FRACTURES OF BOTH BONES FOREARM – A COMPARATIVE STUDY ON FIXATION TECHNIQUES AND FUNCTIONAL OUTCOME BETWEEN PLATE OSTEOSYNTHESIS, INTERLOCKING NAILING AND TITANIUM ELASTIC NAILING

DISSERTATION SUBMITTED FOR

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CERTIFICATE

This is to certify that the work entitled **FRACTURES OF BOTH BONES FOREARM – A COMPARATIVE STUDY ON FIXATION TECHNIQUES AND FUNCTIONAL OUTCOME BETWEEN PLATE OSTEOSYNTHESIS, INTERLOCKING NAILING AND TITANIUM ELASTIC NAILING** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr. J. MAHESWARAN**, Post Graduate Student at Department of Orthopaedics, Tirunelveli Medical College, Tirunelveli.

DEAN

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He has completed the necessary period of stay in the Department and has fulfilled the conditions required for the submission of this thesis according to the University regulations. The study was undertaken by the candidate himself and the observations recorded have been periodically checked by us.

Recommended and forwarded

Prof. R. RAMAKRISNAN

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MASTER CHART

S No.	Age	Sex	Side	Mode of Injury	Type	Time of surgery (day)	Associated injuries	Treat-ment Moda-lities	Weeks			Complicat ions	Score
									Union Time	ROM	Return to work		
1.	31	M	R	RTA	A3	3	Head injury	Plate	9	12	14	Infection	10
2.	66	M	L	Assault	A3	6	-	Plate	9	10	12	Infection	10
3.	48	M	R	RTA	B1	3	-	Plate	9	12	15	Stiffness	10
4.	69	F	L	RTA	A3	6	Infection	Plate	9	12	15	Infection/ Stiffness	8
5.	47	M	R	RTA	A3	3	-	Plate	8	12	14	Infection	10
6.	35	F	L	Assault	A3	6	Head injury	Plate	8	12	15	Stiffness	10
7.	21	M	R	RTA	B1	5	Humerus fracture	Plate	8	14	15	Stiffness	10
8.	29	F	R	RTA	A3	6	Head injury	Plate	8	12	12	-	10
9.	39	M	R	Assault	A3	4	-	Plate	9	12	13	Infection/K wire fixation	8
10.	45	F	L	Assault	B1	5	Head injury	Plate	9	12	12	-	10

S No.	Age	Sex	Side	Mode of Injury	Type	Time of surgery (day)	Associated injuries	Treat-ment Moda-lities	Weeks			Complications	Score
									Union Time	ROM	Return to work		
11.	32	M	R	Fall	A3	2	-	TEN	6	9	12	-	10
12.	34	M	R	Assault	A3	1	-	TEN	7	9	12	-	10
13.	54	M	L	RTA	A3	7		TEN	6	9	12	EPL Injury	5
14.	45	F	R	Fall	C1	2	-	TEN	6	10	13	-	10
15.	53	M	L	RTA	A3	3	-	TEN	10	14	18	Delayed union	10
16.	65	M	R	RTA	A3	5	Femur fracture	TEN	7	9	14	Resurgery	10
17.	22	F	L	RTA	B1	4	-	TEN	6	9	12	-	10
18.	49	M	R	Fall	A3	3	-	TEN	6	8	14	Impacted fracture	8
19.	24	F	R	Fall	B2	4	-	TEN	6	9	12	-	10
20.	49	M	L	RTA	A3	3	# both bones leg	TEN	7	10	13	Radial Styloid fracture	8

S No.	Age	Sex	Side	Mode of Injury	Type	Time of surgery (day)	Associated injuries	Treat-ment Moda-lities	Weeks			Complicat ions	Score
									Union Time	ROM	Return to work		
21.	26	M	R	Assault	A3	5	Chest injury	IL Nail	24	30	34	Nonunion & Resurgery	5
22.	29	M	R	Assault	A3	5	-	IL Nail	7	9	12	-	10
23.	39	M	R	Fall	A3	3	-	IL Nail	6	9	12	-	10
24.	41	F	R	RTA	A3	4	# both bones leg	IL Nail	6	9	12	-	10
25.	60	M	R	Fall	A3	2	-	IL Nail	7	9	13	Ulna open fixation	6
26.	38	F	L	Fall	A3	1	-	IL Nail	7	9	14	Resurgery	10
27.	30	M	L	RTA	A3	4	-	IL Nail	6	10	12	No locking (distal)	7
28.	46	M	R	RTA	A3	4	-	IL Nail	6	9	12	-	10
29.	22	M	L	Assault	A3	5	-	IL Nail	6	9	12	-	10
30.	36	M	L	RTA	A3	5	-	IL Nail	6	8	12	-	10

PART A

INTRODUCTION

Increasing incidence of road traffic accidents, natural disasters and industrial accidents together with assault leads to multiple fractures and higher incidence of morbidity. They form the major epidemic of modern era. 0f these, the fractures involving both the bones of forearm form an important part. Even though these factures can be treated successfully by surgical methods, the anatomical reduction of fracture fragments becomes absolutely essential for effective postoperative function. Delayed hospitalization, use of indigenous bandages and associated vascular and nerve injures contribute to increased incidence of morbidity.

Traditionally majority of adult forearm fractures are treated by traditional bone setters leading to various complications. Awareness about the role of various types of surgical fixation and their role in successful management of forearm fractures is absolutely essential for preventing this practice.

For effective pronation and supination to occur, the maintenance of interosseous space becomes mandatory while fixing the fractures involving radius and ulna. Presence of comminution, the anatomy of fracture pattern and presence of rotatory malalignment significantly contribute to the postoperative morbidity in these fractures.

Better understanding of the injury patterns, availability of better implants, the concept of early surgical fixation and exact post operative protocol all have convincingly improved the functional outcome of the patient to a larger extent.

The successful management of these fractures demands familiarity with the character of fracture, technical aspects of fracture fixation, the varieties of implants available for fixation and the art of postoperative management.

HISTORICAL REVIEW

Till the end of 19^{th} century, the fractures of both bones of forearm were managed conservatively with POP cast immobilization. In the early 1900s, Lane in London and Lambotte in Belgium reported use of plates for treating diaphyseal fractures. However, metal reaction led to frequent failures until modern metals were introduced in 1937 by Veriable and associates. Campbell and Boyd used autologous tibial grafts fixed to the radius and ulna with bone pegs or screws.

