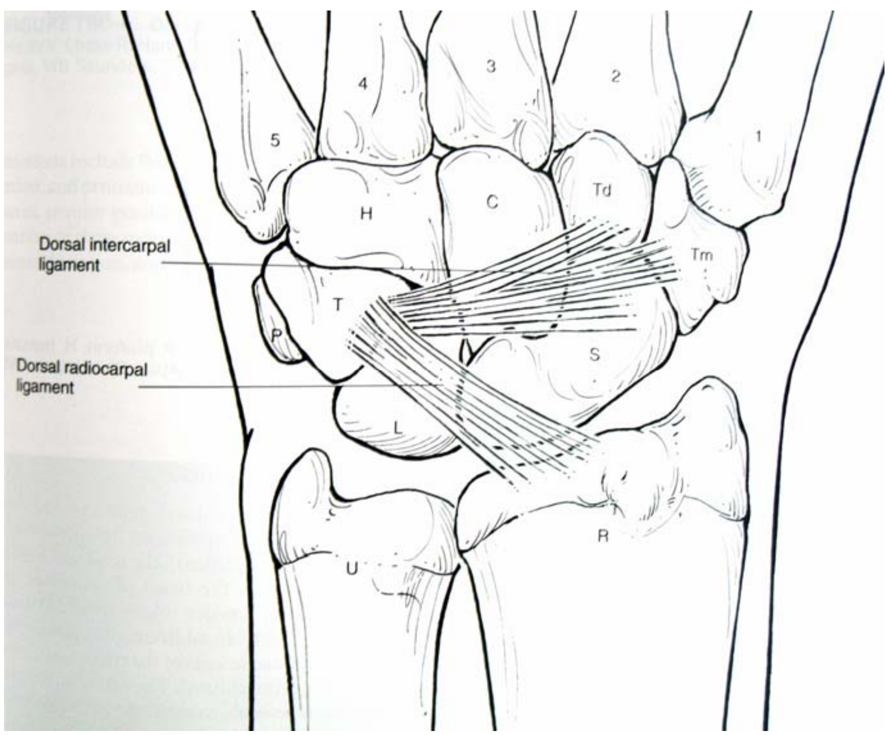
The distal radius has three concave articular surfaces – the scaphoid fossa, the lunate fossa and the sigmoid notch – for articulation with scaphoid, lunate and ulnar head respectively.

LIGAMENTS

The distal radius is connected to carpal bones and ulnar head through a number of ligaments which play vital role in stability, load transfer and wrist kinematics.



VOLAR LIGAMENTS



DORSAL LIGAMENTS

EXTRINSIC LIGAMENTS

They connect carpal bones to forearm bones.

Palmar Radio Carpal ligaments:

1)Radio Scapho Capitate ligament

- radial component of arcuate complex

2) Long Radio Lunate ligament

3) Short Radio Lunate ligament

4) Radio Scapho Lunate ligament

Dorsal Radio Carpal ligaments:

1) Radio Scaphoid ligament

2) Radio Triquetral ligament

3) Dorsal Intercarpal ligament

Ulno Carpal ligaments:

1) Ulno Capitate ligament

- ulnar component of cruciate ligament

2) Ulno Triquetral ligament

3) Ulno Lunate ligament

Distal Radio Ulnar ligaments:

1) Triangular Fibro Cartilage Complex

It is the most important stabilizer of Distal Radio Ulnar Joint. It arises along the entire ulnar aspect of the distal articular surface of the radius, at the distal margin of the sigmoid notch. It is inserted into base of ulnar styloid, lunate, triquetrum, hamate and finally at the base of fifth metacarpal. The central 80% of Triangular Fibro Cartilage Complex is avascular

2) Dorsal and Volar RadioUlnar ligaments.

INTRINSIC LIGAMENTS

They interconnect carpal bones. Important are

Scapho Lunate interosseous ligament and Luno Triquetral interosseous ligament.

KINEMATICS

The motors of the wrist are attached to the metacarpals. Capitate is the centre of rotation of wrist joint.

Wrist flexion – extension occur equally through radio carpal and midcarpal joints.

Radial – ulnar deviations occur 60% through midcarpal joint and 40% through radio carpal joint.

Normal range of movements:

Flexion	0 to 70-90º
Extension	0 to 70-90º
Radial deviation	0 to 15-25º
Ulnar deviation	0 to 25-35º
Supination	0 to 70-90º
Pronation	0 to 70-90º

Normally, 82% of the axial load at the wrist is borne by Radius and 18% by Ulna.

