A PROSPECTIVE ANALYSIS OF OUTCOME OF FRACTURE SHAFT OF HUMERUS TREATED BY MIPO TECHNIQUE

Dissertation submitted to

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With fulfillment of the regulations

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BRANCH – II

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CERTIFICATE

This is to certify that **Dr. B. SUNDEEP,** post graduate student (2018-2021) in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Government Madras Medical College Hospital, has done dissertation on '**A PROSPECTIVE ANALYSIS OF OUTCOMES OF FRACTURE SHAFT OF HUMERUS TREATED BY MIPPO TECHNIQUE**' under my guidance and supervision in partial fulfillment of the regulation laid down by the' **THE TAMILNADU DR MGR MEDICAL UNIVERSITY, CHENNAI 32'** for M.S.(Orthopedic Surgery) degree examination to be held in March 2021

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DECLARATION

I, **Dr. B. Sundeep** declare that the dissertation entitled '**PROSPECTIVE STUDY OF ANALYSIS OF FUNCTIONAL OUTCOME OF SHAFT OF HUMERUS FRACTURE TREATED BY MIPO PLATING HUMERUS'** submitted by me for degree of MS ORTHO is the record work carried out by me during the period of November 2018 to November 2020 under the guidance of Prof. M. Antony Vimal Raj M.S Ortho, Professor of Orthopaedics, Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai.

This dissertation is submitted to the Tamilnadu DR. MGR Medical University towards the partial fulfillment of the requirement of the award of M S degree in Orthopaedics (Branch II).

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CONTENTS

INTRODUCTION

The rapid growing population with its constantly increasing vehicles has lead to proportionate increase in road traffic accidents. Humeral shaft fractures are commonly encountered in orthopedic surgery accounting for 1 to 3 % of all fractures. The humerus is a single long bone constituting the upper arm analogous to the femur of the lower limb. It articulates with glenoid forming the shoulder joint in the proximal part which is an inherently unstable joint and in the distal part it forms the elbow joint with the ulna and radius which is quite stable. The humerus shaft fractures are caused mostly due to direct trauma which causes transverse, comminuted or oblique fractures. In case of twisting injury spiral fractures occur. The conservative treatment of these fractures results in satisfactory results due to wide range of motion in shoulder joint supplemented by elbow joint. Hence the treatment of these fractures are a much debated topic. But in some cases conservative treatment results in varus deformity and limitation of shoulder and elbow motion which leads to reduced function.

The non operative treatment option includes a wide spectrum ranging from the sling and bandage to the latest extension cast technique. Even if the fracture unites in malunion anterior angulation of < 20 degrees and varus of less than 30 degrees are usually well tolerated. The extreme degree of motion

offered by the shoulder and elbow joint makes small degrees of malunion not affect the patients function.

The functional cast bracing has replaced all conservative methods as it preserves the shoulder and elbows range of motion, preventing stiffness and making the patient functionally active at the earliest.

There are several techniques available to operatively fix humeral shaft fractures such as tens nail, intramedullary nail, plate fixation. Recently MIPO technique of humerus fracture have been developed which does not interfere with biological union going on at fracture site and simply augments the natural healing of fracture site. Various neurovascular structures traversing the bone in close proximity has made the minimal approach to the bone a risk. The most serious complication is the radial nerve palsy. Near normal anatomical reduction and stable fixation without interfering the biological healing of the fracture site with minimal soft tissue disruption makes MIPO plating a favorable option.

AIM

To analyse the **“Functional Outcome Of Humeral Diaphyseal Fractures Treated By Humerus MIPO Plating”.**

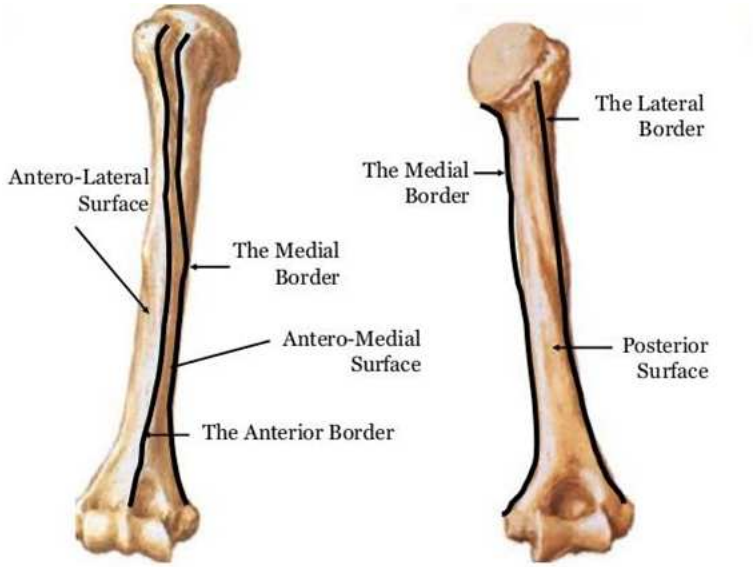
ANATOMY

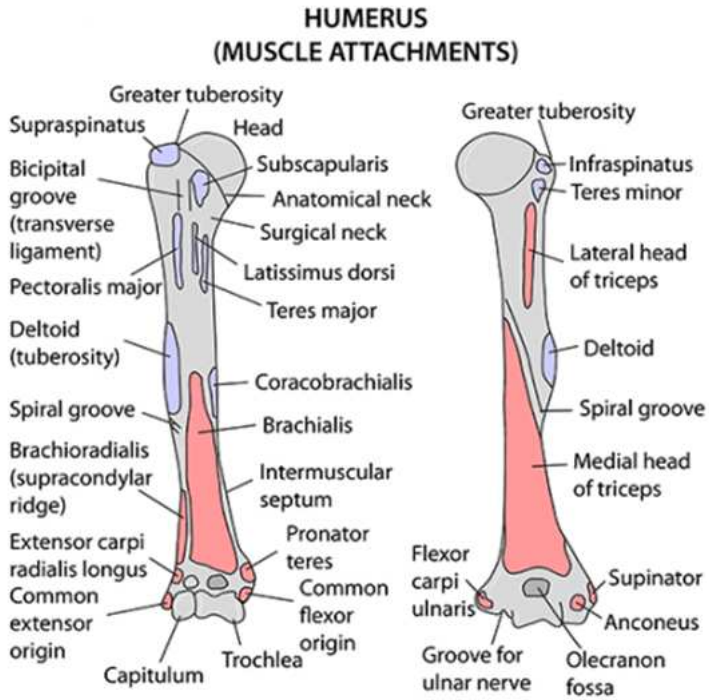
The humerus is a long tubular bone of the upper extremity - the longest and largest. The humeral diaphysis extends from the surgical neck of humerus just below the greater and lesser tuberosities to the supracondylar ridge of the elbow. A cross section of the humeral shaft is round proximally and changes gradually to be triangular distally as the medullary canal becomes narrower distally. It can be divided into proximal middle and distal 3rd. Similar manner the surface of the humerus is divided as anteromedial, anterolateral and posterior parts. Hence it has three borders and three surfaces. The border and surface anatomy is important in considering the plate has to be placed in a flat surface. The anterolateral surface lies between the anterior and lateral borders. We keep the MIPO plate on this anterolateral surface.

The upper half of this surface is covered by deltoid. A little above the middle there is deltoid tuberosity. There is radial groove with its nerve and profunda brachi artery running downwards and forwards across this surface. The knowledge of polymorphy and surface anatomy helps in better placement of the plates for internal fixation. The humerus is covered by a thick envelope of soft tissue that includes muscles and neurovascular structures. Muscles that surround the humerus from proximal to distal include the deltoid, pectoralis major, teres major, lattismus dorsi, coracobrachialis, brachialis, brachioradialis, biceps brachi and triceps brachi. Knowledge of origin and insertion of each

muscle helps in knowing the displacement occurring in diaphyseal fractures and thus helps in planning the operative technique. The muscles surrounding the humeral shaft can be divided into two main categories - the anterior and posterior compartment with septa in between. The anterior compartment contains the flexors of elbow and the posterior compartment contains the extensors of the elbow. The radial nerve enters the posterior compartment and runs between the long and lateral head of triceps, enters the spiral groove, runs its course posterolaterally, and exits the spiral groove on the lateral aspect of the humerus approximately 10 to 15 cms proximal to the lateral epicondyle[3] .

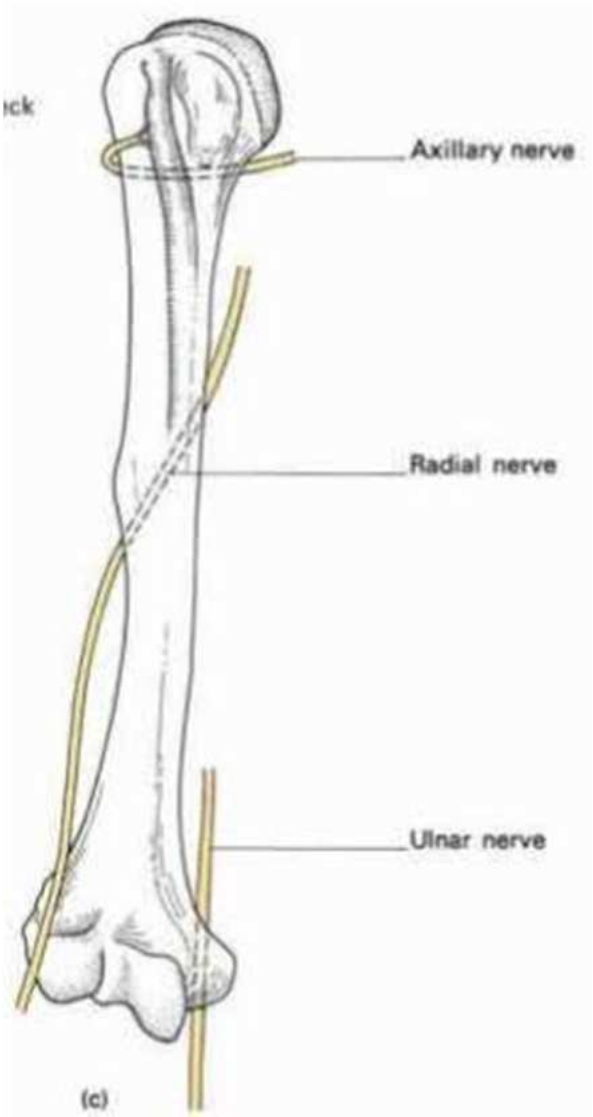
BORDERS AND SURFACES





NERVE INJURY

The most common associated injury in closed diaphyseal humerus fracture is radial nerve injury causing wrist drop and sensory loss in dorsal lateral part of hand and lateral 3 and half fingers. Among the diaphyseal fractures, the displaced spiral fractures with distal end displaced towards the lateral side - the **Holstein Lewis fractures** has an increased rate of radial nerve palsy. It occurs due to the entrapment of radial nerve within the fracture necessitating exploration of the radial nerve. But recent studies performed has showed that irrespective of the type of fracture, an expectant treatment should be followed instead of early nerve exploration. That is in the absence of clinical and electromyographic signs of recovery, intervention should be carried out in about 10 to 12 weeks after the injury. The indications of early exploration includes vascular injury, open wounds, penetrating injury. Injuries of ulnar and median nerves with humeral shaft fractures are not as frequent as radial nerve injury. In case of ulnar or median nerve injury a similar policy to that of radial nerve should be followed.[7,8]



APPLIED SURGICAL ANATOMY

As the radial nerve passes through the lateral intermuscular septum, in the distal 3rd, it is least mobile and is trapped when the fracture occurs in this region or when closed reduction is attempted. Holstein and Lewis described these oblique fractures occurring in the distal 3rd shaft. The humerus bone is not a weight bearing bone, hence the compressive forces does not pose a threat in the operative treatment.