Even after better metals became available, many early plates were poorly designed which led to failures. Slotted plates were introduced by Eggers and associates by late 1960s. The idea of using plates through which active compression could be applied began with Danis of Belgium. In 1958, Muller, Allgower and Willenegges developed what is now known as AO compression plates. The technique of using these plates was published in 1965, and these became the standard mode of fixation since then.

With the advent of intramedullary nails for fractures of shaft of femur, various devices for intramedullary fixation of radius and ulna was introduced in 1957 by Smith and Sage. They used Krischner wires, rush nails, small ‘V’ nails and Steinmann pins for fixation. The results were discouraging. In1959, Sage introduced triangular forearm intramedullary nails. In 1986, Street introduced the concept of reamed forearm nails. Recently interlocking nails for both radius and ulna were introduced. Titanium elastic nails which were developed for fractures of shaft of long bones in pediatric and adolescent age group are being used now in adult diaphyseal forearm fractures.

ANATOMY

Fractures of forearm bones may result in severe loss of function unless adequately treated. The relationship of the radiohumeral, proximal radioulnar, ulnohumeral, radiocarpal and distal radioulnar joints and the interosseous space must be anatomical or else some functional impairment will result, due to the involvement of these various joints.

RADIUS

The radius is the lateral bone of the forearm. Its proximal end articulates with the trochlea of the humerus at the elbow joint and with the ulna at the proximal radioulnar joint. Its distal end articulates with the scaphoid and lunate bones at the distal radioulnar joint.

At the proximal end of the radius is the small circular, head. The upper surface of the head is concave and articulates with the convex capitellum of the humerus. The circumference of the head articulates with the radial notch of the ulna. Below the head is the neck, below which there is the bicipital tuberosity for the insertion of biceps muscle. The shaft of the radius is wider below. It has a sharp interosseous border medially for the attachment of interosseous membrane. The pronator tuberosity for the insertion of the pronator teres muscle, lies half way down on its lateral side.

At the distal end of the radius is the styloid process; this projects distally from its lateral margin. On the medial surface is the ulnar notch, which articulates with the distal ulna. The distal articular surface articulates with the scaphoid and lunate bones. On the posterior aspect of the distal end is a small tubercle, the dorsal tubercle of Lister, which is grooved on its medial side by the tendon of extensor pollicis longus.

ULNA

The ulna is not a straight bone. It has a dorso medial bowing. The proximal end articulates with the humerus at the elbow joint and with the head of the radius at the proximal radioulnar joint. Its distal end articulates with the radius at the distal radioulnar joint, but it is excluded from the wrist joint by the articular disc.

The proximal end of the ulna forms the olecranon process. It has a notch on its anterior surface, the trochlear notch, which articulates with the trochlea of the humerus. Below the trochlear notch is the triangular coronoid process, which has on its lateral surface the radial notch for articulation with the head of radius.

The shaft of ulna tapers from above down. It has a sharp interosseous border laterally for the attachment of the interosseous membrane. The posterior border is rounded and subcutaneous. Below the radial notch is a depression, the supinator fossa, which gives clearance for the movement of the bicipital tuberosity of the radius. The posterior border of the fossa is sharp and it is known as the supinator crest: it gives origin to the supinator muscle.

At the distal end of ulna is the small rounded head, which has projecting from its medial aspect, the styloid process.

INTEROSSEOUS MEMBRANE

The interosseous membrane is a thin but strong membrane connecting the radius and ulna. It is attached to their interosseous borders. Its fibers run obliquely downward and medially. This provides attachment for the neighboring muscles.

The various muscles attached to radius are

Proximal third

(1) Biceps brachiaii (insertion)

(2) Supinator (insertion)

(3) Pronator teres (insertion)

(4) Flexor digitorum superficialis (origin)

Middle third

(1) Flexor pollicis longus (origin)

(2) Abductor pollicis longus (origin)

Distal third

(1) Pronator quadratus (insertion)

(2) Branchioradialis (insertion)

(3) Extensor pollicis brevis (origin)

The various muscles attached to ulna are

Proximal third:

1) Brachialis (insertion)

2) Pronator teres (origin)

3) Flexor pollicis longus (origin)

4) Triceps (insertion)

5) Anconeus (insertion)

6) Supinator (origin)

7) Abductor pollicis longus (origin)

Middle third

1) Flexor digitorum profundus (origin)

2) Flexor carpi ulnaris (origin)

3) Extensor carpi ulnaris(origin)

4) Extensor pollicis longus (origin)

Distal third

1) Extensor indices (origin)

2) Pronator quadratus (origin)

BIOMECHANICS

Diaphyseal fractures of the radius and ulna present specific problems in addition to those common to all fractures of the shafts of long bones. In addition to regaining length, apposition and axial alignment, achieving normal rotational alignment is necessary if a good range of pronation and supination are to be restored.

The movements of supination and pronation of the forearm involve a rotatory movement around a vertical axis at the proximal & distal radioulnar joints. The axis passes through the head of radius above and the attachment of apex of the triangular articular disc below. During pronation, the entire radius moves around the ulna through the longitudinal axis of forearm.

Pronation is performed by pronator teres and pronator quadratus. Supination is performed by biceps brachiaii and supinator. Supination is the powerful of the two movements, because of the strength of biceps muscle. Maintenance of the interosseous space is essential for pronation and supination. The biceps and the supinator exert rotational forces on fractures of the proximal third of radius. Distally, the pronator teres at the level of mid shaft and the pronator quadratus on the distal fourth of shaft of radius exert both rotational and angulatory forces. Fractures of distal radius tend to angulate toward the ulna by the action of the pronator quadratus and the pull of long forearm muscles.

Rotational deformity will limit radioulnar movement. The supinator muscles are inserted proximally and the pronators distally. Consequently in a fracture of mid shaft of radius the proximal fragment supinates and the distal fragment pronates, resulting in 90˚ of rotational displacement. Shortening of the two bones following overriding may also occur. Both angular and rotational deformities are compounded by the presence of comminution. Hence, in addition to regaining length, bony apposition, axial alignment and achieving normal rotational alignment is necessary, if a good range of pronation and supination are to be restored.

CLASSIFICATION

Fractures of forearm are classified according to the level of fracture, the pattern of fracture, the degree of displacement, the presence or absence of comminution or segmental bone loss and whether they are open or closed. Each of these factors may have some bearing on the type of treatment to be selected and the ultimate prognosis. For descriptive purposes, it is useful to divide the forearm into thirds, based on the linear dimensions of radius and ulna. Disruption of proximal or distal radioulnar joints is of great signifance to the treatment and prognosis. It is imperative to determine whether the fracture is associated with joint injury because effective treatment demands that both the fracture and joint injuries are treated in an integrated fashion.