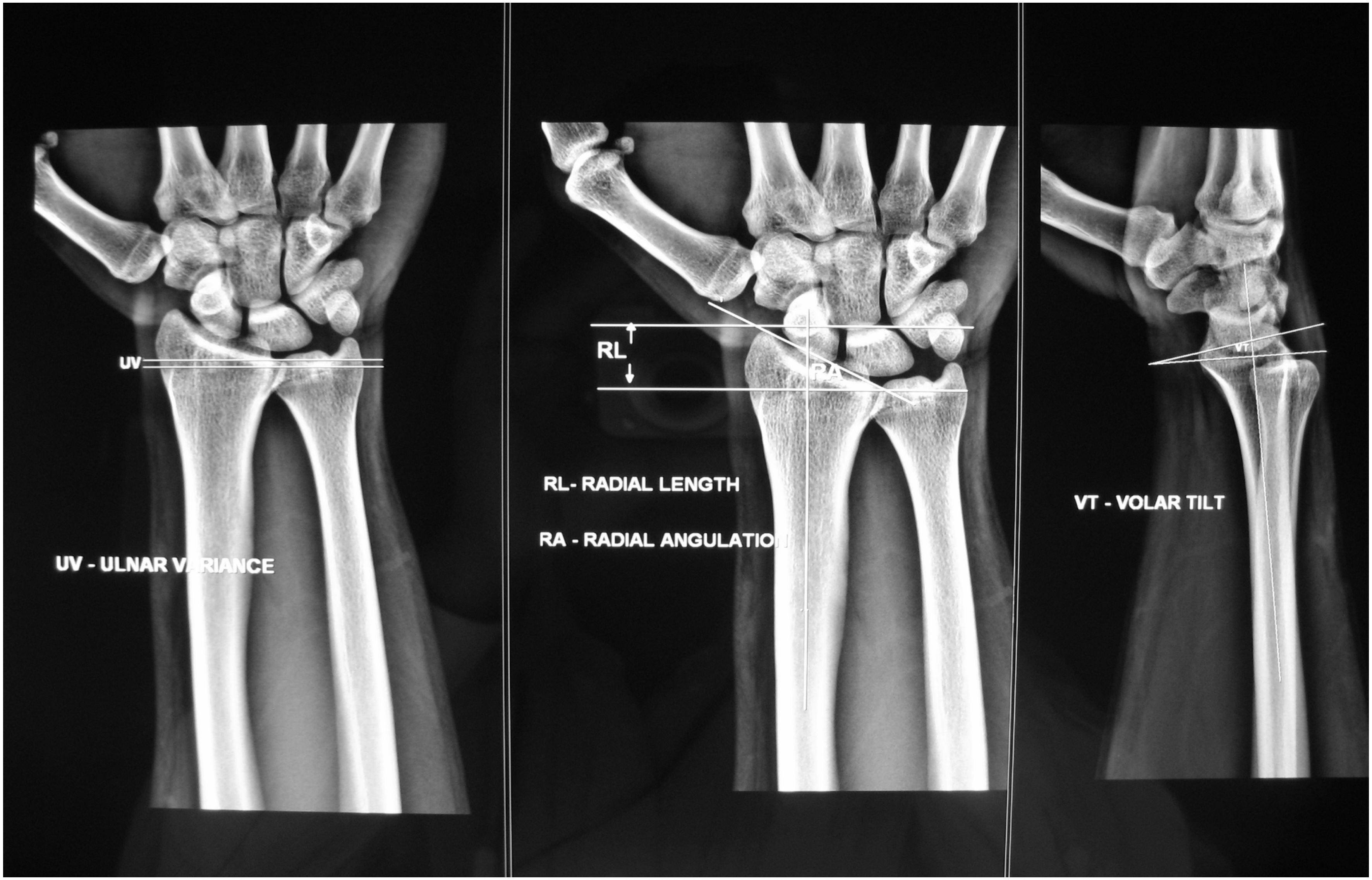
RADIOLOGICAL ANATOMY

Radial length or height

It is the measurement along the longitudinal radial axis between tip of radial styloid and articular surface of ulna in postero-anterior view. This length is influenced by radial inclination and ulnar variance. Normal radial length is 11-12mm.

Radial angulation or inclination

In postero-anterior view, it is the angle between plane perpendicular to longitudinal radial axis and a line drawn touching tip of radial styloid and radial articular surface. Normal is 22 - 23º.


UV
UV - ULNAR VARIANCE
RL
RA
RL- RADIAL LENGTH
RA - RADIAL ANGULATION
VT
VT - VOLAR TILT

Ulnar variance

In postero-anterior view, it is the difference between articular surfaces of radius and ulna. It may be neutral, positive or negative. Positive ulnar variance means loss of radial height. Normal is 0.9 - 1mm.

Palmar tilt

In lateral view, it is measured by the angle between plane of distal articular surface and the plane perpendicular to longitudinal axis of radius.

Normal is 11 - 12^{o}.

In a suspected case of fracture of distal radius, standard postero anterior and lateral views are taken.

In the postero anterior view, for an extra articular fracture distal radius, the following are noted.

1) Radial shortening
2) Ulnar variance

3) Radial angulation

4) Comminution

5) Ulnar styloid fracture location

In the lateral view, for an extra articular fracture distal radius, following are noted.

1) Palmar tilt

2) Extent of metaphyseal comminution

3) Displacement of volar cortex

4) Position of distal radio ulnar joint.

A 5º rotational change produces 1.6º change in palmar tilt in conventional lateral view.

An oblique view may be useful to assess comminution in an extra articular fracture.

Postero anterior and lateral views are taken also for contralateral wrist to assess the patient's normal radiological parameters.

MECHANISM OF INJURY

A fall on the outstretched hand is the most common mechanism for causing distal radius fracture. The fracture pattern can be based on the following variables.

1) Velocity
2) Position of hand and wrist at impact
3) Degree of rotation of forearm
4) The individual's bone quality and density

In a forward fall in which the forearm is pronated and the hand and wrist extended, the body weight of the patient is transmitted along the axis of radius resulting in bending forces at the level of metaphyseal bone. The volar cortex fails under tensile stress and the dorsal cortex fails from compressive forces at impact. Impaction and collapse of the cancellous bone of the metaphysis also occur due to penetration of the harder and stiffer cortical bone at the proximal diaphyseal section. With dorsally displaced fractures, the distal fragment supinates with respect to the radial diaphysis.

Ulnar styloid fractures have been identified in approximately 50-60% of distal radius fractures. The Triangular Fibro Cartilage can be injured with or without an associated fracture of ulnar styloid.

CLASSIFICATION

Various classification systems are available for distal radius fractures.

They are 1) Frykman classification

2) Gartland and Werley classification

3) Melone classification

4) Rayhack universal classification

5) Mayo clinic classification

6) AO classification

7) Fernandez and Geissler classification

Rayhack's universal classification is based on articular involvement, reducibility and stability. This classification gives treatment options for distal radius fractures.

Fernandez and Geissler system consists of type1 through type 5.

Type 1 – bending fractures of metaphysis.

Type 2 – shearing fracture of joint surface

Type 3 – compression fracture of joint surface

Type 4 – avulsion fracture and radio carpal dislocation

Type 5 – combination types 1 to 4.

This system also provides associated injuries of DRUJ.

Type 1 represents stable DRUJ

Type 2 represents unstable DRUJ

Type 3 represents potentially unstable DRUJ.

Fernandez system also dictates treatment for individual type.

The <u>AO system</u>

1. Identifies displacement as well as extent of communication present.

2. Provides for a system to document any ulnar sided involvement and

3. Subclasifies volar distal radius fractures more accurately.

This system consists of types A, B and C. Type A is extra articular fracture and further subdivided in to A1, A2 and A3 based on comminution.

<u>Type A – Extra articular fracture.</u>

A1 – Extra articular ulnar fracture

- A1.1 – styloid process fracture
- A1.2 – simple fracture of metaphysis
- A1.3 – multifragmentary metaphyseal fracture

A2 – Simple or impacted extra articular radius fracture.

- A2.1 – Undisplaced
- A2.2 – with dorsal tilting
- A2.3 – with anterior tilting

A3 – Simple or impacted multi fragment extra articular fracture.

- A3.1 – with axial impaction and shortening
- A3.2 – with a wedge
- A3.3 - complex

Type B – Partially articular fracture.

B1- sagittal rim fracture

B1.1 – simple lateral

B1.2 – multifragmentary lateral

B1.3 – medial

B2 – dorsal rim fracture.

B2.1 – simple

B2.2 – with an additional lateral sagittal fracture.

B2.3 – with dorsal dislocation of the carpus.

B3 – volar rim fracture.

B3.1 – simple with a small fragment

B3.2 – simple with a large fragment

B3.3 – multi fragmentary

Type C – Intra articular fracture.

C1 – simple articular, simple metaphyseal fracture

C1.1 – with a postero medial articular fragment

C1.2 – articular fracture line in sagittal plane

C1.3 - articular fracture line in frontal plane.

C2 – simple articular, multi fragment metaphyseal fracture.

C2.1 - articular fracture line in sagittal plane.

C2.2 - articular fracture line in frontal plane.

C2.3 – metaphyseal fracture extends into the diaphysis

C3 – complete articular multi fragment metaphyseal fractures.

C3.1- metaphyseal simple

C3.2 – metaphyseal fracture also multi fragmentary

C3.3 – multi fragmentary metaphyseal fracture extending into the diaphysis.

The complete AO classification when applied in a distal radius fracture shows poor interobserver reliability and the main group are sufficient to be used reliably to grade the severity of the lesion.

No classification system is universally accepted or capable of identifying fractures at risk of malunion. The key principle is that one should be able to define the fractures when examining the radiographs and assess inherent biomechanical stability. The stability of the fracture pattern will dictate treatment.

For an extra articular fracture, either one of the following features

1) Dorsal angulation more than 20 degrees
2) Dorsal communication more than 50% of width
3) Radial shortening of more than 5mm
4) Volar Comminution

5) Translation more than 1 cm.

6) Severe osteoporosis

on initial presentation indicates instability.