MECHANISM OF INJURY

As in the case of any long bone fracture, the shaft of humerus fracture can be caused by direct or indirect violence. In older population with low energy trauma due to osteopaenic nature of bone, transverse fracture and oblique fractures are most commonly caused. High energy fractures causes comminuted fractures. Twisting forces causes spiral fractures. The fractures with a butterfly fragment is caused by twisting with a bending forces. In sports sometimes fracture of the bone is caused due to violent muscular contraction, or forceful throw of a ball or javelin.

History

Just as any other long bone injury in the body, a careful history is important to predict the mechanism and severity of injury which plays an important role in the management and prognosis of fracture. For example, a fracture in a young patient due to a simple fall or trivial trauma should alert the orthopaedic surgeon the possibility of a pathological fracture which totally changes the management unlike the fractures that are caused by high velocity injuries of young patients. The patients are assessed clinically for general condition.

Clinical Features of Humeral Shaft Fractures:

Most of these fractures occurs as a result of ground level falls or minor twisting injuries in older osteoporotic patients. In younger patients these fractures are caused due to high energy/high velocity injuries. In case of a fracture following a trivial trauma in a young patient the possibility of a pathological cause should be excluded. The patient often comes with a injured arm supported by the opposite hand. The arm and axilla must be thoroughly inspected. The neurovascular status of the arm must be carefully examined. The radial and ulnar pulses are palpated at the wrist and the adequacy of the capillary refill is examined. Neurological status of the arm is then examined by assessing all the main peripheral nerves of the upper limb. But special attention must be given to the examination of the radial nerve because of its close relationship to the humeral shaft. [3]

CLASSIFICATION [3,20]

The AO classifies humerus as a bone (1) , divided it into three parts

Proximal (1 1)

Diaphyseal (1 2)

Distal (1 3)

The diaphyseal fractures are further classified into

Simple fractures (12-A)

Wedge fractures (12-B)

Complex fractures (12-C)

A1 Simple fracture, spiral

1. proximal zone
2. middle zone
3. distal zone

A2 Simple fracture, oblique (> or = 30°)

1. proximal zone
2. middle zone
3. distal zone

A3 Simple fracture, transverse (< 30° :)

1. proximal zones

2. middle zone

3. distal zone

B1 Wedge fracture, spiral wedge

1. proximal zone

2. middle zone

3. distal zone

B2 Wedge fracture, bending wedge

1. proximal zones

2. middle zones

3. distal zone

B3 Wedge fracture, fragmented wedge

1. proximal zone

2. middle zone

3. distal zone

C1 Complex fracture, spiral

1. with two intermediate fragments

2. with three intermediate fragments

3. with more than three intermediate fragments

C2 Complex fracture, segmental

1. with one intermediate segmental fragment

2. with one intermediate segmental and additional wedge fragment(s)

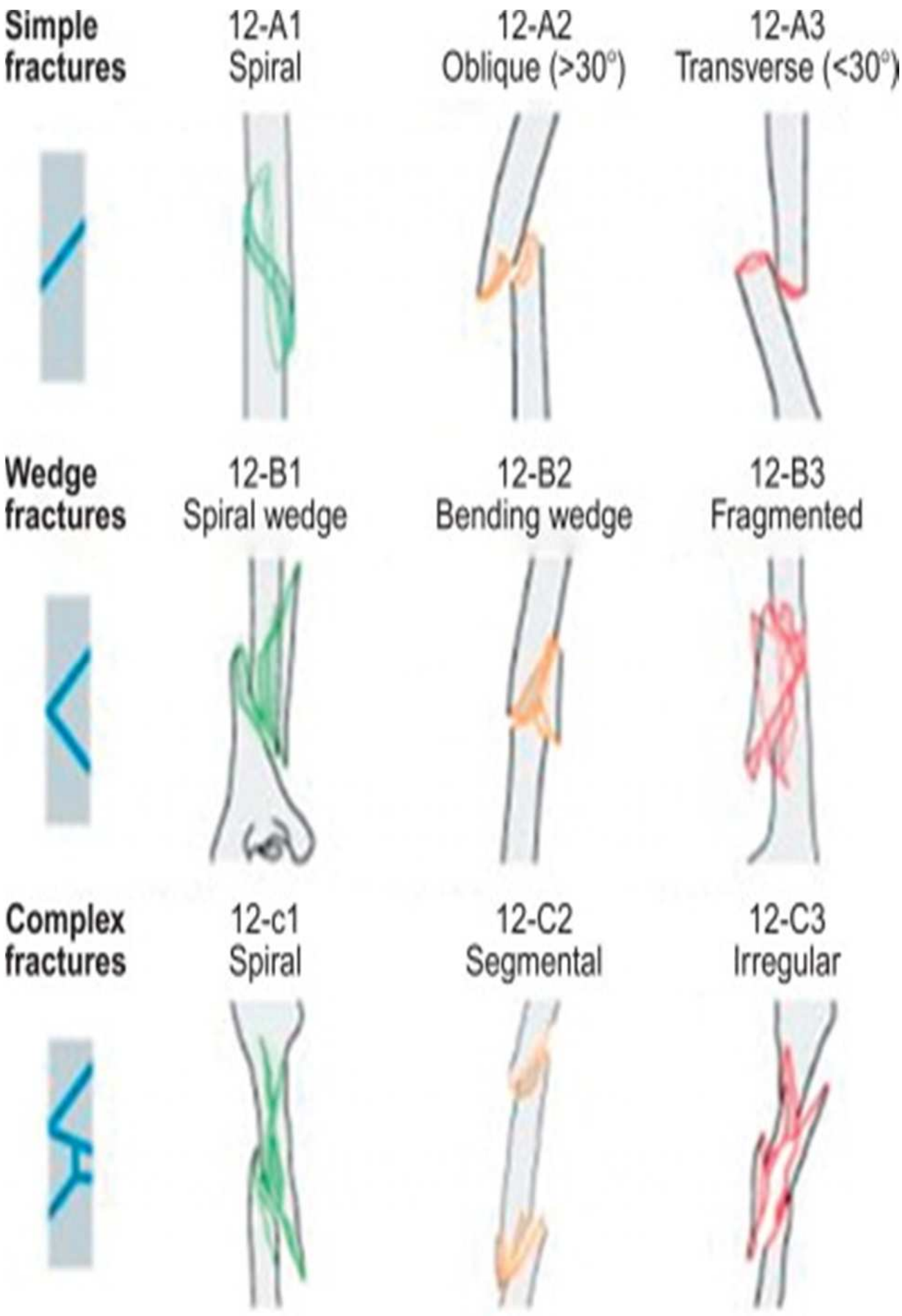
3. with two intermediate segmental fragments

C3 Complex fracture, irregular

1. with two or three intermediate fragments

2. with limited shattering (< 4 cm)

3. with extensive shattering (> or = 4 cm)


Simple fractures
12-A1 Spiral
12-A2 Oblique (>30°)
12-A3 Transverse (<30°)
Wedge fractures
12-B1 Spiral wedge
12-B2 Bending wedge
12-B3 Fragmented
Complex fractures
12-c1 Spiral
12-C2 Segmental
12-C3 Irregular

MANAGEMENT OF HUMERAL SHAFT FRACTURES[3,15]

Non-Operative Management

Operative Management

- External fixation
- ORIF and plating
- IM nailing
- MIPO plating

Non - operative management [3, 14,15]

Humeral shaft fracture is one of those which responds positively to conservative treatment. It is a well known fact that given sufficient time, the human body heals on its own, which forms the basic principle of orthopaedics. But this natural healing comes at a cost- functional outcome can be compensated due to loss of length, malunion, non union. But in this case excellent results have been reported even with malunions with anterior angle of less than 20 degree or a varus of less than 30 degree because of the large range of motion of the shoulder joint, the functionality is not much compromised, making the humerus fractures an apt bone to be treated non-operatively.

This is due to the following reasons - the angular deformities of the humerus upto 15 degrees is unrecognizable to the naked eye. And the wide range of movements of the shoulder joint makes up for range of movement restriction - if any, occurs due to fracture.

Indications

- An acute closed fracture in a co-operative and ambulatory patient.

Contraindications

- Polytrauma
- Vascular injury
- Increasing or persisting neurological dysfunction
- Pathological fractures
- Open fractures
- Unacceptable degree of angulation after attempted closed reduction
- Non - compliant patient

The non - operative treatment includes many modalities such as traction, abduction splint, sling and swathe, U-slab, hanging cast, functional cast brace. Of these the skeletal traction and abduction cast brace are of historical value only.[6]

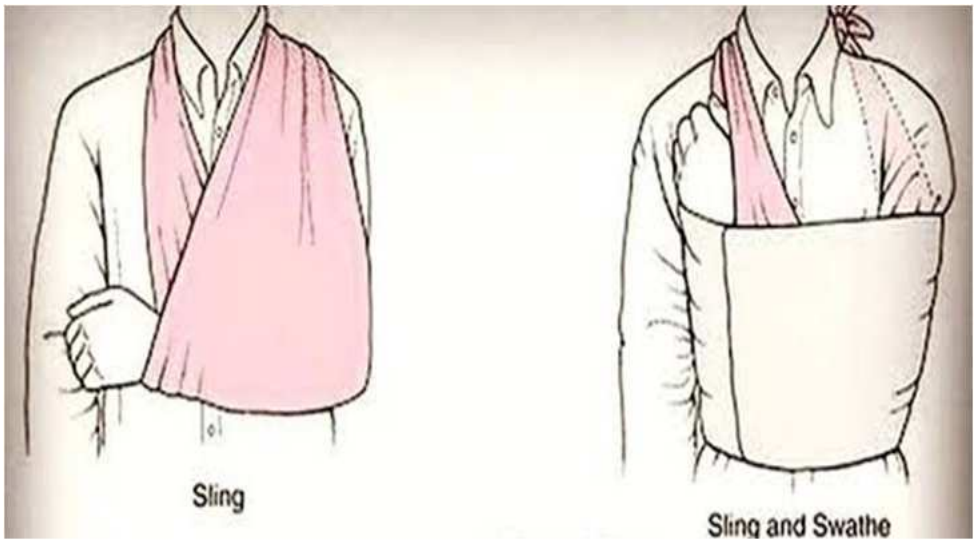
Initial Management

The Humeral shaft fractures must be initially stabilized with above elbow cast or with a coaptation splint. To help in aligning the fracture fragments and provide comfort to the patient in the initial stage, the pendulum exercises are begun as soon as possible.