AO CLASSIFICATION

Type	22 A	Simple fractures of one or both bones
	A1	Simple fracture of ulna
	A2	Simple fracture of radius
	A3	Simple fracture of both radius & ulna
Type	22 B	Wedge fractures of one or both bones
	B1	Wedge fracture of ulna
	B2	Wedge fracture of radius
	B3	Wedge fracture of both radius & ulna

Type 22 C Complex fracture of one or both bones

C1 Grossly comminuted fracture of ulna with simple fracture of radius

C2 Grossly comminuted/segmental fracture of radius with simple fracture of ulna

C3 Grossly comminuted fractures of both bones

MECHANISM OF INJURY

The mechanisms of injury that causes fractures of the radius and ulna are myriad. By far the most common is some form of vehicular accident, especially automobile and motor cycle accidents. Most of these vehicular accidents result in some type of direct blow to the forearm. Other causes of direct blow injuries include fights in which one of the adversaries is struck in the forearm with a stick or rod. The person throws the forearm upto protect his or her head, and the forearm is the recipient of the violence. Following violent twisting of forearm, rotational deforming forces act leading to fracture of forearm bones.

Gunshot wounds can cause fractures of both bones of forearm. Such injuries are commonly associated with nerve or soft tissue defects and frequently have significant bone loss. The other common mechanism is due to some type of fall. The force generated is usually much greater than that required to cause Colle's fracture. Most forearm shaft fractures resulting from fall occur in the athletes or in fall from heights.

The last and least common cause of diaphyseal fractures of both bone forearm is due to pathological fractures.

INVESTIGATIONS

A minimum of two views – anteroposterior and lateral – are mandatory in all suspected forearm fractures. Additional oblique views may be required. The following features are noted in the radiographs.

1) Degree of offset

2) Degree of angulation

3) Amount of shortening

4) Presence of comminution

Additional visualization is needed to rule out involvement of wrist, elbow and both radioulnar joints. A line drawn through the radial shaft, neck and head should pass through the center of the capitellum on any projection.

The rotational alignment of the forearm is difficult to determine in routine antero posterior and lateral views. The bicipital tuberosity view recommended by Evans is helpful in those instances. Since the proximal radial fragment could not be controlled with closed methods, the distal radial fragment must be brought into correct relationship with the proximal fragment. Ascertaining the rotation of the proximal fragment from the tuberosity view before reduction, gives some idea of how much pronation or supination of distal fragment is needed. The tuberosity view is made with the x-ray tube tilted 20˚ towards the olecranon, with the subcutaneous border of ulna flat on the cassette. The x-ray can then be compared with the diagram showing the prominence of the tubercle in various degree of pronation and supination. As an alternative, a film of the opposite elbow can be made in a given degree of rotation for comparison.

PRINCIPLES OF MANAGEMENT

There are a number of factors which play a dynamic role in determining the type of management, thereby influencing the prognosis. They include:

1) Amount of overriding of fracture fragments

2) Degree of Comminution

3) Extent of soft tissue injuries

4) Associated neuro vascular injuries

5) Magnitude of joint involvement

6) Presence of multiple trauma

7) The width of medullary canal

8) Degree of osteoporosis

9) Complex ipsilateral injuries (side swipe injury)

So the objectives of treatment of diaphyseal fractures of both bones in adults are:

1) To obtain and maintain satisfactory reduction and rigid fixation.

2) To regain functional range of movement of elbow joint.

3) To regain adequate pronation and supination

4) To treat associated injuries.

The absence of pronation and supination is a permanent handicap since they cannot be regained by physiotherapy or rehabilitation.

METHODS OF TREATMENT

There are a variety of options for treating an adult with a fracture of both bones of forearm. It is fair to say that the vast majority of fractures of both bones of the forearm can be most effectively treated by accurate anatomical reduction, rigid plate fixation, and early mobilization. The various modalities of treatment available for treating adult diaphyseal fractures of both bones of forearm are:

1) Conservative Management:

a) Cast Immobilization \

b) Closed reduction and cast immobilization

2) Surgical Management:

a) Open reduction and internal fixation with plate osteosynthesis

b) Closed reduction and titanium elastic nail fixation

c) Closed reduction and interlocking nail fixation

d) External fixator application

CONSERVATIVE MANAGEMENT

a) Cast Immobilization:

The rare non displaced fracture of both bones of the forearm in adults can usually be treated by immobilization in above elbow cast with elbow in 90˚ flexion and forearm in midprone position. Angulation can be prevented by incorporating a plaster loop on the radial side of the cast proximal to the level of fractures. Despite good technique, an initially non displaced fracture can become displaced while being immobilized in plaster.

b) Closed reduction & Cast immobilization:

It is difficult to reduce and maintain satisfactory position of the fragments by closed methods due the various deforming forces acting on the fragments and due to the role of supinators and pronators leading to rotatory instability. Closed reduction is most successful for fractures of both radius and ulna when the fractures are located in distal third. Functional cast bracing of forearm fractures following 6 weeks of immobilization in arm cast helps in starting early elbow mobilization exercises leading to lesser incidence of elbow stiffness. Before closed reduction is undertaken, the patient must be advised that, surgical fixation may be necessary at any time to ensure solid union in acceptable position.

Technique of closed reduction

Relaxation of muscles is mandatory for closed reduction and general anesthesia is preferred. Tuberosity view is taken with image intensifier to identify the degree of rotation. Traction and counter traction are applied and ulna is reduced under direct palpation. The radius could not be palpated in the proximal half. The forearm is placed under appropriate supination as determined by the tuberosity view. When the fractures seem reduced and the alignment of forearm appears satisfactory, an above elbow plaster slab is applied and check X-rays are taken. Above elbow cast conversion is done after 1 week and radiographs in two planes are taken at weekly intervals through the cast for the first month and every two weeks thereafter until solid union is obtained.

There are only a few indications available for conservative treatment in adult forearm fractures. These include

1) Undisplaced/ incomplete fractures

2) Associated life threatening trauma like head injury, chest injury etc.

SURGICAL MANAGEMENT

INTRODUCTION:

During the last century, surgical management of diaphyseal fractures of both bones forearm in adults has gained widespread acceptance as operative techniques and the quality of implants have improved. The combination of properly designed implants, better understanding of the personality of the fracture, minimal soft tissue handling techniques, preoperative antibiotics have made surgical fixation safe and practical while treating these fractures.