Even stable extra articular fracture with only mild to moderate displacement once reduced can redisplace back to the initial deformity. Thus frequent follow up is required.

COMPLICATIONS:

The reported complication rates of distal radius fracture in the literature vary from 6% to 80%. Complication may occur from the fracture or its treatment.

Immediate complications:

1) Nerve injuries - commonly Median nerve.

2) Acute Carpal Tunnel Syndrome.

3) Compartment syndrome.

4) Open fractures

5) Skin injury during manipulation in the elderly.

6) Missed associated injuries.

Early complications (less than six weeks):

1) Loss of reduction

2) Plaster related complications

3) Infection in open fractures and operated cases.

4) Carpal Tunnel Syndrome.

5) Tendon rupture.

Late complications (more than six weeks):

1) Carpal Tunnel Syndrome.

2) Reflex Sympathetic Dystrophy

3) Malunion

4) Delayed union

5) Post traumatic arthritis

6) Tendon rupture and adhesions.

7) Dupuytren's contracture.

Complications related to External Fixation:

1) Pin site infection

2) Pin loosening

3) Radial sensory nerve injury

4) Over distraction which may lead to stiffness, Pain and iatrogenic nonunion.

MATERIALS AND METHODS

This is a randomized prospective study conducted in Thanjavur Medical College Hospital, Thanjavur from June 2005 to February 2007.

Skeletally mature patients with potentially unstable dorsally angulated extra-articular fracture of distal radial metaphysis of AO type A2 or A3 were enrolled in this study.

Patients with

1) Open fracture
2) Stable fracture with dorsal angulation $< 20^{\circ}$
3) Intra articular fracture
4) Volar angulated fracture
5) Previous ipsilateral or contralateral fracture of wrist.
6) Patients with dementia or psychiatric illness

were excluded from study.

On presentation, the following were evaluated.

1) Condition of skin

2) Condition of local nerve function

3) Condition of vascularity

4) Tendon function

5) Function of elbow, shoulder and fingers

6) Forearm rotation

7) General medical condition.

PREOPERATIVE RADIOLOGICAL ASSESSSMENT

Preoperative radiographs of affected and unaffected distal radius were taken. Postero anterior and lateral X rays were taken. Following observations were made.

1) Radial length

2) Dorsal angulation

3) Radial inclination

4) Ulnar variance

5) Dorsal comminution

6) Step

7) Gap

The patients were randomly divided into two groups. All procedures were carried out under brachial plexus block or intravenous anaesthesia within 72 hours after injury. After closed reduction, to maintain reduction, cast immobilization was applied in twenty five patients and external fixation was applied in twenty three patients.

A successful reduction is defined as

1) step deformity of 2mm or less

2) neutral palmar tilt or better and

3) radial shortening of less than 5mm as compared to normal side.

CLOSED REDUCTION AND CAST IMMOBILIZATION GROUP

Closed reduction was achieved by longitudinal traction and gentle manipulation. With longitudinal traction and slight extension forces, fracture was disimpacted. With continuous traction across the fracture site, flexion and ulnar deviation forces were applied to reduce the distal fragment. Finally the fracture was locked in place by applying pronation, flexion and ulnar deviation forces.

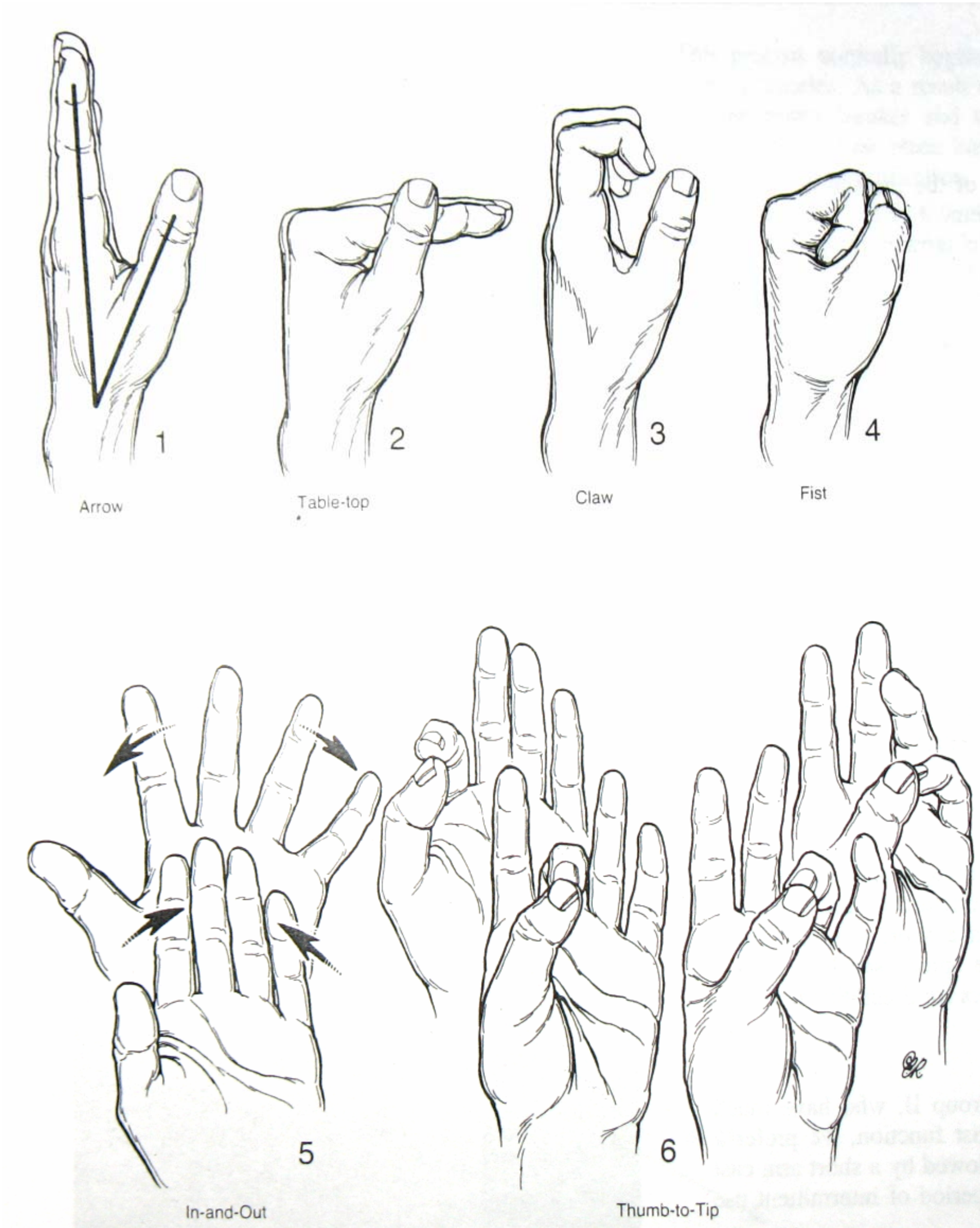
Then dorso-radial below elbow slab was applied with wrist in slight flexion, slight ulnar deviation and pronation. Cuff and collar was given to elevate the wrist.

The patients were observed for 48 hours for excessive swelling, neurovascular compromise.

Active finger movements were encouraged from day one.