Sling - swathe / valpeau bandage[15]

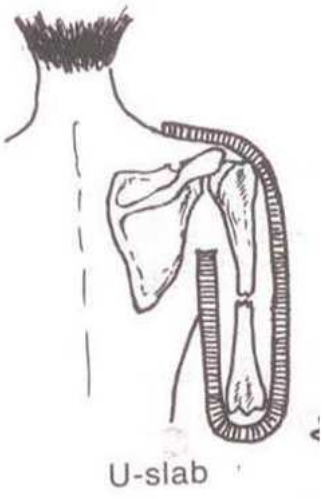
"though simple in form and principle , this sling is rich in security , ease , and comfort ." - Sir John Charnley.

It helps in initial management of fracture that helps in rapid immobilization. The patients elbow is flexed and it helps in preventing further displacement of the fracture and the weight of the forearm is bared by the sling and the arm is supported by swathe. The velpeau bandage also offers similar effect but it is more restrictive.



U - Slab [15]

This slab is in the shape of U. It is used as a temporary immobilization of humeral shaft fractures, especially if they are located in the middle and distal third. Care must be taken to see that one end of the U - Slab is not at the fracture site - it acts as a fulcrum and causes more displacement of the fracture. They also have a tendency to slide down from the arm.

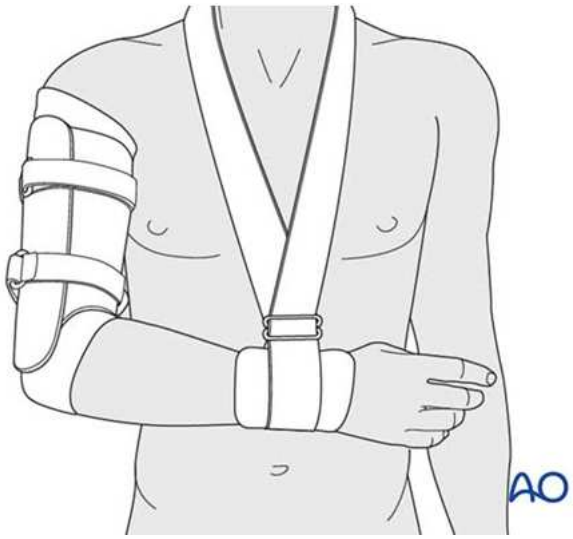


Hanging Cast[15]

The hanging cast is used in the shortened and displaced fractures, the fractures that have over- riding edges. It uses gravity to its aid - to reduce the fracture with gravity and then it is converted to functional cast brace. If the hanging cast is continued for a longer period of time, it causes over distraction of the fracture fragments that causes problems of healing. They are most commonly used for middle third shaft fractures that are displaced - for a period of 1week to ten days.

The Functional Cast Brace[15]

After the initial stabilization of the shaft fracture with any of the methods described above, after the swelling and the initial symptoms subside, a functional brace is applied. The name functional brace is derived from the fact that one joint above and one joint below the fracture immobilization is not necessary for fracture healing.



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The elbow joint does not tolerate the immobilization for a period of more than 10 days and hence it is mandatory to mobilize the joint before it gets stiff. The functional cast brace should not be applied on the day of injury as the swelling and pain becomes more intensive. This brace requires compression of high grade and hence not suitable when there is swelling or edema. The brace must be made adjustable so that frequent tightening of the brace is required during the initial 2 weeks. The brace is applied as soon as acute symptoms have subsided and additional swelling is not anticipated. The brace should extend

from approximately 1 inch below the axilla to 1 inch above the humeral condyles. The brace is supplemented with a sling but the patient is instructed to move their arm at frequent intervals; but the arm elevation above head, abduction and resting the arm on chair or table is discouraged as it may cause varus angulation at the fracture site. Regular periodic follow up is required and the patients are instructed to gradually increase the range of motion.

OPERATIVE MANAGEMENT [3,20]

The indications of operative fixation:

- **Fracture Characteristics**

- Segmental fractures
- Pathological fractures
- Fractures with intra articular extensions
- Shortening >3cm
- Angulations >20 degrees
- Rotations > 30 degrees

- **Associated Factors**

- Bilateral fractures
- Polytrauma patients
- Brachial plexus injury or Vascular injury
- Open wound / penetrating injuries
- Morbidly obese patients causing varus deformity

EXTERNAL FIXATION

The external fixation is mainly used in damage control orthopaedics in extensive soft tissue damage exposing the bones and in vascular damage necessitating vascular repair. The external fixation should be replaced by definitive fixation of humeral shaft fracture as soon as possible. In some instances such as polytraumatised patients or critical patients, it may not be feasible to return to operation theatre anytime soon. So the external fixation acts as a definitive management in such cases. Pins used in external fixation are prone to get infected and daily pin site care is advisable. It is not advisable to leave the external fixation for more than three weeks.

INTRAMEDULLARY NAILING [3,16,17]

The use of intramedullary nail for humeral shaft fractures have expanded over the following years. It is just that, the nail is better in the biological and biomechanical point of view. The advantages are minimal surgical trauma, biological osteosynthesis, high stability and minimal operating time. The polytrauma patients are mainly benefited by the use of intramedulary nailing than plating - as the arm crutches requires levering higher weight loads and as a load sharing device, the nail is less prone for failure than a plate. The nail is much less prone to bending forces and unlike a plate they do not fatigue easily.

There is no stress shielding - no osteopaenia beneath the plate and the risk of fracture after plate removal is absent. Multilevel fractures can be safely stabilized by nail fixation than a plate which requires a longer incision. In case of pathological fractures or impending pathological fractures, a nail fixation is preferred method of treatment. Both antegrade and retrograde nailing is available but the antegrade technique is performed most frequently as it offers easy patient position and insertion of nail is easier. Patient is seated in beach chair position and incision is made from the ventral edge of acromion towards the lateral side. The deltoid is split and subdeltoid bursa is exposed and entry is taken in the greater tuberosity. The entry point must be checked with image intensification as unnecessary incision will damage the rotator cuff. Reduce the fracture and pass the guide wire through the fracture site. Ream the canal. Take care to avoid injury to the radial nerve if the fracture is located in the middle / distal 3rd of the fracture. Select the appropriate size nail and maintain reduction while passing nail. The nail should not protrude out of the head. Locking is necessary for maintaining the rotational stability of the implant.

PLATE OSTEOSYNTHESIS

The plating of shaft fractures is the most popular form of treatment. The axial distraction between fragments lead to problems in healing and nerve palsy and hence it requires surgical stabilization. Since the patient compliance are necessary for functional bracing, the polytrauma patients are usually managed surgically. It provides sufficient stabilization for earlier mobilization of the limb. Through plates, one can achieve anatomical reduction and stable fixation.

Implant

Mostly the implant used in humeral shaft fracture is Narrow Dynamic Compression Plating, with its 4.5 mm system of screws. Sometimes Limited Contact Dynamic Plating is also used. If the fracture is located in the proximal 3rd shaft of humerus, PHILOS plate can be used. If the bone is small, Asian Dynamic Compression plating with 3.5 mm screws are used. Newer locking plates that function as internal fixators are used in some cases. These plates have special locking screws that lock onto the plate and does not require bicortical purchase, that is normal compression plates need bicortical purchase (near and far cortex) and compress the plate to the bone surface. But in locking plates, the screw heads are locked and there is gap between the plate and bone surface anatomic reduction of each fragment is unnecessary. Attaining correct length, rotation and alignment without much soft tissue

stripping is the goal. For oblique and spiral fractures, lag screw with neutralization plate is applied and for transverse fractures, compression plate is applied. For comminuted fractures, bridge plating is applied. Whatever the technique and implant, nerve must be protected at all costs.

Approaches [3,11,12,13]

Of the many surgical approaches available, whatever chosen, regardless of the fracture location, it is of importance that during dissection, care should be taken not to devitalize any bony fragments by excessive soft tissue stripping or periosteal stripping. All the approaches to the humerus are potentially dangerous because the major vessels and nerves run in close proximity to the bone than else where in the body.

Anterior Approach

The anterior approach exposes the anterior surface of the shaft of humerus. The patient is positioned supine on the operating table with arm abducted. A longitudinal incision is made from tip of corocoid to distally in line with deltopectoral groove. There are 2 different internervous planes. Proximally, the plane is between deltoid and pectoralis major muscle and distally the plane lies between medial and lateral fibers of brachialis muscle. When fixing the fracture in the middle third of the humerus, care must be taken when placing drills and screws in anteroposterior direction as it may injure the radial nerve.

In the distal 3rd of the humeral shaft the nerve may be cushioned by lateral part of the brachialis muscle which is split acting as a cushion to the nerve.

Anterolateral Approach

The patient is positioned supine with arm abducted on the arm table. The skin incision extends from the tip of corocoid to the lateral aspect of humerus at the deltoid insertion. The incision continues along the lateral border of biceps till about 5cms of flexor crease. At the proximal part, the cephalic vein in the deltopectoral groove must be identified and protected. Care must be taken during retraction of the deltoid as excessive retraction may cause paralysis of axillary nerve by compression. Distally the radial nerve must be identified as it comes out of the lateral intermuscular septum. The nerve is identified between brachialis and brachioradialis.

Lateral Approach

The approach extends from insertion of deltoid to the lateral epicondyle and plane is between the lateral intermuscular septum and lateral border of triceps. The radial nerve is seen coming out of the lateral intermuscular septum and can be traced between brachialis and brachioradialis. The approach can be extended distally over the olecranon with olecranon osteotomy for distal humerus, but cannot be extended proximally because the position of the radial nerve in the spiral groove.