The goals of operative treatment for diaphyseal forearm bones fractures in adults include

a) Anatomical alignment

b) Stable fixation

c) Early mobilization

d) Early functional rehabilitation of upper limb.

Indications for operative management include virtually all diaphyseal fractures of both bones of forearm in adults.

Open Reduction and Internal fixation:

An AO dynamic compression plate (Asian) with 3.5 mm screw system provides for secure fixation without cast protection. In an adult, fixation by semitubular plate does not provide with a rigid fixation. Plates are especially useful in fixation of fractures of distal 3rd or proximal 4th of both bones of forearm.

a) Principles:

- Plate osteosynthesis provides for static compression at the fracture site.
- Plates should be applied on the tension side of bones whenever possible.
- For both radius and ulna, dorsal side is the tension side.
- Minimal stripping of periosteurn from ends of fracture fragments.
- Both radius and ulna has to be fixed with similar type of implant.
- Autologous bone graft is added whenever there is comminution involving more than 1/3rd of circumference of bone.
- Before plate application, larger comminuted fragments should be secured to the main fragments to produce interfragmentary compression.
- Fractures of both radius and ulna should be exposed and reduced temporarily before a plate is applied to either.

- Plates must be accurately centered over the fracture site and there must be a minimal of six cortical purchases with screws on either side of fracture.
- If autologous bone graft is added, they should not be placed in the interosseous border, else cross union may occur.

b)Technique of fixation:

RADIUS

Approach:

- for proximal half, dorsal Thompson's approach
- for distal half, anterior Henry's approach
- for mid 3^{rd}, either of the approaches may be used.
- minimal stripping of periosteum is done to preserve blood supply
- Clear away all the clotted blood from the ends of the bone
- All soft tissue attachments of the comminuted fragments should be retained, if possible
- Reduce the fracture as anatomically as possible fitting any butterfly fragments into position
- Larger butterfly fragments should be fixed to the main fragment by lag screw principle

- An Asian DCP, usually a 6 or 7 holed plate is selected in accordance with the fracture pattern and applied over radius
- A 2.7 mm drill bit is used to drill hole in the radius, and then tapped. An appropriate sized 3.5 mm cortical screw is measured with depth gauge and used to fix the plate to the bone
- Always drill one hole at a time and insert screw before drilling the next screw
- Similarly all the 6 or 7 holes of the plate are drilled and fixed with screws.
- Autologous bone graft is added if the comminution involves more than one third of the circumference of radius.

ULNA

Approach

- Incision along subcutaneous border of ulna.
- Plate is fixed on either anterior or posterior surface on which it fits best.
- Posterior surface is better since it is the tension side of ulna
- If there is comminution, place the plate on the side of comminution since it stabilizes the loose fragments.
- Add autologous bone grafts if needed.

Closed intramedullary nail fixation

While selecting an intramedullary device, it is mandatory to select a nail of appropriate diameter for fixation. If the size of the nail is small, there is side to side and rotatory movement leading to instability. If the size of the nail is large, further comminution or additional fracture may occur.

Principle:

- Since the fractures of both radius and ulna are fixed in closed manner, fracture hematoma is preserved leading to early union and consolidation. Moreover, the chance of infection is minimized.
- The ulna is fixed first
- An appropriate sized nail is selected, so that the nail fits snuggly inside the medullary canal.
- Titanium elastic nail offers three point fixation thereby stabilizing the fracture fragments.

Technique of fixation

- C arm is mandatory
- Closed reduction of the bones is achieved with traction, counter traction and manipulation

- The reduction is checked with C arm.
- For the ulna, entry point in made over the olecranon with an awl and the position is confirmed
- A nail is introduced through the olecranon and passed across the fracture site under image control
- For the radius – the entry point is from distal aspect and three entry points are described
    - (a) just medial to Lister tubercle
    - (b) just lateral to Lister tubercle
    - (c) from radial styloid
- All 3 entry points are made 5 mm proximal to wrist joint.
- The entry point that is just medial to Lister's tubercle is the most preferred.
- The nail is passed, across the fracture site under C arm control.

Titanium elastic nail

- Both the radius and ulnar nails are cut at their ends and buried

Interlocking nail

- A 2 mm screw is used to lock the proximal fragment in ulna and distal fragment in radius.
- A 1.5mm threaded K wire is used to lock the distal fragment in ulna and proximal fragment in radius
- Wound suturing done.

Post operative protocol:

- If the fixation is rigid and stable, no external support in the form of cast is needed.
- Gentle active exercises of the elbow, wrist and hand are started immediately

The callus response is monitored by post operative radiographs every 3 weeks until there is good fracture union.

IMPLANT REMOVAL

Plates & screws and intramedullary nails placed on forearm bones are not removed routinely unless they cause symptoms. In any case they should not be removed before 2 years, even though the fracture will have appeared solid on radiographs much earlier. The limb has to be protected in above elbow slab for minimum 6 weeks after removal.

COMPLICATIONS

The complications following operative treatment for diaphyseal fractures of both bones forearm in adults are relatively less common because of better surgical techniques and improved implants.

Complication of fractures:

(a) Infection

(b) Malunion

(c) Non union

(d) Cross union

(e) Associated vascular and nerve injuries

(f) Post traumatic Stiffness

Complication of operative treatment

(a) Incomplete reduction

(b) Incongruous reduction

(c) Unstable fixation

(d) Inadequate implant

(e) Infection.

The use of state of the art implants and instrumentation for diaphyseal fractures of both bones forearm does not always guarantee a favourable outcome. The surgeon must have a thorough understanding of local anatomy, mechanics of fracture fixation and patterns of fracture healing after internal fixation if consistently good results are to be achieved.

Infection

The major drawback of operative fixation is infection. It is less common with closed intramedullary fixation than with open reduction techniques. If post operative infection develops, appropriate antibiotics are given for 3 to 6 weeks intravenously. Even in the presence of infection, every effort should be made to retain the implants since stable infected fractures are easy to manage than unstable infected fractures. However if the infection is severe, the implant has to be removed.

Malunion

This is relatively more common in conservatively treated cases than in surgically treated cases, since it is difficult to maintain the fracture fragments in alignment when treated conservatively. The varying pull of supinators and pronators on the fracture fragments lead to malunion.