Once the edema subsides, mostly 48 hours after reduction, outer bandage was tightened, maintaining reduction and traction. Then slab was converted into below elbow cast. Patients were taught six pack exercise regimen and encouraged to do exercises at least three times a day. Patients were reviewed on week 1, week 2, week 4 and week 6. After six weeks, union was confirmed and cast removed. Radiographs were also taken. Elasto crepe bandage was applied for another week.

Patients were encouraged to do active wrist movements. Patients were reviewed at three months, six months and one year of treatment. Every time functional and radiological outcome was made and compared to normal side.



SIX PACK EXERCISE

EXTERNAL FIXATION GROUP

In external fixation (ligamentotaxis) group, the fracture reduction was first achieved under anaesthesia by the same method as for closed reduction group.

Then, the limb was painted and draped. The metacarpal pins were applied first. 1cm incision made over metaphyseal flare of second metacarpal. Blunt dissection was carried out avoiding injury of superficial radial nerve and first dorsal interosseous muscle.

Second metacarpal was drilled with 2.0mm drill bit while protecting soft tissues using drill guide. Then 2.5mm × 100mm schanz pin inserted. A second pin was applied distally by same method.

Radial pins were applied 10cm proximal to radial styloid.

1 cm incision was made along the line joining lateral condyle Humerus and Lister's tubercle of distal Radius, blunt dissection carried out to reach radial shaft avoiding injury to radial sensory nerve and extensor tendons. Radial shaft was drilled with 2.5mm drill bit while protecting soft tissues with drill guide. Drilling was done in such a way that pins were placed on radial side and 30º dorsally. A 3.5mm × 100mm schanz pin inserted. Second radial pin was applied distal to first pin by same method.

The metacarpal pins were connected to multiaxial ball clamp and radial pins were connected to another multiaxial ball clamp. The ball clamps were connected to distraction rod. Check X rays taken and fine tuning of distraction done. No more than 2 - 3mm distraction was applied over radio carpal joint.

Postoperatively patients were encouraged to do active finger movements from day one. Six pack exercises were taught.

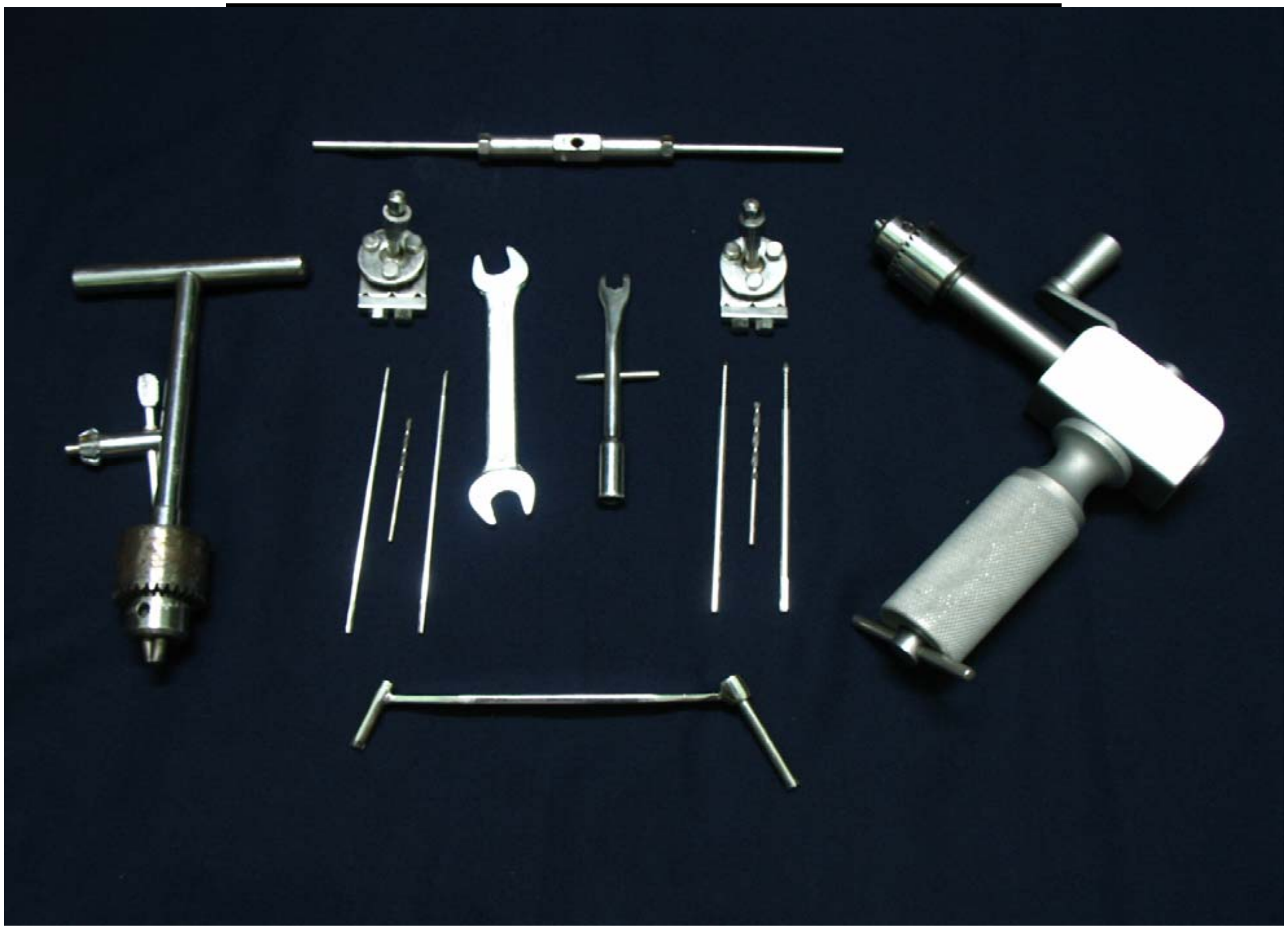
Limb was kept elevated for 24 – 48 hours. Parental antibiotics were given for two days followed by oral antibiotics for one more week. Pin sites were regularly inspected and Betadine dressings given.

Patients were discharged by fifth day and reviewed every week till six weeks. On every visit, extent of finger movements was noted. Pin site was examined for infection.

At six weeks after confirming union, external fixator was removed and sterile dressing and elastocrepe bandage applied. A radiograph was also taken.

Active wrist mobilization was started. Patients were reviewed on three months, six months and one year of treatment. Every time functional and radiological assessment were made and compared to the normal side.

INSTRUMENTS FOR EXTERNAL FIXATION



OBSERVATIONS AND RESULTS

Forty eight patients were enrolled in this study. Twenty five patients were treated with cast immobilization and twenty three patients with external fixation. Of them seventeen were males and thirty one were females. The mean age is 49.5 years for males and 50.3 years for females. The dominant side was involved in 39% in external fixation group and 44% in cast immobilization group. 73% patients had metaphyseal comminution.