Anteromedial Approach

This approach is mainly used when the neurovascular structures requires repairing in case of injury to these structures. The surgical incision runs along medial margin of the biceps and run along the medial epicondyle. The ulnar nerve identified and retracted posteromedially. The approach is also good cosmetically as the scar is concealed in the medial side of the arm.

Posterior Approach

This is the most common approach that is used. A midline posterior approach is extensile approach that can expose almost two thirds of the bone. The patient is positioned prone or lateral and incision extends from the midline of the posterior aspect of the arm, the landmarks including the acromion process and the olecranon fossa. The lateral and long heads of triceps is identified and split by blunt dissection. distally the common extensor tendon is split by a sharp incision. The radial nerve and the accompanying vessel is identified and retracted carefully. The medial head is split along the midline and the periosteum is stripped to the bone. The danger area in this approach includes the neurovascular structures in the spiral groove. Studies have demonstrated that the radial nerve lies about 40mm between the joining of long and lateral head of triceps.

Approach Used For MIPO Plating

This is most commonly used for fractures that are situated around the shaft of the humerus that are comminuted. There are 2 different approaches - **anterior and anterolateral approach**, each with a proximal and a distal window.

The anterolateral approach - the proximal window is between the biceps and brachialis and distal window is made in the lateral border of biceps 5cms proximal to the elbow crease.

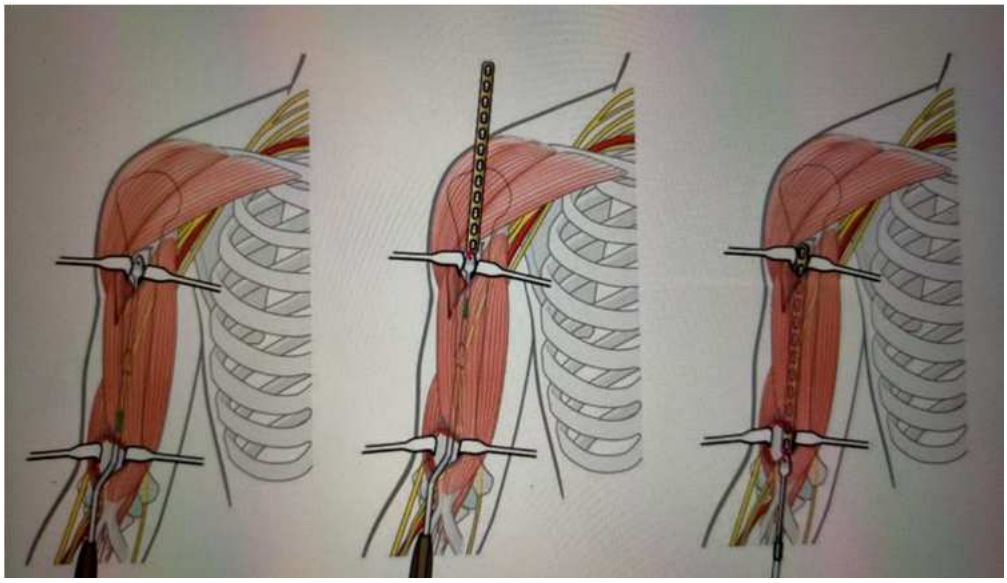
The anterior approach - the proximal approach uses the deltopectoral approach and the distal incision splits the brachialis muscle (deep plane) into medial and lateral halves through the interval between biceps and brachialis (superficial plane).

The approach though providing merits in form of minimal incision and protecting the fracture site for biological fixation, is not without its demerits. There is close proximity of the musculocutaneous nerve and the radial nerve. However both these nerves can be protected by adequacy of the incision made (5-6 cm) and visualizing these nerves. Cushioning these nerves is provided by the split brachialis muscle that when retracted, these fibers protect the nerves.

Rationale Behind The MIPO Plating [1,18,19]

Most of the humeral shaft fractures can be treated by conservative means, due to the wide range of motion of the shoulder a little degree of malunion can be compensated without any functional deficit. When surgery is indicated, intramedullary nail or plating by MIPO technique is advocated due to biological fixation. Absolute stability that offers anatomical reduction of fragments and solid union needs excessive soft tissue stripping that denies the injured bone of its essential periosteal blood supply that is most important to healing. The biological osteosynthesis by bypassing the fracture site through the MIPO plating denies the stripping of soft tissues preserving the blood supply that helps in union of the broken bone. MIPO plating is a relatively flexible fixation, means there is no absolute stability like the traditional plating. But the motion at the fracture site helps in callus formation that is stronger than the union that is achieved by absolute stability. The current studies have proven that the mean time of union after humerus MIPO plating is shorter as compared to the ORIF and plating, also the functional and radiological outcomes were similar, making the MIPO plating for humerus a valuble option the MIPO plating acts as an internal splint, permitting micromotion at the fracture site. However the close proximity of the neurovascular structures, particularly the radial nerve makes the minimally invasive technique a dangerous surgical procedure but outlines have been made to safely isolate the nerve avoiding

iatrogenic injury making minimally invasive technique a procedure of low morbidity, rapid patient recovery, earlier return to work and activities of daily living.



Healing By MIPO Technique [2, 4]

Fracture bridging by MIPO plating preserves the fracture haematoma and healing occurs by the formation of periosteal callus. The periosteal blood supply accounts for the outer one third blood supply of the cortex and extensive soft tissue stripping in open reduction causes loss of this blood supply. By preserving the fracture hematoma, the pleuripotent stem cells that have rich osteogenic potential is utilized. Moreover with minimally invasive approach; there is less soft tissue stripping, reduced blood loss, reduced infection rates & lesser hospital stay.

LITERATURE

Hatem SA Elgohary et al [21]2017 in a study analysed 23 patients with communited humeral shaft fractures, with age of the patients ranging from 19 to 61 years treated with MIPO plating. The fractures were followed up for a period of 34 weeks. All fractures united within 15 weeks with a mean period of 12.6 weeks. One patient had iatrogenic radial nerve injury that recovered spontaneously in a period of 2 months.

Gerardo L Gallucci et al[22] 2014, 25 patients were operated by MIPO plating for humeral fracture. The mean age of the patients were 37 years (range 23 - 73). The average followup was 22 months and fracture union was obtained in all cases, one patient developed post operative radial nerve palsy which resolved in 6 weeks.

Riccardo Luigi Alberio et al[25] 2018, from 2011 to 2016, studied 39 patients with humeral shaft fractures (32 women and 7 men) with a mean age of 64.9 years (48 - 80 years) treated with MIPO technique. All fractures united without problems. Radiographic evaluation showed no non union.

Apivatthakakul et al[19] studied on ten arms from five fresh cadavers. Two separate incisions were made in each arm, one proximal and one distal, with the forearm in full supination. A 9-holed narrow DCP was inserted using an anterior approach and fixed with 2 screws each on the proximal

and distal humerus. Then the tunnel was explored to identify the relationship between the radial nerve and the plate. There was no radial nerve compression or entrapment by the plate. The distance measured from the closest part of the plate to the radial nerve was 2.0-4.9 mm (average 3.2 mm). When the forearm was pronated, the radial nerve moved closer to the plate by 0-3 mm. Hence during the procedure, it is advisable to keep the forearm in supinated position. The results of this study verified the safety of minimally invasive plate osteosynthesis (MIPO) for treating middle-distal one third of shaft of humerus fractures.

Mohammad Ibrahim et al[26], studied 10 patients with humeral shaft fractures from 2016 to 2017, treated them with closed reduction and mipo plating using a 4.5 mm dynamic plate fixation over the anterolateral aspect in bridging mode. The mean age of the patients were 38 years (24 to 60 years). Seven out of ten patients had dominant side fractured. The mean period of radiological union was 11. 8 weeks (10 - 18) weeks. The shoulder function was good in 9 cases and fair in one case. It was concluded that there is high rate of union and excellent functional outcome by this procedure.

Mahmound M Hadhoud et al[24] studied 31 patients who sustained humerus shaft fractures from 2009 to 2013, treated with 4.5 mm dynamic compression plate using MIPO technique. The mean time for union was 12.4 weeks. Two cases had transient radial nerve palsy that improved in 8 weeks. It was

concluded that MIPO plating for humeral shaft fractures was a valuble technique.

Ali Akbar et al[23] in 2014, conducted a comparative study to analyse the results of humeral shaft fractures treated with MIPO plating vs open reduction and internal fixation. 65 patients with humeral shaft were treated -32 patients with MIPO and 33 patients with ORIF plating. Clinical and functional outcomes were the same. Time to union was shorter in MIPO technique .

METHODOLOGY

To analyse the functional outcome of shaft of humerus fracture by surgical fixation by MIPO technique.

Objectives

Functional evaluation of patients with shaft of humerus fractures surgically fixed by MIPO technique

To evaluate the healing time of the fracture

Period of study : NOV 2018 to NOV 2020

Study design : Prospective study

Study population : Patients diagnosed with Humeral Shaft Fractures which required operative intervention

Study place : Institute of Orthopaedics and Traumatology, Rajiv Gandhi Government General hospital , Chennai -3.

Study duration : 24 months (November 2018 to November 2020)

Sample size : 15 patients with Humerus shaft fracture

Selection of sample : All patients presenting with Humerus shaft fracture during study period

MATERIALS AND METHODS

In our study, a series of 15 patients with acute shaft of humerus fractures were treated with minimally invasive plate osteosynthesis. The study was conducted for a period of 2 years.

INCLUSION CRITERIA:

- Age above 18 years
- Both Male and Female patients
- Closed fractures
- Fractures with unacceptable displacement after attempting closed reduction
- Diaphyseal transverse fracture
- Shaft Fractures which required operative intervention
- Intact vascularity

EXCLUSION CRITERIA:

- Skeletally immature patients
- Patients not fit for surgery
- Patients managed conservatively
- Pathological fractures

Timing of surgery - Fractures in the study are fixed within 3 weeks of initial injury

Pre-op evaluation:

- Clear history excluding head and other systems injury
- X-ray of the shaft of humerus including the shoulder and the elbow joint both AP and Lateral views
- Distal neurovascular status
- Consent for the surgery after complete description of the procedure and the study in patients own language
- Physician and Anesthetist fitness for the procedure (regional block and if required general anesthesia)
- Systemic antibiotics given one hour before skin incision

OPERATIVE TECHNIQUE [27,19, 20]

After the anesthesia, patient is positioned supine in operating table with forearm in supination and arm in 90 degree abduction. The supination reduces the risk of radial nerve palsy by increasing the interval between the radial nerve and the plate. After preparation and draping, traction is given and fracture reduction is confirmed under c - arm guidance.