Non union

The varying causes of nonunion are inadequate immobilization, improper fixation, implant failure and the presence of underlying infection. Gross osteoporosis of the bones is also an important cause for nonunion. Inadequate internal fixation, with plates which are too small, nails which are of inappropriate size is a potent cause of nonunion. Loss of substance of radius or ulna following gun shot injuries also lead to nonunion. Repeated manipulation by traditional bone setters may also lead to nonunion. In a case of non union, open reduction and internal fixation with autologous bone grafting is the treatment of choice.

Cross union

Cross union of the radius and ulna results from a continuous hematoma between the two fractures. The important cause of cross union following conservative treatment is improper reduction with bony fragments encroaching the interosseus space. Cross union may also occur if the fractures are stabilized by open methods and bone grafting with bone grafts kept in the interosseous border of either bones. If cross union occurs there is loss of pronation and supination due to a bridge of bone between radius and ulna. This bridge of bone has to be excised for pronation and supination to occur.

Post traumatic stiffness

This is more common is patients managed conservatively than by surgical fixation. Elbow joint is notorious for developing stiffness if it is immobilized too long. The main advantage of surgical fixation is that, since the fracture fragments are stable after fixation, active mobilization exercises of wrist, elbow and hand can be started early.

Nerve injuries

Injury to posterior interosseous nerve can occur in Henry's approach during plating of radius. Also, there are chances of injury to recurrent radial artery and superficial branch of radial nerve through this approach. These can be prevented by knowing the proper anatomy of forearm and gentle handing of soft tissues.

Complications of intramedullary nail fixation:

Most complications result from improper selection of nail size. A nail that is too long may be driven through the bone end. One that is too short may not adequately stabilize the fracture. A nail with too large a diameter may split the cortex and one with a smaller diameter may not adequately control rotational alignment resulting in non-union.

IMPLANT PROFILE

DYNAMIC COMPRESSION PLATE 3.5 MM

These plates are used with cortical screws of size 3.5mm, hence the name. The holes allow for 1mm displacement if a load screw is used, thereby producing compression. The plate can be used with an articulated tension device.

Important dimensions:

a) Thickness 3 mm

b) Width 10 mm

c) Hole spacing 12mm and 16 mm

d) Hole length 6.5mm

e) Length 25mm to 145 mm

f) Holes 2 to 12

AO stainless steel implants are produced from implant quality 316L stainless steel which typically contains iron 62.5%, chromium 14.5%, nickel 2.8%, molybdenum and minor alloy elements.

ONE THIRD TUBULAR PLATES

These plates have the form of one third of the circumference of a cylinder. They have low rigidity since they are only 1 mm thick. The oval holes permit eccentric position of screws which can be used for axial compression. The plate is fixed with 3.5 mm cortical screw.

Important dimensions

Thickness	1 mm
Width	9 mm
Hole spacing	12 mm and 16 mm
Length	25 mm to 145 mm
Holes	2 to 12

3.5 mm CORTICAL SCREW:

The holding power of the cortical screw on dense cortical bone is due to its 1.75mm pitch and the asymmetrical buttress threads.

Important Dimensions:

Head diameter	6mm
Hexagonal socket width	2.5 mm
Core diameter	2.4 mm
Thread diameter	3.5 mm
Pitch	1.75 mm
Length	10 mm – 110 mm

TITANIUM ELASTIC NAIL

These nails are made of alloys such as Ti-6Al-7Nb. They offer outstanding corrosion resistance, excellent biocompatibility and higher strength. Titanium alloy implants may be ceramic shot peened and either chemically panivated in nitric acid or anodized as a final surface treatment.

Implant profile

Length	:	44 cm
Width	:	2 mm to 5 mm Color coded for different sizes
End	:	Beak shaped for easy insertion and may be used as a reduction tool.

INTERLOCKING NAIL

The intramedullary nail is a load sharing device which permits early union, if axial and rotational stability are ensured. These are made of 316L stainless steel.

Implant profile

Length :19 to 29 cm

Width :3mm to 5mm

Screw :2.7mm

Threaded K wire : 1.5mm

EVALUATION OF OUTCOME

For evaluating the functional outcome of fracture fixation, we used the MODIFIED GRACE AND EVERSMANN SCORING SYSTEM. This system takes into account the following parameters:

1. SUPINATION AND PRONATION

(Normal – pronation & supination 80 degrees each)

RATING	RANGE OF MOVEMENT	SCORE
EXCELLENT	> 80	4
GOOD	60 TO 80	3
FAIR	40 TO 60	2
POOR	< 40	1

2. RADIOLOGICAL UNION (End of 6th week)

RADIOLOGICAL UNION	SCORE
UNION PRESENT (good callus)	2
NON UNION	1

3. RANGE OF MOVEMENT – ELBOW

Range	Result	Score
Flexion > 120	**Excellent**	**4**
Flexion 100 to 120	**Good**	**3**
Flexion 80 to 100	**Fair**	**2**
Flexion < 80	**Poor**	**1**

Final Analysis

RESULT	SCORE
EXCELLENT	10 and above
GOOD	8 to 9
FAIR	6 to 7
POOR	Less than 5

PART- B

PREAMBLE

The diaphyseal fractures of both bone fractures of forearm is one of the most common fracture pattern occurring in adults. These fractures are routinely fixed by plate osteosynthesis with 3.5 mm Asian DCP efficiently and successfully. Since this system is of load bearing type which necessitates distruption of fracture hematoma during fixation, the choice of intramedullary nail fixation for forearm fractures comes into play. Both titanium elastic nail and interlocking nail prevent axial and rotatory instability.

This series includes 30 cases (10 cases of plate osteosynthesis, 10 cases of titanium elastic nails and 10 cases of interlocking nails), all of whom were adults. The diaphyseal fractures of both radius and ulna were selected. The outcome was analysed with special emphasis on rotatory stability at the fracture site and time taken for full range of motion to occur.

Based on our findings we hereby submit **"Fractures of both bones forearm – A comparative study on fixation techniques and functional outcome between Plate Osteosynthesis, Interlocking Nailing and Titanium Elastic Nailing".**

AIM OF STUDY

Even though fractures of both bones of forearm is one of the most common fractures occurring in adults, they are also one of the most common fractures to be mismanaged. Even today most of these fractures are treated by traditional bone setters leading to increased morbidity and infection.

Traditionally, these fractures are treated by plate osteosynthesis using AO Dynamic compression plate (Asian) very efficiently. The aim of our study is to compare the functional outcome of fixation of both bones of forearm using plate osteosynthesis with that of both titanium elastic nail and interlocking nail.