Table 1. NUMBER OF PATIENTS

	EXTERNAL FIXATION	CAST IMMOBILIZATION
MALE	8	9
FEMALE	15	16
SUM	23	25
TOTAL	48	

Table 2. AGE OF PATIENTS

AGE IN YEARS	EXTERNAL FIXATION – NUMBER OF PATIENTS		CAST IMMOBILIZTTION - NUMBER OF PATIENTS	
	MALE	FEMALE	MALE	FEMALE
30 - 40	1	2	2	1
41 - 50	3	5	4	8
51 – 60	3	7	2	7
61 - 70	1	1	1	0
MEAN	50.25	51.2	48.8	49.5

Table 3. SIDE OF INJURY

SIDE OF INJURY	EXTERNAL FIXATION	CAST IMMOBILIZATION
RIGHT	9	11
LEFT	14	14
% DOMINANT SIDE INJURY	39%	44%

Table 4. TYPE OF FRACTURE BY AO CLASSIFICATION

AO TYPE	EXTERNAL FIXATION	CAST IMMOBILIZTION
A2	6	8
A3	17	17

The mechanism of injury was fall onto the outstretched hand in forty two patients. Six patients were injured in road traffic accidents. Two patients in external group had associated fractures – closed metatarsal fracture left foot in one patient and closed bimalleolar fracture right ankle in another patient.

The mean duration between injury and procedure was two days. In external fixation group, two patients (8.6%) developed pin site infection necessitating pin removal at five weeks in one patient. One patient developed radial sensory nerve deficit. No patient developed metacarpal fracture, median nerve deficit or tendon problem.

Loss of follow up in external fixation group was two patients. Out of remaining twenty one patients, sixteen were followed up to one year and five up to six months.

At follow up, patients were evaluated for pain, working ability, grip strength and complications like stiffness, deformity, reflex sympathetic dystrophy, median nerve deficit and Extensor pollicis longus tendon rupture.

Table 5. PAIN

	EXTERNAL FIXATION		**CAST IMMOBILIZATION**	
	SIX MONTHS	**ONE YEAR**	**SIX MONTHS**	**ONE YEAR**
NIL	**11 (52.38%)**	**13 (81.25%)**	**1 (4%)**	**7 (28%)**
MILD	**8 (38.09%)**	**3 (18.75%)**	**13 (52%)**	**14 (56%)**
MODERATE	**2 (9.52%)**	**-**	**11 (44%)**	**4 (16%)**
SEVERE	**-**	**-**	**-**	**-**

Table 6. FUNCTIONAL STATUS

	EXTERNAL FIXATION		CAST IMMOBILIZATION	
	SIX MONTHS	ONE YEAR	SIX MONTHS	ONE YEAR
REGULAR WORK	18 (85.7%)	14 (87.5%)	9 (36%)	14 (56%)
RESTRIC-TED WORK	3 (14.3%)	2 (12.5%)	15 (60%)	10 (40%)
UNABLE TO WORK	-	-	1 (4%)	1 (4%)

Table 7. GRIP STRENGTH

PERCENTAGE OF OPPOSITE SIDE	EXTERNAL FIXATION		CAST IMMOBILIZATION	
	SIX MONTHS	ONE YEAR	SIX MONTHS	ONE YEAR
76 – 100 %	18 (85.7%)	15 (93.75%)	2 (8%)	5 (20%)
51 – 75 %	3 (14.3%)	1 (6.25%)	21 (84%)	20 (80%)
26 – 50%	-	-	2 (8%)	-

Table 8. STIFFNESS

	EXTERNAL FIXATION	CAST IMMOBILIZATION
6 MONTHS	3 (14.3%)	13 (52%)
ONE YEAR	-	4 (4%)

The range of palmar flexion, extension, radial and ulnar deviation, supination, pronation and grip strength were noted and compared with opposite side.

Table 9. RANGE OF MOVEMENT

PERCENTAGE OF OPPOSITE SIDE	EXTERNAL FIXATION		CAST IMMOBILIZATION	
	SIX MONTHS	ONE YEAR	SIX MONTHS	ONE YEAR
76 – 100%	21 patients (100%)	16 patients (100%)	10 patients (40%)	11 patients (44%)
51 – 75%	-	-	15 patients (60%)	14 patients (56%)

Both wrists were radiographed and parameters were compared.

Table 10. EXTERNAL FIXATION - RADIOLOGICAL EVALUATION

	Pre-operative (23 patients)	Six months (21 patients)	One year (16 patients)
RADIAL LENGTH (mm)	**3.35**	**10.9**	**10.8**
VOLAR TILT (^{o})	**- 26.2**	**3.66**	**2.88**
RADIAL ANGULATION(^{o})	**11.78**	**20.47**	**20.06**
ULNAR VARIANCE(mm)	**+3.39**	**+ 0.9**	**+0.93**

Table 11. CAST IMMOBILIZATION - RADIOLOGICAL EVALUATION

	Pre-reduction	Post reduction	Six months	One year
RADIAL LENGTH (mm)	**3.12**	**11.68**	**7.92**	**7.92**
VOLAR TILT (^{o})	**-23.36**	**+ 3.64**	**- 13.4**	**- 13.4**
RADIAL ANGULATION(^{o})	**12.84**	**20.88**	**17.8**	**17.8**
ULNAR VARIANCE(mm)	**+4.52**	**+0.4**	**+2.48**	**+2.48**

Paired samples T test showed both methods of treatment produced statistically significant results.

Table 12: PAIRED SAMPLES T TEST

VARIABLE	PROCEDURE	MEAN DIFFERENCE (PRE-REDUCTION AND ONE YEAR)	P VALUE
RADIAL LENGTH	CAST IMMOBILIZATION	4.96	< 0.0005
	EXTERNAL FIXATION	7.31	< 0.0005
VOLAR TILT	CAST IMMOBILIZATION	10.04	< 0.0005
	EXTERNAL FIXATION	29.37	< 0.0005
RADIAL ANGULATION	CAST IMMOBILIZATION	4.16	< 0.0005
	EXTERNAL FIXATION	9.00	< 0.0005
ULNAR VARIANCE	CAST IMMOBILIZATION	-2.04	< 0.0005
	EXTERNAL FIXATION	-2.81	< 0.0005

One sample T test for External Fixation showed that results produced are so significant that External Fixation gave far better results when compared to cast immobilization group.

Table 13. ONE SAMPLE T TEST – EXTERNAL FIXATION

	Test Value	test	df	Sig.(2-tailed)	Mean difference	95% confidence interval of the difference	
						lower	upper
RL	**7.92**	**3.457**	**15**	**0.004**	**2.3300**	**O.8936**	**3.7664**
VT	**13.32**	**13.876**	**15**	**0.000**	**16.3200**	**13.8131**	**18.8269**
RA	**16.92**	**9.749**	**15**	**0.000**	**3.1425**	**2.4554**	**3.8296**
UV	**2.48**	**-7.226**	**15**	**0.000**	**-1.5425**	**-1.9975**	**-1.0875**

RL – Radial Length
VT – Volar Tilt
RA – Radial Angulation
UV – Ulnar Variance

In external fixation group, at one year, 81.25% patients had no pain and 87.5% patients returned to regular work. But in cast immobilization group, 72% patients had mild or moderate pain and only 56% patients returned to regular work. At one year none in external fixation had stiffness, and four patients in cast immobilization had stiffness.

The patients were evaluated as per modified criteria suggested by Gartland and Werley for functional assessment. This system consists of subjective evaluation, objective evaluation and complication and accordingly demerit points were awarded. By this system, in external fixation group six patients (28.%) had excellent results and thirteen (61.9%) had good results. In cast immobilization group, none had excellent result, five (20%) had good result, nineteen (76%) had fair result and one (4%) had poor result.