Position of the patient

Incision -

Two incisions - one proximal and one distal

The proximal incision is made between the medial border of deltoid and the lateral border of biceps.

The distal incision was made between the biceps and brachioradialis muscle. [30]

Method

After positioning the patient, the surgeon stands on the caudal side of the patient with the c - arm coming from the contralateral side. Incisions are made as described. The radial nerve is protected by the substance of the brachialis muscle and carefully placing the retractors over the muscle. The langenberg retractors are used in the distal exposure as the homans retractors inserted deep may cause neurovascular injury. After the dissection and guarding the nerve, a submuscular tunnel is created through the proximal incision to the distal incision through a cobbs elevator or through the plate itself. The subperiosteal tunnel should be created carefully avoiding injury to the surrounding soft tissues, atraumatic as much as possible. Then gentle traction is given by assistant with elbow flexed to 90 degrees and forearm in supination to maximize the distance between the nerve and the plate. Reduction is checked with c-arm and the plate is introduced in a graceful manner cautiously avoiding nerve injury. The traction restores the length, alignment and rotation of the fracture. Usually through the proximal and distal incisions, two screw holes are exposed and these screw holes are drilled and screws are placed after confirming the position of the plate on the bone. These screws are not tightened, the position of the plate after the pre-emptive placement of the screws is confirmed in the image intensifier. Then through stab incision additional screws are inserted proximally and distally so that at least 3 screws are placed proximally and distally. The antibiotics are given according the routine guidelines.

POST OP PROTOCOL[4,27]

Check neurovascular status post procedure

Support the operated limb in a broad arm sling

Wound inspection on the second day

Passive motion exercises 2 days post op upto 45 degrees

One week post op passive flexion upto 60 degrees

Suture removal on post operative day 12

One month post op passive flexion upto 90 degrees

6 weeks post op active mobilization begun

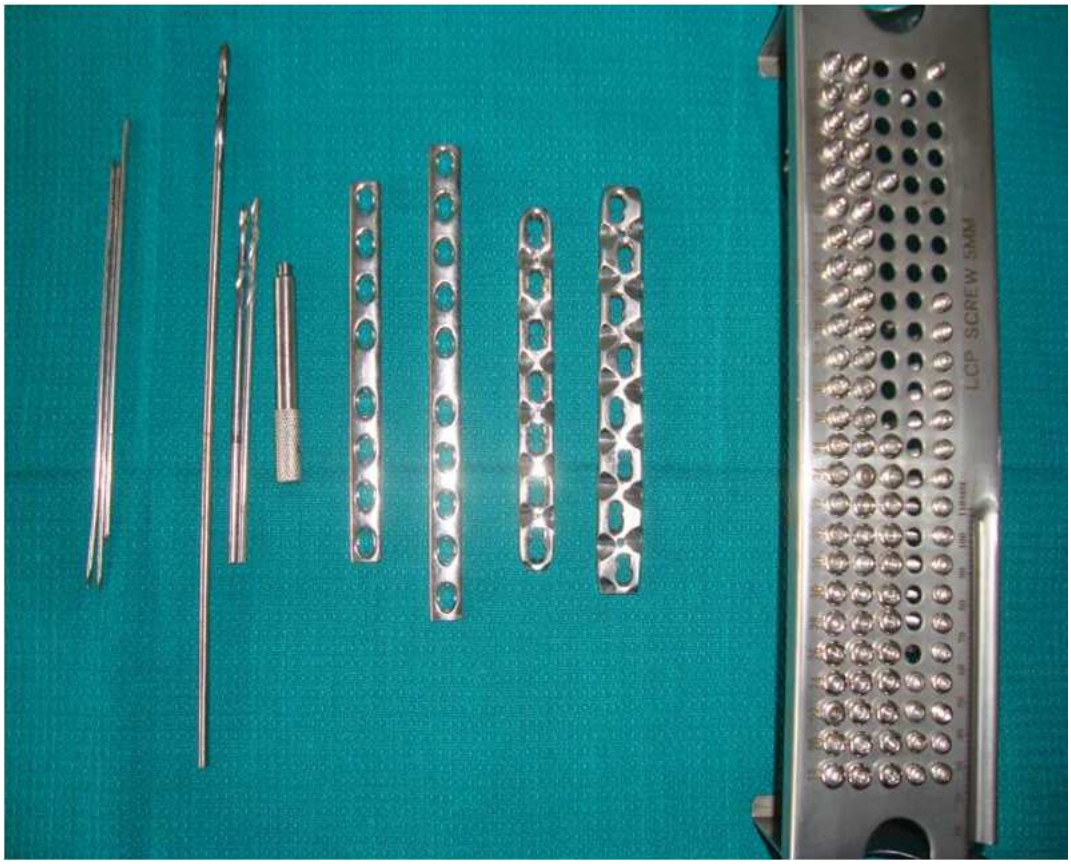
Weight lifing as tolerated

Check x-rays are taken on monthly interval to check for union

INSTRUMENTS & IMPLANTS

The following implants were used:

- 4.5mm long narrow DCP (10 to 12 holes)
- Locking Compression Plates
- 4.5 mm cortical screws
- Locking screws



The following instruments were used during the surgical procedures:

- Homann’s retractor
- Langenberg retractor
- Bone holding forceps
- Cobbs elevator
- Periosteal elevator
- 3.2 drill bits
- Drill machine
- Sleeve
- 4.5 Screw driver
- 2 mm K wires
- C-Arm imaging