This study aims to stress the need for rigid fixation of forearm fractures and to evaluate the early restoration of movements of wrist, elbow and forearm.

MATERIALS AND METHODS

This is a prospective study of 30 cases of diaphyseal fractures of both bone of forearm in adults treated by surgical fixation with various implants.

The period of surgery and follow up extends from September 2008 to November 2009. It includes all diaphyseal fractures of both bones of forearm in adults. Comminuted, segmental fractures are included in this study. All compound fractures, malunited fractures, bones with medullary canal diameter of less than 2mm and fractures in children are excluded from this study.

The cases were analysed as per the following criteria

1) Age distribution
2) Sex distribution
3) Side of injury
4) Mode of injury
5) Classification of fracture
6) Time interval between injury and surgery
7) Associated injures
8) Complications
9) Additional procedures for complications
10) Duration between injury and hospitalization

I. AGE DISTRIBUTION:

The age group varied from 20 years to 70 years with the mean age of 45 years. Incidence of fracture was observed maximum between 30-50 years of age.

Age Group	Number of cases	Percentage
20 – 30 years	8	26.6
30 – 40	8	26.6
40 – 50	8	26.6
50 – 60	3	10
60 – 70	3	10

II. SEX DISTRIBUTION:

Among the 30 cases, males were predominant

Sex	Number of cases	Percentage
Male	20	66.67%
Female	10	33.3%

III. Side of Injury:

Right side was common in our series

Sex	Right	Left	Bilateral	Total
Male	14	7	-	19
Female	4	5	-	11
Percentage	60	40	-	-

IV. Mode of Injury

Commonest mode of injury had been road traffic accident.

Mode of Injury	No. of cases	%
RTA	14	46.67%
Fall	8	26.67%
Assault	8	26.67%

V. Classification of fracture:

Mullers sub type	No. of cases	%
A3	24	80%
B1	4	13.3%
B2	1	3.3%
B3	-	-
C1	1	3.3%

VI. Time interval between injury and surgery

Time interval	No. of cases	%
<2 days	4	13.3%
2 to 5 days	20	66.67%
5 to 7 days	6	20%

VII. Associated Injuries:

Fracture of both bones leg	3
Humerus shaft fracture	1
Femur shaft fracture	1
Chest injury	1
Head injury	4

VIII. Complications

Tourniquet palsy	1 case (recovered)
Infection	4 cases
Tendon rupture	1 case

IX. Duration between injury and hospitalization

Most of injuries were hospitalized within 12 hours.

Time interval	No. of cases
0 – 3 hrs.	2
3 – 6 hrs.	12
6 – 12 hrs	6
8 -12 hrs	10

X. Duration of hospital stay post operatively

Procedure	Duration of stay
Plate osteosynthesis	12 days
Intramedullary Nail	5 days

PROCEDURE AND POST OPERATIVE PROTOCOL

All the patients were received in the casualty department and were resuscitated. If there were any other major associated injuries, they were treated accordingly at first. After the general condition of the patient improved, radiographs (AP View and lateral view) were taken. The fractures were reduced in closed manner at first under sedation and an above elbow slab was applied. Fractures with comminution were taken for fixation with plate osteosynthesis. Other cases were fixed with intramedullary devices.

Most of the cases were taken for elective fixation before 5th day. The patients who had associated major injuries were taken up for surgery between 5th and 7^{h} day.

Open reduction and internal fixation with Dynamic Compression plate:

We routinely used tourniquet during surgery.

The radius was opened first. We always used Henry's approach for exposing the radius. The cleavage between flexor carpi radialis and brachioradialis was developed. The FCR was retracted medially along with radial artery and vein. The branchioradialis was retracted laterally along with the sensory branch of radial nerve. The fractured ends were identified and with minimal periosteal stripping, they were mobilized. The medullary cavity was cleared of any hematoma and the fractured fragments were reduced by carefully matching the interdigitations using bone holding forceps. An Asian DCP of appropriate length was selected and applied to the radius on the volar side and fixed with 3.5mm cortical screws. All the fractures were fixed such that there were at least six cortical purchases on either side of the bony fragment. Then the ulna was opened on its subcutaneous border, centering over the underlying fracture. The interval between flexor carpi ulnaris and extensor carpi ulnaris was identified and developed. The periosteum over the ulna was incised, the fracture fragments were reduced and fixed with an Asian DCP similar to that of radius. Thorough wash of both wounds done. The deep fascia was not sutured; skin closure was done. Compression bandage was applied. Tourniquet was released and an above elbow slab was applied.

POST OPERATIVE PROTOCOL:

In the immediate post operative period the upper limb was immobilized in an above elbow slab, and kept elevated till the edema of fingers subsided. The wound was inspected on the II POD and then suture removal was done on Xth POD. The upper limb was kept in AE cast for 6 weeks. At the end of 3rd and 6th weeks, the cast was removed and check X rays were taken to visualize callus response. Depending upon the stability of the fracture and if the callus response is good at the end of 6th week, the cast was removed and elbow mobilization exercises were started. The pronation and supination movements were started by the end of 8th week.

II. Closed Reduction and Fixation with Intra meduallary nailing:

Most of the fractures of Muller type A were fixed with this implant.

(A)Titanium elastic Nail fixation:

The patient is placed supine and the forearm is kept in a hand table compatible with C arm. Tourniquet was not used. The width of the medullary canal of radius was measured and an appropriate sized nail was selected such that, the nail should occupy at least 60% of the medullary space. The entry was made on the distal radius just medial to Lister tubercle, beneath the extensor pollicis longus tendon about 5 mm proximal to wrist joint, with a 3.2 mm drill bit. The medullary canal was entered with a curved awl and the position was confirmed with C arm. The selected titanium elastic nail was introduced and passed into the medullary canal of radius and gently pushed till it reaches the fracture site. The fracture fragments were reduced by gentle manipulation and the nail was entered into the distal fragment by gently rotating the tip. The position of the nail was continuously confirmed with C arm. The nail was passed till it reached the radial neck. The nail was then slightly withdrawn and cut. The cut end of the nail was gently hammered so that the tip lies flush with the bone.

The ulna was entered from the olecranon and an appropriate nail was inserted, fracture fragments reduced and the nail gently manipulated into distal fragment. The tip of the nail was cut and buried. The wounds were sutured.