Table 14. FUNCTIONAL RESULT

GARTLAND AND WERLY DEMERIT SCORING SYSTEM

RESULT	EXTERNAL FIXATION		CAST IMMOBILIZATION	
	Number	Percentage	Number	Percentage
EXCELLENT	6	28.57%	-	-
GOOD	13	61.9%	5	20%
FAIR	2	9.5%	19	76%
POOR	-	0%	1	4%

Anatomic evaluation was done as per Lindstrom and Frykmann criteria. In external fixation group, eighteen (85.7%) had grade I i.e. no deformity and remaining grade II i.e. mild deformity. In cast immobilization group, only one patient (4%) had grade one result and fifteen patients (60%) had grade III or IV result.

Table 12. ANATOMICAL RESULT

(LINDSTROM & FRYKMAN GRADING)

	EXTERNAL FIXATION		CAST IMMOBILIZATION	
	Number	Percentage	Number	Percentage
GRADE I	18	85.7%	1	4%
GRADE II	3	14.3%	9	36%
GRADEIII	-	0%	7	28%
GRADEIV	-	0%	8	32%

CASE ILLUSTRATIONS

CASE ONE – EXTERNAL FIXATION

PREOPERATIVE



POSTOPERATIVE


ONE YEAR

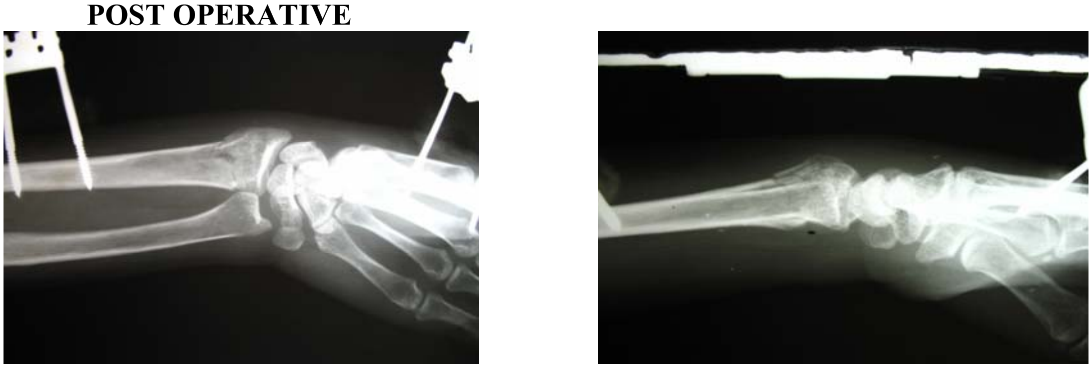




CASE TWO – EXTERNAL FIXATION:

PRE OPERATIVE

POST OPERATIVE



ONE YEAR

CASE THREE – EXTERNAL FIXATION

PRE-OPERATIVE



POST OPERATIVE


ONE YEAR



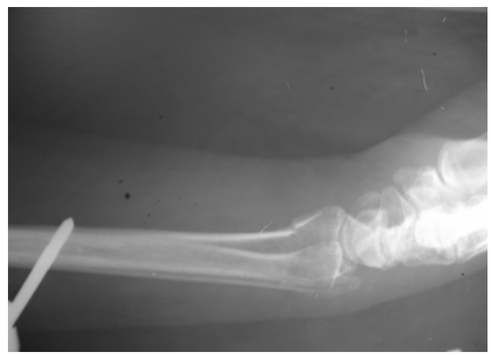



CASE FOUR- EXTERNAL FIXATION

PRE OPERATIVE



POST OPERATIVE

ONE YEAR




CASE FIVE – CAST IMMOBILIZATION

PRE REDUCTION

POST REDUCTION

ONE YEAR

CASE SIX – CAST IMMOBILIZATION

PRE REDUCTION

POST REDUCTION

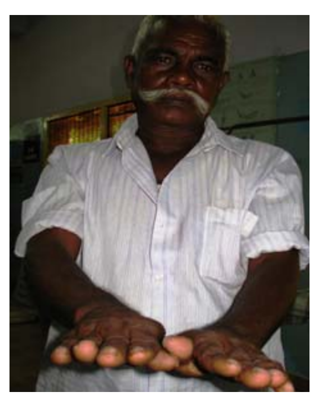
ONE YEAR

CASE SEVEN – CAST IMOBILIZATION

PRE REDUCTION

POST REDUCTION

ONE YEAR



CASE EIGHT – CAST IMMOBILIZATION

PRE REDUCTION

POST REDUCTION

ONE YEAR

DISCUSSION

In this study, functional and anatomical results of 48 patients with unstable extra articular fractures of distal radius treated with closed reduction and cast immobilization and closed reduction and external fixation were analyzed.

On functional analysis based on Gartland and Werley demerit system, 90.5% of patients in external fixation group had excellent to good results but only 20% patients in cast immobilization group had good results. There was no poor result in external fixation group, but one patient in cast immobilization group had poor result.

Paul A. Vaughan et al in their study on unstable distal radius fracture treated by external fixation obtained 29% excellent and 60% good result.

In our study, on anatomical grading by Lindstrom and Frykman system, 85.7% patients in external fixation group had grade I result i.e. no significant deformity. But only one patient in cast immobilization group was able to get grade I result and 60% of patients produced only grade III or IV results.

In external fixation group, two patients developed pin site infection and one patient developed radial sensory nerve deficit. At six months, three patients (14.3%) in external fixation group had stiffness, whereas, almost half of the patients in cast immobilization group had stiffness.

Thus, closed reduction and maintenance of reduction with external fixation produced far better results than cast immobilization for an unstable extraarticular distal radius fracture. External fixation is a simple and easy technique with low complication rate.

Restoration of normal anatomy is important for restoration of function. Normally 82% of the compressive load across the wrist is borne by distal radius and remaining by distal ulna. With 2.5mm loss of radial length, ulna bears 42% load and at 20 degree dorsal angulation, ulna bears 50% load.

Preservation of radial length is the most important factor for preservation of function. Loss of radial length can lead to ulnar impaction or dysfunction of Distal Radio Ulnar Joint, with limited range of motion in pronation and supination, depending on the volar or dorsal subluxation of the ulnar head within the sigmoid notch.

Residual dorsal angulation can precipitate ulnar impaction, midcarpal instability and altered stress concentration which may lead to early arthritis. Porter, in his study, felt that loss of function did not occur until at least 20 degrees of palmar tilt was lost.

In ligamentotaxis with external fixation, radial length, ulnar variance and radial angulation are restored to normal but correction of volar tilt though adequate, is not complete. This is attributed to the fact that volar ligaments are stronger and become taut on distraction before the dorsal ligaments which are in a relative ‘Z’ orientation. So, on distraction, palmar cortex is brought out to length before dorsal cortex preventing full correction of dorsal tilt.

Cast immobilization could not maintain reduction in unstable fractures resulting in poor anatomical results. 60% of patients treated with cast immobilization had moderate to severe deformity. One patient had poor functional result and nineteen (76%) had fair results.

CONCLUSION

Fractures of the distal radius though common and appear simple, affect the function of the wrist considerably. It is the commonest fracture seen in the outpatient department and most are treated with plaster immobilization. Most of these fractures are unstable resulting in loss of reduction and hence malunion, altered wrist kinematics, poor range of motion and early arthritis.