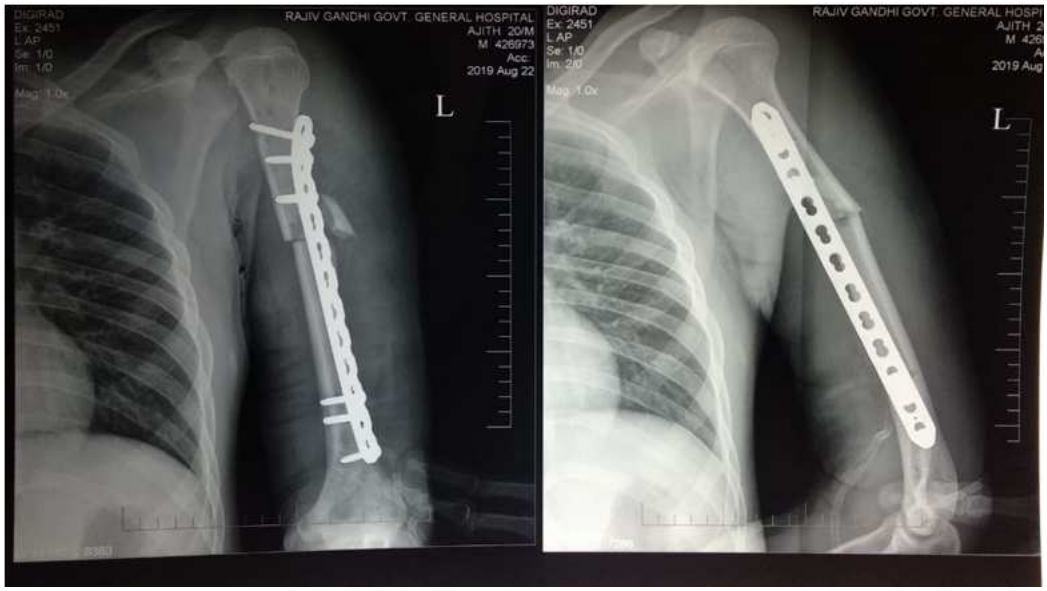
CASE ILLUSTRATIONS

CASE - 1: 25/M

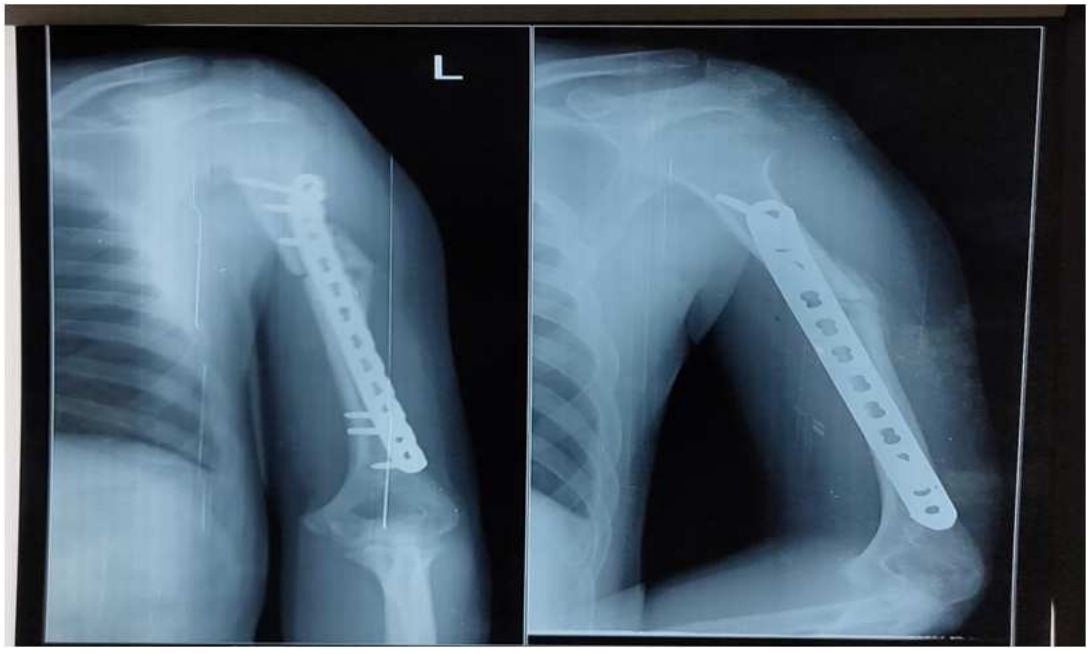
Preop

Intra- op

Post Op



6 Months Post Op







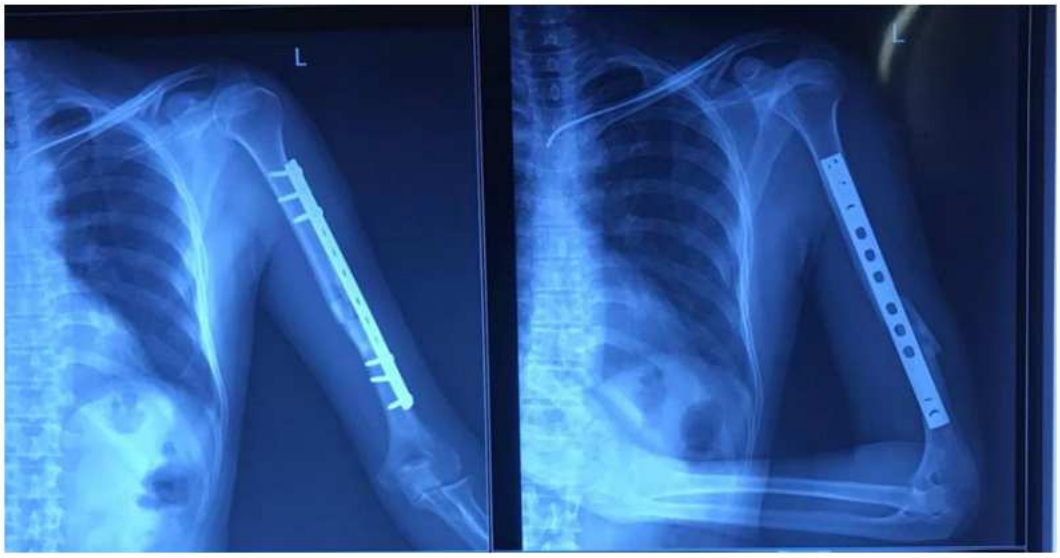

CASE 2: 44/m

Pre Op

Intra Op

Post Op

6 Months Post Op



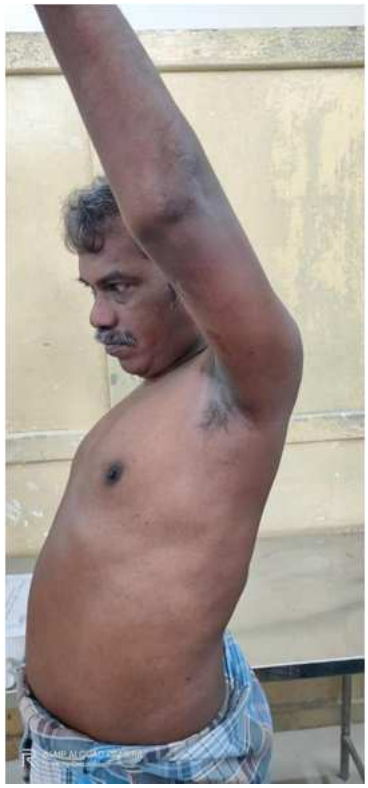
Case 3: 56/m

Pre Op

Intra Op

Post Op

6 Months Post Op



CASE 4: 51/M

Pre - Op

Intra - Op

Immediate Post- Op

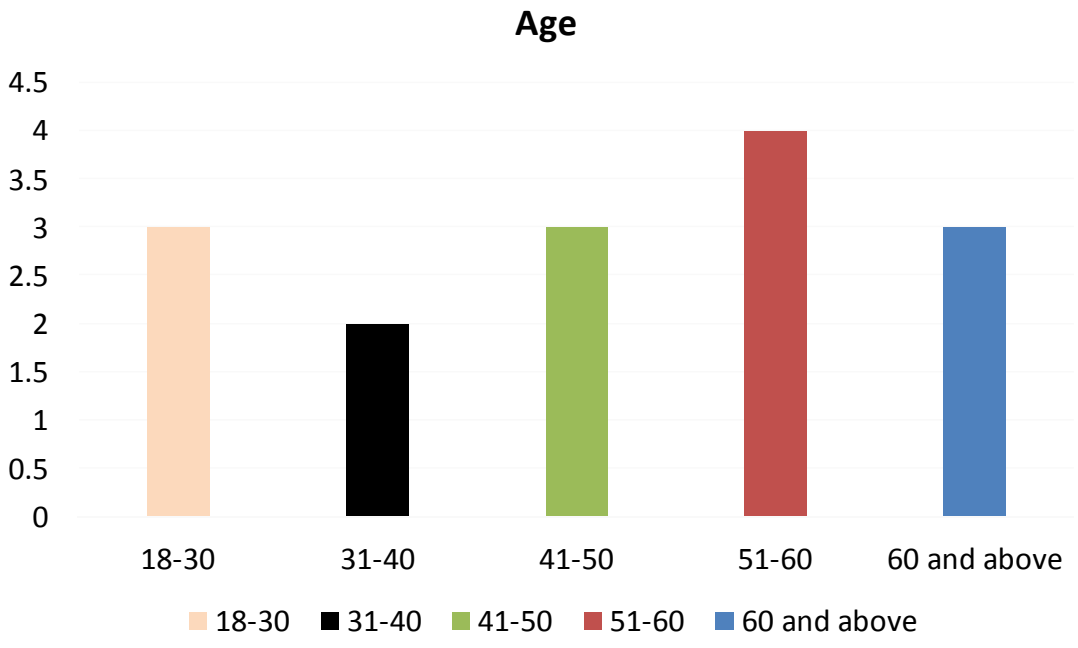
6 Months Post Op

OBSERVATION AND RESULTS

The present study consists of 15 cases of shaft of humerus fractures treated by minimally invasive plate osteosynthesis.