B. Interlocking Nail fixation:

The surgical procedure is almost similar to that of titanium elastic nail fixation. Here it is mandatory to select a nail with appropriate width such that it fits snugly inside the canal. Tourniquet is not used during surgery. Radius is fixed first and locking of proximal hole is done with a 2.7 mm cortical screw using a jig and making a drill hole with a drill bit of 1.9 mm. The distal hole was locked with a 1.5 mm threaded K wire using free hand technique. The K wire was cut, bent and then buried beneath the muscles. The ulna is then fixed similarly. The positions of both nails, screws and ‘K’ wires were confirmed with C arm; wound wash and suturing done. Compression bandage applied. Above elbow slab was given.

Post operative protocol:

The upper limb was kept elevated. Wound inspection was done on II POD. Suture removal was done on Xth POD, and above elbow cast was applied. After 3 weeks the cast was removed and a below elbow cast was applied, after obtaining check X rays. Active elbow mobilization exercises were started at the end of 3rd week. By the end of 6 weeks, the cast was discontinued and active pronation and supination exercises were started.

PITFALLS AND THEIR MANAGEMENT

1. Infection:

Fhive cases developed wound infection, 4 of them treated with plate osteosynthesis, one with interlocking nail. In the patient who was treated with interlocking nail, there was superficial infection at the site of locking screw over distal radius. The screw was removed on 21st day and wound wash and secondary suturing was done. The radius went on to unite well.

4 cases of plate osteosynthesis developed infection – 3 of which are superficial and one deep. Pus culture for sensitivity was sent in all the four cases and treated with appropriate antibiotics. The three superficial infections subsided with treatment for 3 weeks, but the one with deep treatment subsequently went for plate removal for ulna alone. Wound debridement of the ulnar wound was done and the fracture was stabilized with a 3mm K wire.

2. Delayed union:

Delayed union developed in one case treated with titanium elastic nail. The patient had segmental fracture of ulna fixed with 3 mm nail. At the end of 6th week, there was tenderness at the proximal segmental fracture site.

Radiologically there was no callus. The fracture was immobilized with above elbow cast for another 4 weeks. Eventually there was adequate callus response and the fracture went on to unite well.

3. Non Union

Non union of the fracture of radius occurred in a case treated with interlocking nail. There was angulation at the fracture site which involved the distal 3^{rd} of shaft of radius. The nail was removed on the 15^{th} week and plate osteosynthesis with bone grafting done.

4. Elbow stiffness:

8 Patients who were treated with plate osteosynthesis developed elbow stiffness at the end of 6^{th} week while removing above elbow cast. The patients were put on strict regimen involving active mobilization exercises of elbow. Eventually all 8 patients had good range of motion of elbow.

5. Tendon injury:

One case treated with titanium elastic nail developed rupture of tendon of extensor pollicis longus at the wrist. It occurred during the drilling of outer cortex of distal radius just medial to Lister tubercle. The tendon of EPL was caught by the drill bit while drilling. Eventually the procedure was cancelled and the forearm was fixed with plate osteosynthesis.

6. Technical complications:

a) Fracture of Radial styloid:

This complication occurred in a patient treated with titanium elastic nail. The entry point was made more laterally over the radial styloid. During manipulation, the tip of radial styloid fractured. This was visualized on the immediate post operative radiograph. The patient developed wrist stiffness which was treated with intense mobilization exercises.

b)Impaction fracture of radius:

In a patient treated with titanium elastic nail, there was impaction fracture involving the distal fragment of radius after fixation. There was prolonged fracture site tenderness even after 8 weeks. The patient was managed with above elbow cast for 9 weeks and below elbow cast for another 3 weeks. The fracture united well, but the patient developed elbow stiffness.

c) Resurgery:

In 2 cases (1 with titanium elastic nail, 1 with interlocking nail) one end of nail of radius was out of the medullary canal. Both cases were taken up for resurgery. In the patient who had interlocking nail, the nail was removed and titanium nail was inserted. In the other case, the titanium elastic nail was reused.

d) Open reduction and internal fixation with interlocking nail:

In one case treated with interlocking nail, the ulna could not be reduced in closed fashion. Eventually the fracture site was opened and the nail was fixed.

e)Difficulty in locking:

Locking with threaded 'K' wire could not be done for one case treated with interlocking nail for both radius and ulna. The patient was treated with above elbow cast for 6 weeks and below elbow cast for another 3 weeks and the fracture eventually united.

RESULTS

Average time of fracture healing was 8 weeks. In patients who had undergone plate osteosynthesis, it was 9 weeks whereas in patients who had undergone nail fixation it was 6 weeks. Muller Type 22 C1 fracture united by 11 weeks. Other fracture patterns healed between 6 and 9 weeks.

One patient who had undergone interlocking nail fixation, developed non union of fracture of radius. After a period of 15 weeks, since there was angulation of the distal fragment with no callus response at the fracture site, the nail was removed and open reduction and internal fixation with plate osteosynthesis and bone grafting was done. The fracture went on to unite after a period of further 10 weeks.

2 patients had restricted pronation & supination and both of them eventually recovered. All these patients were treated with plate osteosynthesis. 8 patients treated with plate osteosynthesis gave excellent results with regard to pronation & supination.

4 patients developed post operative stiffness of elbow joint. All of them were treated with plate osteosynthesis. However, all these patients eventually had fair range of motion by the end of 12 weeks following intense physiotherapy.

The patient who had sustained fracture of radial styloid process during titanium nail fixation following far lateral entry point developed stiffness of wrist joint. With active exercises, the ROM was increased.

Restoration of pronation & supination activities were possible by the end of 6th week using intramedullary nailing whereas they were possible by the end of 9th week using plate osteosynthesis

ANALYSIS OF FUNCTIONAL OUTCOME

The Analysis was done using modified GRACE AND EVERSMANN RATING SYSTEM and the following results were obtained.

I. OVERALL RESULTS

Grading	Number of Cases	Percentage
Excellent	**22**	**73.3**
Good	**4**	**13.3**
Fair	**2**	**6.6**
Poor	**2**	**6.6**

II. RESULTS ACCORDING TO IMPLANT USED

	Number of cases	Grading	Percentage
Plate Osteosynthesis	8	Excellent	80
	2	Good	20
	-	Fair	-
	-	Poor	-

	Number of cases	Grading	Percentage
Titanium Elastic nail	7	Excellent	70
	2	Good	20
	-	Fair	-
	1	Poor	10
Interlocking nail	7	Excellent	70
	-	Good	-
	2	Fair	20
	1	Poor	10

DISCUSSION

The aim of this study is to compare the results of treating diaphyseal fractures of both bones in adult forearm using plate osteosynthesis with that of titanium elastic nail fixation and interlocking nail fixation.