The goals of treatment are

- To achieve perfect anatomical reduction and maintenance of reduction till union.
- Early mobilization to achieve good range of movements and to prevent stiffness.
- To prevent early and late complications.

In an unstable dorsally angulated extraarticular distal radius fracture, external fixation applying the principle of ligamentotaxis gives good to excellent results with minimal complications.

Applying external fixator in a 30 degree dorsal plane allows early finger movements. Six pack exercises while fixator in place, prevent finger stiffness. Simple and sincere pin site care will prevent any pin related complication.

Our study equalled previous studies on external fixation for unstable distal radius fractures in results, showing simplicity and superiority of ligamentotaxis with external fixation for the management of these fractures.

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APPENDIX I

GARTLAND & WERLEY SYSTEM TO EVALUATE RESULTS OF HEALED # DISTAL RADIUS (DEMERIT POINT RATING SYSTEM)

RESIDUAL DEFORMITY	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	3
SUBJECTIVE EVALUATION	
EXCELLENT: no pain, disability or limitation of movement	0
GOOD: occasional pain, slight ↓ of motion, no disability	2
FAIR: occasional pain, limitation of movement, feeling of weakness, activities slightly restricted	4
POOR: pain, loss of motion, disability, activities more or less restricted	6
OBJECTIVE EVALUATION	
Dorsiflexion < 45º	5
Loss of ulnar deviation < 15 º	3
Supination < 50 º	2
Pronation < 50 º	2
Palmar flexion < 30 º	1
Radial deviation < 15 º	1
Loss of Circumduction	1
Pain in DRUJ	1
Grip strength 60 % or less to opposite side.	1
COMPLICATION	
Arthritic change – minimum	1
Arthritic change – minimum with pain	2
Arthritic change – moderate	3
Arthritic change – moderate with pain	4
Arthritic change – severe	4
Arthritic change – severe with pain	5
Nerve complication	1-3
Loss of finger motion	1-3

POINTS	RESULTS
0 – 2	Excellent
3 – 8	Good
9 – 20	Fair
21 & above	Poor

APPENDIX II

LINDSTROM AND FRYKMAN CRITERIA FOR ANATOMICAL RESULT

	DEFORMITY	DORSAL ANGULATION	RADIAL SHORTENING
GRADE I	No significant deformity	Not exceeding neutral	< 3mm
GRADE II	Slight deformity	1 – 10 º	3 – 6 mm
GRADE III	Moderate deformity	11 – 14 º	7 – 11 mm
GRADE IV	Severe deformity	> 14 º	> 11 mm

APPENDIX III

Consent Proforma

Title : Treatment of unstable extra articular fracture distal radius by closed reduction and plaster immobilization / external fixation.

Aim : To analyse the functional outcome of unstable extra articular distal radius fracture treated with closed reduction and cast immobilization / external fixation.

Consent : I have been explained about the nature of my injury, methods of treatment, potential complications and need of regular follow up visits in my own vernacular language.

I hereby give my consent for including me in the study.

Signature

APPENDIX IV

CLINICAL PROFORMA

1. Name

2. Age

3. Sex

4. In-Patient no.

5. Mode of injury

6. Side of injury

7. Dominant side

8. AO type

9. Associated injury

10. Associated compliations

11. Date of injury

12. Date of surgery / plaster immobilization

13. Date of fixator / plaster removal

14. Preoperative radiology
    Radial length –
    Volar tilt –
    Radial angulation -
    Ulnar variance –
    Dorsal comminution –

15. Post operative radiology
    Radial length –
    Volar tilt –
    Radial angulation -
    Ulnar variance –

16. Pin site infection

17. Pin site loosening

THREE MONTHS:

18. Stiffness

19. Pain

20. Functional status

21. Median nerve deficit

22. Radial sensory nerve deficit

23. Tendon rupture

24.

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

25.

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

26. Grip strength - (% 0f opposite side)

SIX MONTHS

27. Stiffness

28. Pain

29. Functional status

30. Median nerve deficit

31. Radial sensory nerve deficit

32. Tendon rupture

33.

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

34.

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

35. Grip strength - (% 0f opposite side)

ONE YEAR:

36. Stiffness

37. Pain

38. Functional status

39.

MOVEMENT	ROM	% OF NORMAL
Palmar flexion		
Dorsi flexion		
Radial deviation		
Ulnar deviation		
Supination		
Pronation		

40.

	FINDINGS	DIFFERENCE FROM NORMAL
Radial length		
Volar tilt		
Radial angulation		
Ulnar variance		

41. Grip strength - (% 0f opposite side)

42. Lindstrom and Frykman anatomical grade: I / II / III / IV

43. Gartland and Werley demerit score:

44. RESULT: Excellent / Good / Fair / Poor.

Key to Master Chart

Sex : M	-	Male
F	-	Female
Side of injury: R	-	Right
L	-	Left
RL	-	Radial length
VT	-	Volar tilt
RA	-	Radial angulation
UV	-	Ulnar variance
DC	-	Dorsal comminution
complicn	-	Complication
Pi	-	Pin site infection
Pain N	-	Nil
M	-	Mild
md	-	Moderate
Fn status	-	Functional status

W	-	Working
R	-	Restricted work
U	-	Unable to work
PF	-	Palmar flexion
DF	-	Dorsi flexion
RD	-	Radial deviation
UD	-	Ulnar deviation
SP	-	Supination
PR	-	Pronation
GS	-	Grip strength
Df fr N	-	Difference from Normal
G & W score	-	Gartland and Werley score
L & F grade	-	Lindstrom and Frykman grade