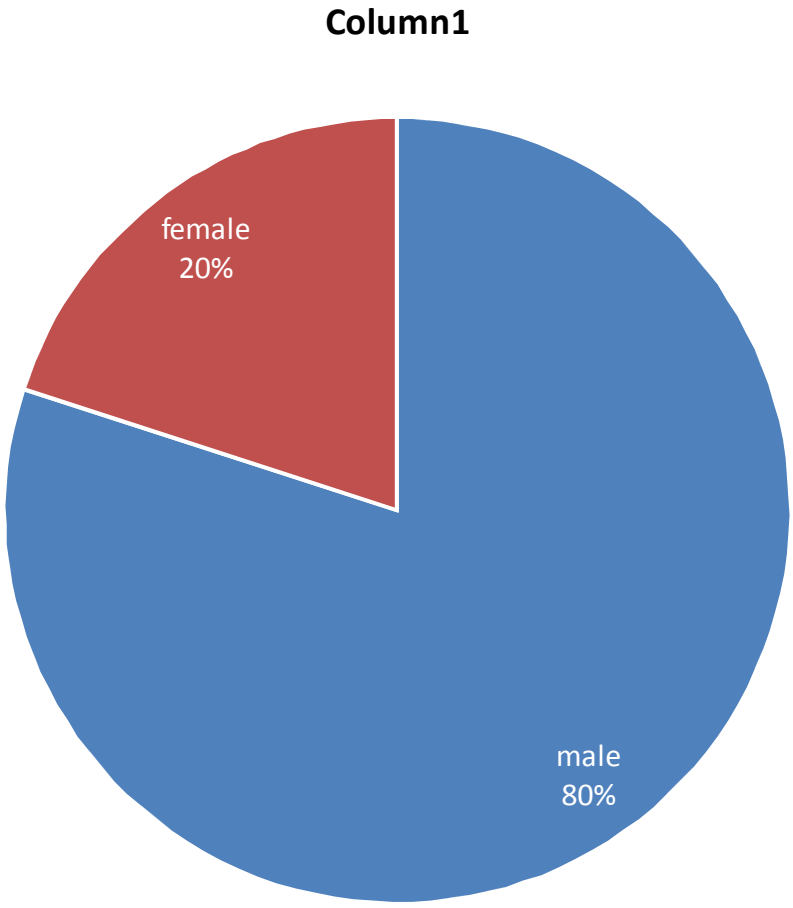
AGE DISTRIBUTION

Age	No. of patients
18-30	3
31-40	2
41-50	3
51-60	4
Above 60	3



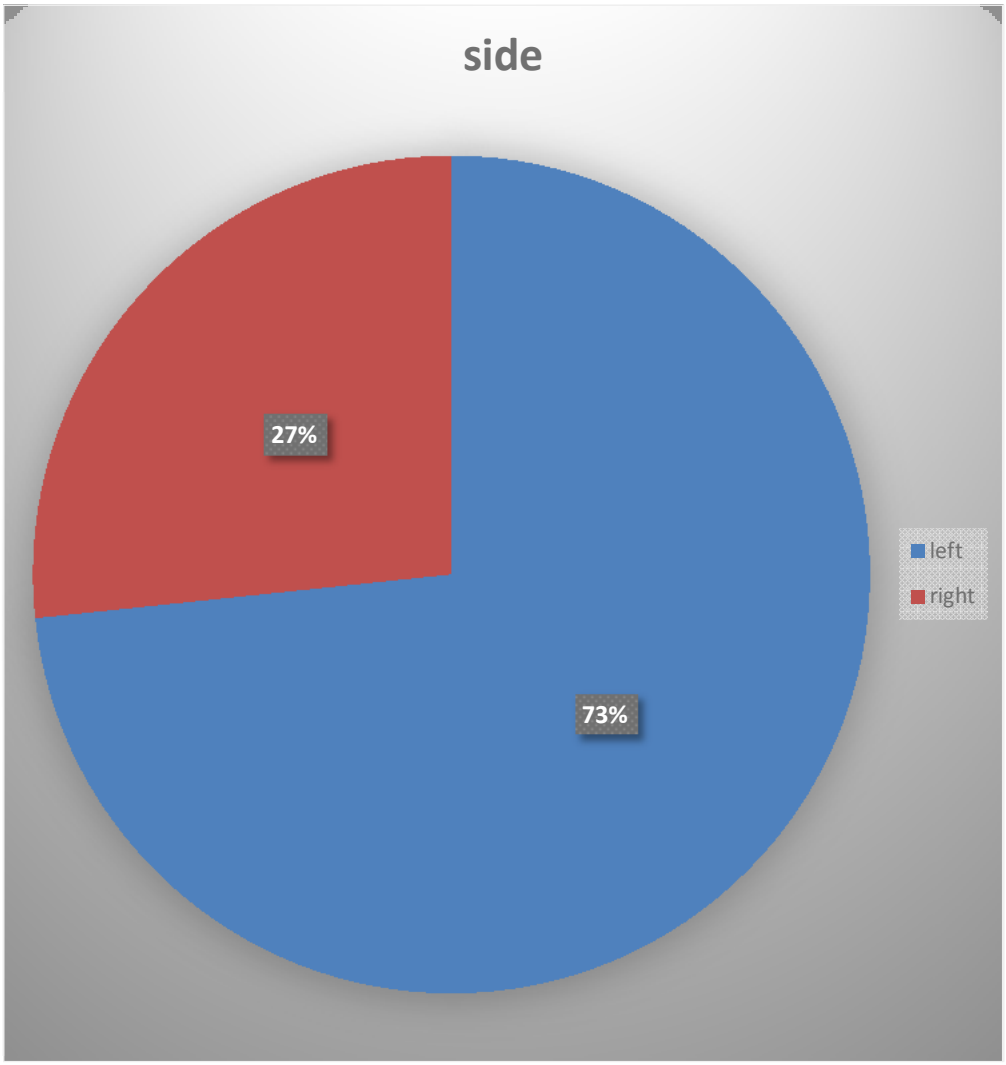
SEX DISTRIBUTION

	Sex	Frequency	Percent
Valid	Female	3	20
	Male	12	80
	Total	15	100.0



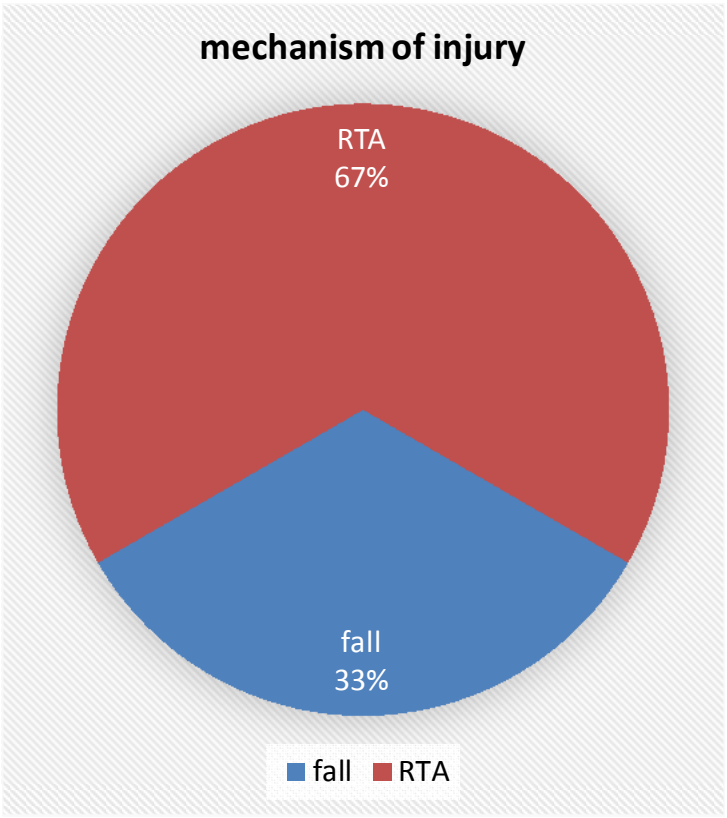
SIDE OF INJURY:

Side	Frequency	Percent
Left	11	73
Right	4	27
Total	15	100.0



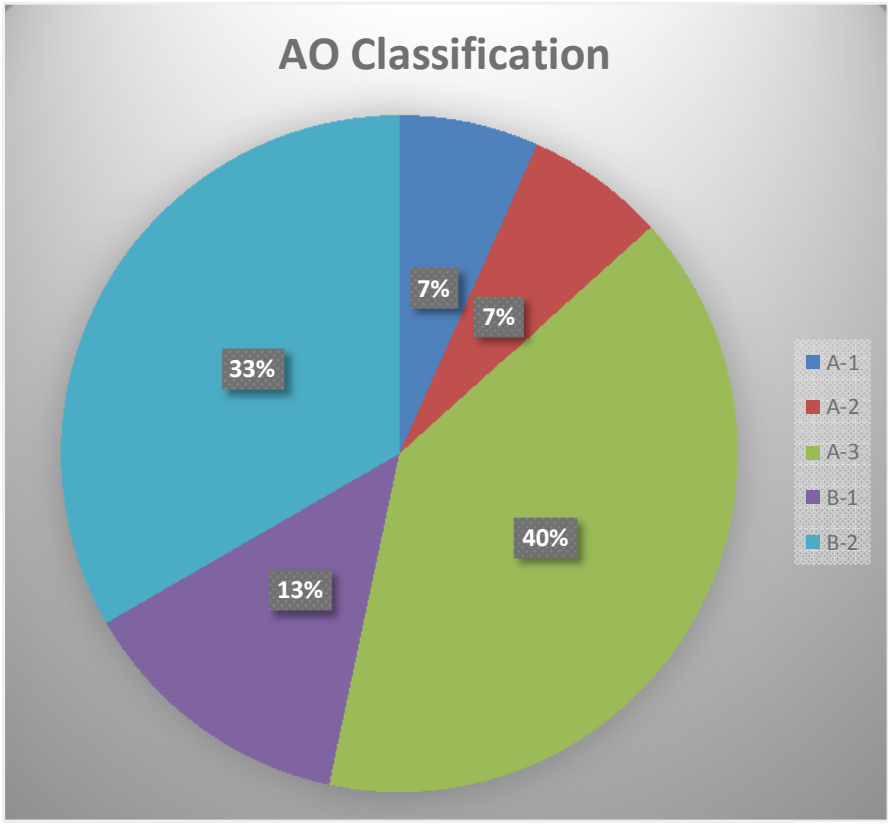
MODE OF INJURY:

Mode of injury	Frequency	Percent
Fall	5	33
RTA	10	67
Total	15	100.0



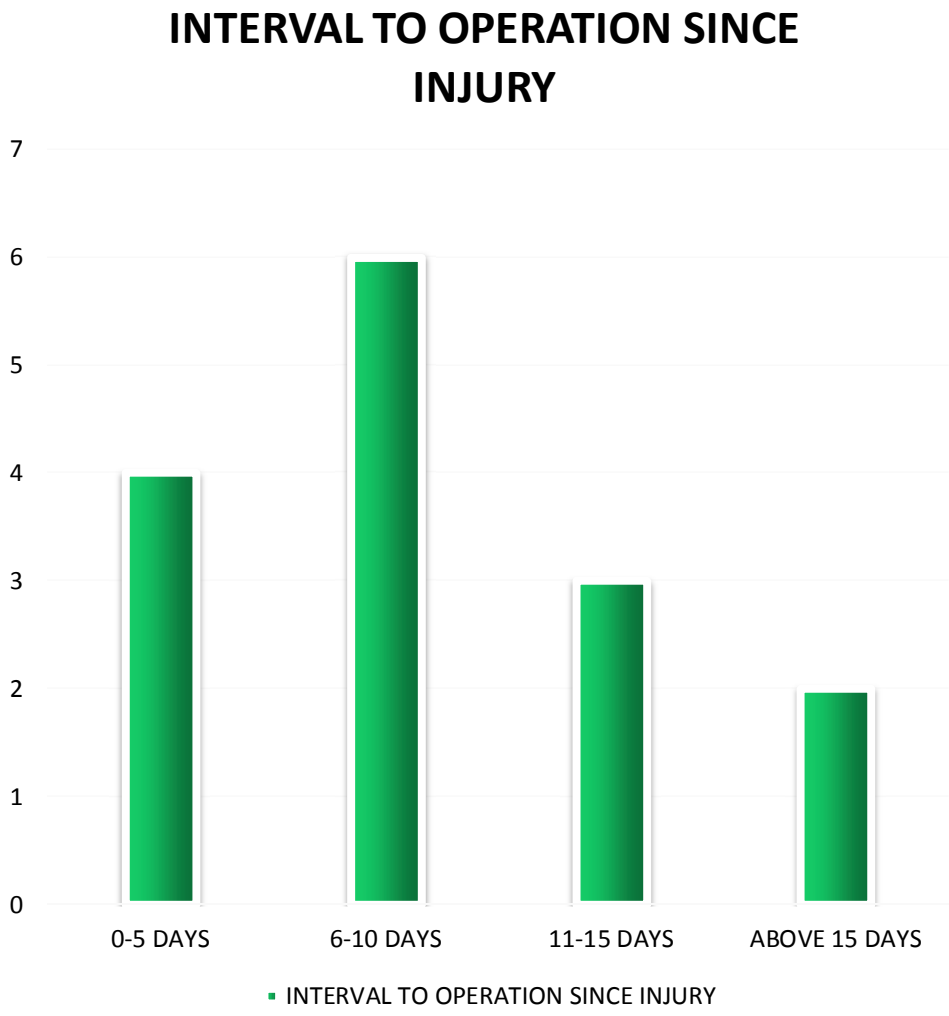
AO CLASSIFICATION

AO Classification	Frequency	Percent
A-1	**1**	**7**
A-2	1	7
A-3	6	40
B-1	2	13
B-2	5	33
Total	15	100.0



TIME INTERVAL

1-5 days	**4**
6-10 days	**6**
11-15 days	**3**
> 15 days	**2**



FUNCTIONAL EVALUATION

	UCLA SCORE	**MEPS SCORE**
EXCELLENT	**2**	**15**
GOOD	**9**	**-**
FAIR	**4**	**-**
POOR	**-**	**-**

TIME OF UNION

The average time to union was 14.53 weeks

	Frequency	**Percentage**
<14 weeks	8	53.33
>14 weeks	7	46.66
Total	15	100

Complications

Nerve Injuries

There was transient radial nerve palsy in 3 patients which improved without operative intervention.

Non - Union

There were no cases of non union.

Shoulder Stiffness

Two patients affected with moderate shoulder stiffness. To be precise abduction and external rotation were affected. They improved with physiotherapy.

Infection

Due to the minimally invasive technique, and short operating time, no cases developed infection of the operative site.

RESULTS

A total of 15 patients were studied for a period of 2 years in Rajiv Gandhi Government General Hospital Chennai who had shaft of humerus fractures.

The age group of the patients varied from 18 to 72 years with an average age being 47.13 years

The follow up ranged from 16 to 42 weeks with a mean followup duration of 30.8 weeks.

Mechanism of injury - most of the fractures were caused due to high velocity injury - Road Traffic Accidents (67%) and other was due to low velocity falls (33%)

Another observation made in this study was that the **left side** was more commonly involved(73%) than the right side (27%)

The time period of union varied from 12 to 18 weeks with a mean time to union of 14 weeks

The surgical time of humerus MIPO plating ranged from 70 to 85 minutes (mean - 76 minutes)

The shoulder function was assessed by **UCLA shoulder score (University of California Los angels)**. In the 15 patients operated, 2 patients had excellent outcome, 9 patients had good results and 4 patients had fair results.

The elbow function post operatively was assessed using **Mayo elbow performance score** - by which all 15 patients had excellent result.

3 patients had post op radial nerve palsy that recovered eventually with physiotherapy.