We selected 30 cases of diaphyseal fractures involving both the bones in the forearm in adults. The period of study was between July 2008 and November 2009. Most of these patients fell into middle age, group with majority of them being males. The mode of violence is either due to RTA, assault or due to accidental fall. The patients who had simple Muller’s A3 fracture pattern were fixed with intramedullary nail fixation and the fractures with comminution and segmental pattern were fixed with plate osteosynthesis. Compound fractures were excluded from our study.

A satisfactory device for internal fixation must hold the fracture rigidly, eliminating as completely as possible angular and rotatory motion. This can be accomplished by either a strong intramedullary nail or AO dynamic compression plate.

During plate osteosynthesis, to minimize further injury to blood supply of the bone, the periosteum was stripped sparingly with a periosteal elevator and only sufficiently for applying a plate. The fragments were carefully reduced with interdigitating bone spicules being fitted properly. Comminuted fragments were fitted accurately in place. The plates were selected such that at least there were six cortical purchases on either side of fracture fragments. The plates were contoured before they were applied to the bone. Our study has showed good fracture union occurred in 80% of cases.

Earlier studies have reported an alarming refracture rate of 40% when the plates were removed before 1 year. It is well established that the cortex beneath a rigid plate weakens because of stress shielding, becoming thin, atrophic and almost cancellous in nature. If soft tissue stripping has been extensive, osteonecrosis and revascularization weakens the cortex further. In our series involving 10 cases treated with plate osteosynthesis, we did not have refracture in any of our patients.

While using intramedullary device for fixing the adult forearm fractures involving both bones, rotational control in fractures near the metaphyseo-diaphyseal junction was difficult because of wide medullary canal. Interference fit nails do not maintain bone length if associated with bone loss. When an intramedullary fixation is used, errors in selecting the proper diameter or length of the nail and operative technique contributed to poor results. In case of the titanium elastic nail, the distal end of nail must abut subchondral bone to prevent shortening. The lower modulus of elasticity of titanium nails allow easier insertion and provide more load sharing with the bone. Titanium elastic nails produced interference fit which was responsible for the return of forearm rotation and grip strength.

Our study had showed that good to excellent union occurred with 90% of fractures fixed with titanium elastic nail and excellent union in 70% with interlocking nail fixation.

We compared the results of plate fixation with that of intramedullary fixation. Apart from the incidence of infection we did not have any complications while treating forearm fractures with plate osteosynthesis. Three out of the 4 cases healed well on controlling the infection and one went in for eventual replacement of ulnar plate with a ‘K’ wire.

We had technical difficulties while using both titanium elastic nail and interlocking nail. While fixing fractures of radius involving distal 3^{rd} shaft, the titanium elastic nail did not provide with adequate stability of fracture fragments because of wide medullary canal. While using titanium elastic nail we had entry point fracture at radius, since the entry point was shifted far laterally. That led to the fracture of styloid process of radius which was treated conservatively. In another case, there was avulsion of tendon of extensor pollicis longus by a drill bit. This occurred following failure of separation of soft tissue upto the bone with a curved artery forceps after skin incision was made.

While using interlocking nail it was technically demanding to lock the distal locking site with 1.5 mm threaded K wire even with image control. Hence the average operating time was prolonged in case of interlocking nail. Further more, if the medullary canal diameter is narrow (3mm) the size of the nail is used is also thin, hence it was very difficult to manipulate the proximal fragment with the nail. That was one of the reasons for performing open reduction at the fracture site in one case.

Earlier, intramedullary devices like K wires, square nails and Rush nails were used for fixing radius and ulna. These implants did not provide with rotational stability at the fracture site. This lead to higher incidence of non union. But both interlocking nail and titanium elastic nail, provided with excellent rotational stability of fracture fragments.

We used tourniquet in fractures fixed with plate osteosynthesis. One case of tourniquet palsy occurred but recovered eventually. Since tourniquet was not used during intramedullary fixation, the chance for occurrence of this neurological complication was totally eliminated.

Closed Intramedullary fixation offers the following advantages when compared with plate osteosynthesis.

a) No periosteal stripping is required

b) Smaller operative wound

c) Bone grafting not necessary

d) No potential for diaphyseal refracture after implant exit.

In our study, the rehabilitation time was much shorter for fractures fixed with intramedullary nail when compared with that of plate osteosynthesis. The average time required for functional recovery is more than 9 weeks when plates are used, and about 6 weeks when intramedullary nails are used. The duration of hospital stay post operatively was also less (on an average of 5 days for intramedullary devices and 12 days for plate osteosynthesis).

Intramedullary fixation provides for short operating time, short hospital stay and early rehabilitation.

CONCLUSION

The conclusion of this study are

- Diaphyseal fractures of both bones of forearm in adults are one of the commonest fractures being reported to orthopaedic emergency
- Early fixation of fracture followed by intense physiotherapy produced excellent results.
- Fixation with plate osteosynthesis has stood the test of time and provides excellent fixation.
- The advantages of intramedullary fixation are
    - Preservation of fracture hematoma
    - Early mobilization.
    - Can be done as a day care procedure
    - Less post operative morbidity.
    - Smaller incision – hence better cosmesis
    - Last, but not the least; since there is no axial loading (like weight bearing) after intramedullary fixation, the chances of implant failure is very less.
- Interlocking nail fixation is especially useful in fixation of comminuted and segmental fractures of radius and ulna. It helps is maintaining the length as well as maintenance of rotational stability of these fractures.

- Interlocking nail fixation is also useful in fractures of distal 3rd of radius and ulna where the medullary canal is wide.
- Titanium elastic nail fixation is particularly useful in fractures involving middle third of radius and ulna. Providing for 3 point fixation leads to stable fixation and proper alignment of fracture fragments.
- Being newer techniques, these intrameduallary devices require further evaluation and there is a steep learning curve.
- The presence of image control (C arm) helps in easy reduction of fractures fragments thereby shortening intraoperative duration.

To conclude:

Even though, plate osteosynthesis is still the most commonly used form of fixation in adult both bone forearm fractures, both titanium elastic nail and interlocking nail fixation are relatively newer techniques which offer a viable and more efficient alternative especially in fixation of fractures involving shafts of radius and ulna.