MASTER CHART – EXTERNAL FIXATION

Sl.No.	Name	Age	Sex	Side of injury	AO type	Pre operative					Post Operative				Complcn	Pain	Fn. status	stiffness	OUTCOME											G&W score	L&F grade	RESULT
																			% of normal							Df fr N.						
						RL	VT	RA	UV	DC	RL	VT	RA	UV					PF	DF	RD	UD	SP	PR	GS	RL	VT	RA	UV			
1	Nr	38	F	L	A2	4	-24	15	+2	-	11	8	20	+1	-	N	W	-	100	100	100	100	100	100	90	0	2	2	0	0	I	E
2	Ml	52	F	R	A3	6	-25	10	+3	+	12	4	22	+1	-	N	W	-	92	100	100	100	88	88	82	0	6	0	0	4	I	G
3	An	45	M	R	A3	2	-27	12	+5	+	11	-4	20	+1				-														
4	Lk	62	F	R	A3	3	-24	12	+4	+	11	0	18	+2	-	N	W	-	88	94	94	100	88	100	86	0	9	2	1	4	I	G
5	Kr	46	M	L	A3	4	-26	15	+3	+	13	2	21	0				-														
6	Ps	58	M	L	A3	5	-24	18	+3	+	12	3	20	+1	-	N	W	-	88	100	100	88	88	100	92	0	8	4	0	5	I	G
7	Jy	47	F	L	A2	7	-20	14	0	-	12	2	20	0	-	N	W	-	94	100	97	100	100	100	100	0	9	2	0	2	I	E
8	Mg	50	F	R	A3	4	-36	15	+3	+	10	-2	20	0	Pi	M	R	-	85	88	100	80	84	84	75	2	12	2	0	9	II	F
9	Mk	60	F	L	A3	3	-33	13	+5	+	12	5	21	0	-	N	W	-	82	100	100	100	88	88	90	0	5	1	0	6	I	G
10	Ng	64	M	L	A3	4	-35	10	+4	+	12	-5	20	+1	-	N	R	-	89	100	67	100	100	100	65	0	13	0	0	5	II	G
11	Kn	60	F	R	A3	-2	-28	10	+9	+	10	0	18	+2	-	M	W	+	78	88	100	80	88	88	75	2	6	2	1	4	I	G
12	Vn	40	M	L	A3	3	-30	10	+3	+	10	0	20	+2	-	md	W	+	88	94	100	80	88	100	85	1	10	2	1	4	I	G
13	Sm	55	M	R	A3	-2	0	5	+7	+	11	8	20	+2	Pi	M	W	+	88	100	92	100	88	88	76	1	2	0	1	10	II	F
14	Sj	46	F	R	A3	6	-26	20	+4	+	9	4	22	+2	-	N	W	-	88	88	75	80	88	100	88	1	7	0	0	4	I	G
15	Er	50	F	R	A3	2	-28	4	+2	+	9	-4	18	0	-	N	W	-	88	100	100	100	88	100	100	0	13	0	0	0	I	E
16	Rn	52	F	L	A2	-4	-45	0	+6	+	10	8	20	0	-	N	W	-	100	100	100	100	88	100	96	2	2	0	0	4	I	G
17	Sw	47	F	L	A2	5	-24	16	+1	-	10	5	20	+1	-	M	W	-	89	94	100	100	94	100	92	2	5	2	1	2	I	E
18	Si	53	F	L	A3	3	-20	5	+2	+	12	12	22	0	-	M	W	-	88	100	100	100	88	100	90	0	0	0	0	0	I	E
19	Gs	42	M	L	A3	3	-22	10	+3	+	12	10	20	+2	-	N	W	-	100	94	100	100	100	100	92	1	2	0	1	2	I	E
20	Pl	56	F	L	A3	6	-24	15	+2	+	11	4	22	0	-	M	W	+	78	88	92	80	88	88	70	1	6	0	0	5	I	G
21	Ch	35	F	R	A3	5	-22	16	+2	+	12	5	22	0	-	N	W	-	88	100	100	100	88	88	85	0	5	0	0	4	I	G
22	Sl	60	F	L	A2	6	-20	16	+2	-	11	11	23	+1	-	M	W	-	82	86	100	80	88	88	76	2	6	0	0	3	I	G
23	Sr	52	M	L	A2	4	-20	10	+2	-	12	6	22	+1	-	N	W	-	88	100	100	100	88	88	86	0	6	0	0	4	I	G

MASTER CHART – CAST IMMOBILIZATION

Sl.No.	Name	Age	Sex	Side of injury	AO type	Pre Reduction					Post Reduction				Pain	Fn. status	stiffness	OUTCOME											G&W score	L&F grade	RESULT
																		% of normal							Df fr N.						
						RL	VT	RA	UV	DC	RL	VT	RA	UV				PF	DF	RD	UD	SP	PR	GS	RL	VT	RA	UV			
1	Tr	70	M	R	A2	6	-22	14	+3	-	12	+2	22	0	M	R	+	62	61	50	80	75	89	60	1	21	2	1	17	II	F
2	Sb	60	F	L	A2	4	-24	15	+2	-	11	+3	20	0	M	R	-	63	66	75	40	67	76	65	3	20	5	1	15	II	F
3	Sm	46	M	L	A3	-2	-42	10	+4	+	10	0	22	+1	M	W	+	50	78	50	67	88	75	70	6	32	4	4	8	IV	G
4	Pp	52	F	R	A3	5	-30	14	+4	+	12	+5	20	0	md	R	-	44	67	67	80	67	74	60	4	28	6	2	18	IV	F
5	Jo	45	F	L	A2	3	-26	14	+4	-	12	+6	22	0	M	W	-	67	88	100	75	66	82	70	4	22	2	2	18	III	F
6	Ki	60	F	L	A3	0	-24	8	+3	+	12	+6	20	-1	M	R	-	55	78	100	60	74	82	70	3	26	7	2	12	IV	F
7	Ps	40	M	R	A3	-2	-10	10	+5	+	12	+5	22	+1	M	W	+	69	75	66	60	86	75	70	4	28	5	4	10	IV	F
8	Up	60	M	R	A3	5	-30	12	+4	+	11	0	22	+1	N	W	-	56	66	96	82	78	67	66	5	30	5	3	12	IV	F
9	An	42	F	L	A3	8	-15	14	+1	+	12	+4	20	0	md	U	+	56	36	33	60	78	86	50	3	20	6	1	21	II	P
10	Pd	44	F	R	A3	2	-30	14	+6	+	12	+5	20	0	md	R	-	44	67	67	80	67	74	60	4	28	4	2	18	IV	F
11	Kl	53	F	L	A3	-2	-15	8	+8	+	10	0	20	+1	M	R	-	54	78	100	80	66	74	60	6	22	8	2	18	III	F
12	Ay	48	F	L	A3	4	-26	15	+4	+	11	+4	22	0	md	R	-	54	67	100	60	67	74	55	5	25	6	0	14	III	F
13	Kl	50	M	R	A3	6	-20	10	+5	+	13	+6	18	+1	M	W	-	66	74	100	60	66	74	66	5	23	3	1	14	III	F
14	Ml	42	F	L	A2	5	-20	16	+3	-	12	+7	22	0	N	W	-	74	82	100	80	67	76	70	3	16	6	0	7	II	G
15	Jk	43	F	L	A2	6	-24	18	+3	-	11	+3	22	+1	N	W	-	78	88	100	80	78	88	85	2	11	4	1	8	I	G
16	Il	57	F	R	A3	-3	-32	12	+7	+	11	0	18	+1	M	R	-	56	66	100	60	66	66	60	5	30	8	2	14	IV	F
17	Jd	42	M	R	A3	2	-36	12	+7	+	12	0	20	+1	M	W	-	66	74	100	80	74	74	70	5	33	7	2	10	IV	F
18	Sv	56	F	L	A3	5	-22	14	+4	+	12	+4	20	0	N	W	-	74	74	100	60	74	88	80	5	32	8	1	12	III	F
19	Rj	41	M	L	A2	4	-26	14	+4	-	13	+4	22	0	N	W	-	74	88	100	80	78	88	90	3	20	3	2	8	II	G
20	Du	56	F	R	A3	5	-18	14	+5	+	11	+5	21	+1	M	R	-	56	66	90	60	67	67	55	4	22	4	1	18	III	F
21	Js	52	M	R	A3	0	-12	6	+7	+	12	+6	20	+1	M	W	-	66	74	90	60	66	74	80	6	22	4	3	14	II	F
22	Sv	40	F	L	A3	4	-20	16	+4	+	12	+6	22	0	M	W	-	66	74	100	60	67	74	70	4	18	5	2	15	II	F
23	Ml	46	F	R	A3	6	-24	18	+4	+	12	+4	23	0	N	W	-	67	74	100	80	74	74	75	3	21	6	2	17	III	F
24	Sb	48	F	L	A3	-2	-14	5	+8	+	11	0	20	+1	M	R	-	54	67	100	60	67	67	60	5	20	3	3	18	II	F
25	Kv	38	M	L	A2	5	-22	16	+4	-	13	+6	22	0	N	W	-	74	88	100	80	78	89	85	3	18	4	2	7	II	G