DISCUSSION

Minimally invasive surgical technique does not imply that the length of the incision is small, but rather the soft tissue dissection and the fracture reduction is from a distance, remote to the fracture site. The instruments and implants are inserted through this small soft tissue window created and indirect reduction is achieved.

This way, the soft tissue and bone biology is preserved and indirect reduction preserves fracture hematoma, which obliviates the need of excessive soft tissue dissection which is needed for open reduction and internal fixation.

The placement of plate over bone with absolute stability results in primary bone healing which devoids the bone of the essential callus formation that occurs in secondary bone healing. It is considered that bone healing by callus formation is far more superior than the healing that occurs in primary healing. Also, the plate in open reduction and internal fixation causes osteonecrosis beneath the plate causing refracture after the removal of plate.

The union rate of fracture under our study was one hundred percent with no cases of delayed or non union with a mean time to union of 14.5 weeks.

There was no case of postoperative shoulder impingement as that occurs with nailing. The scar was cosmetic when compared to ORIF. The average blood loss was also less when compared with traditional open technique. The union time was shorter and patients returned to work earlier.

Limitation

MIPO plating, due to indirect reduction method had higher incidence of radial nerve palsy(transient).

Suggestions

The plate must be advanced from proximal to distal in close contact to the bone. The forearm must be supinated at all times (pronation causes the nerve to move closer to the plate according to Apivathukakul[1,19] study). Homans retractors must not be used in the distal incision. Instead, Langenbergs retractor can be used.

CONCLUSION

The humerus MIPO plating has a good result with quick recovery following operation when compared with conventional open reduction and internal fixation technique.

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ANNEXURE I

PROFORMA FOR FRACTURE SHAFT OF HUMERUS MIPO PLATING

Name

Age

Sex

IP number

Address

Date of Admission

Date of Surgery

Date of Discharge

Mode of Injury

AO Classification of fracture

Neurovascular injury

Duration between injury and surgery

Duration of procedure

Implant used

Post operative complications

Duration of Followup

UCLA Score

MEPS score

Time taken for union

Complications (if any)

ANNEXURE -II

CONSENT FORM FOR OPERATION / ANESTHESIA

I _____ in my full senses hereby give my full consent for 'HUMERUS MIPO PLATING ' to be performed on me under anesthesia. The nature, risks and complications involved in the procedure have been explained to me in my own language and to my satisfaction. For academic and scientific purpose the operation may be photographed.

Date :

Signature / Thumb Impression

Of Patient

ANNEXURE - III

UCLA SHOULDER RATING SCALE[29]

Section 1 - Pain

- Present always and unbearable; strong medication frequently
- Present always but bearable; strong medication occasionally
- None or little at rest; present during light activities; salicylates used frequently
- Present during heavy or particular activities only; salicylates used occasionally
- Occasional and slight
- None.

Section 2 – Function

- Unable to use limb
- Only light activities possible
- Able to do light housework or most activities of daily living
- Most housework, shopping, and driving possible; able to do hair and to dress and undress, including fastening bra
- Slight restriction only; able to work above shoulder level
- Normal activities.

Section 3 - Active forward flexion

- 150°

- 120°-150°
- 90°-120°
- 45°-90°
- 30°-45°
- <30^{o}

Section 4-Strength of forward flexion (manual muscle testing)

- Grade 5 (normal)
- Grade 4 (good)
- Grade 3 (fair)
- Grade 2 (poor)
- Grade 1 (muscle concentration)
- Grade 0 (nothing)

Section5 - Satisfaction of patient

- Satisfied and better
- Not satisfied and worse

The maximum score is 35 points.

Excellent - 34 to 35 points

Good - 29 to 33 points

Fair - 21 to 28 points

Poor - 0 to 20 points

ANNEXURE -IV

MAYO ELBOW PERFORMANCE SCORE[28]

Elbow Function

- **Pain (max., 45 points)**
  - None (45 points)
  - Mild (30 points)
  - Moderate (15 points)
  - Severe (0 points)
- **Range of motion (max., 20 points)**
  - Arc > 100 degrees (20 points)
  - Arc 50 to 100 degrees (15 points)
  - Arc < 50 degrees (5 points)
- **Stability (max., 10 points)**
  - Stable (10 points)
  - Moderately unstable (5 points)
  - Grossly unstable (0 points)
- **Function (max., 25 points)**
  - Able to comb hair (5 points)

- Able to feed oneself (5 points)
- Able to perform personal hygiene tasks (5 points)
- Able to on shirt (5 points)
- Able to put on shoes (5 points)

Mean total (max: 100 points)

Excellent - > 90 points

Good - 75 to 89 points

Fair - 60 to 74 points

Poor - < 59 points

ஆராய்ச்சி ஒப்புதல் படிவம்

ஆராயச்சியின் தலைப்பு

'A PROSPECTIVE ANALYSIS OF OUTCOMES OF FRACTURE SHAFT OF HUMERUS TREATED BY MIPPO TECHNIQUE'

ஆய்வு நிலையம் : சென்னை மருத்துவக் கல்லூரி
சென்னை – 3.

பங்கு பெறுவரின் பெயர் : உறவுமுறை:

பங்குபெறுபவரின் எண் :

மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்கள் எனக்கு விளக்கப்பட்டது. என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டது.

நான் இவ்வாய்வில் தன்னிச்சையாகதான் பங்கேற்கிறேன். எந்த காரணத்தினாலோ எந்த கட்டத்திலும் எந்த சட்ட சிக்கலுக்கும் உட்படாமல் நான் இவ்வாய்வில் இருந்து விலகி கொள்ளலாம் என்றும் அறிந்து கொண்டேன்.

இந்த ஆய்வு சம்பந்தமாகவோ, இதை சார்ந்த மேலும் ஆய்வு மேற்கொள்ளும் போதும் இந்த ஆய்வில் பங்குபெறும் மருத்துவர் என்னுடைய மருத்துவ அறிக்கைகளை பார்ப்பதற்கு என் அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். நான் ஆய்வில் இருந்து விலகிக் கொண்டாலும் இது பொருந்தும் என அறிகிறேன்.

இந்த ஆய்வின் மூலம் கிடைக்கும் தகவல்களையும், பரிசோதனை முடிவுகளையும் மற்றும் சிகிச்சை தொடர்பான தகவல்களையும் மருத்துவர் மேற்கொள்ளும் ஆய்வில் பயன்படுத்திக்கொள்ளவும் அதை பிரசுரிக்கவும் என் முழு மனதுடன் சம்மதிக்கின்றேன்.

இந்த ஆய்வில் பங்கு கொள்ள ஒப்புக்கொள்கிறேன். எனக்கு கொடுக்கப்பட்ட அறிவுரைகளின்படி நடந்து கொள்வதுடன் இந்த ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையுடன் இருப்பேன் என்று உறுதியளிகிறேன். என் உடல் நலம் பாதிக்கப்பட்டாலோ அல்லது எதிர்பாராத வழக்கத்திற்கு மாறான நோய்க்குறி தென்பட்டாலோ உடனே அதை மருத்துவ அணியிடம் தெரிவிப்பேன் என உறுதி அளிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் ……..…….. இடம்…….. தேதி……

கட்டைவிரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் ……

ஆய்வாளரின் கையொப்பம் …….. இடம்…….. தேதி…….

ஆய்வாளரின் பெயர் ……

ஆராய்ச்சி தகவல் தாள்

ஆராய்ச்சி தலைப்பு

'A PROSPECTIVE ANALYSIS OF OUTCOMES OF FRACTURE SHAFT OF HUMERUS TREATED BY MIPPO TECHNIQUE'

ஆய்வாளர் :

பங்கேற்பாளர் பெயர் :

சென்னை ராஜீவ் காந்தி அரசு பொது மருத்துவமனைக்கு வரும் நோயாளிகளிடம் ஆராய்ச்சி நடைபெறுகிறது. அதற்கு தாங்கள் ஒத்துழைக்குமாறு கேட்டுக் கொள்கிறோம்.

நீங்களும் இந்த ஆராய்ச்சியில் பங்கேற்க நாங்கள் விரும்புகிறோம். இதில் உங்களுடைய தகவல்களை ஆராய்வோம். இதனால் தங்களது ஆய்வறிக்கையோ, அன்றாட செயல்பாடுகளோ பாதிக்கப்படாது என்று தெரிவத்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியின் முடிவுகளை அல்லது கருத்துக்களை வெளியிடும் போதோ அல்லது ஆராய்ச்சியின் போதோ தங்களது பெயரையோ அல்லது அடையாளங்களையோ வெளியிடமாட்டோம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில்தான் இருக்கிறது. மேலும் நீங்கள் எந்த நேரமும் இந்த ஆராய்ச்சியில் இருந்து பின் வாங்கலாம் என்பதையும் தெரிவித்துக்கொள்கிறோம்.

இந்த ஆராய்ச்சியின் முடிவுகளையும் நோயின் தன்மை பற்றியும் ஆராய்ச்சியின் போது அல்லது ஆராய்ச்சி முடிவின்போது தங்களுக்கு அறிவிப்போம் என்பதையும் தெரிவித்துக்கொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் பங்கேற்பாளர் கையொப்பம்

தேதி:

URKUND

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PLAGIARISM CERTIFICATE

This is to certify that this dissertation work titled "**A PROSPECTIVE ANALYSIS OF OUTCOME OF FRACTURES OF SHAFT OF HUMERUS TREATED BY MIPO TECHNIQUE**" of the candidate **Dr.B**.**Sundeep** with registration number **221812011** for the award of M.S ORTHOPAEDICS branch II. I personally verified the urkund. Com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **6 percentage** of plagiarism in the dissertation.

Guide & Supervisor sign with seal

Prof. M. ANTONY VIMAL RAJ M.S Ortho.,
Professor
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INSTITUTIONAL ETHICS COMMITTEE
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CERTIFICATE OF APPROVAL

To
Dr.**B.SUNDEEP,**
Post Graduate, MS (Orthopaedic Surgery)
Institute of Orthopaedics & Traumatology
Madras Medical College
Chennai-03.

Dear Dr. B.SUNDEEP,

The Institutional Ethics Committee has considered your request and approved your study titled **"A PROSPECTIVE STUDY OF MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS FOR HUMERAL DIAPHYSEAL FRACTURES" AT MADRAS MEDICAL COLLEGE AND GOVT. GENERAL HOSPITAL,CHENNAI-NO.18032019.** The following members of Ethics Committee were present in the meeting held on **05.03.2019** conducted at Madras Medical College, Chennai 3

1. Prof.P.V.Jayashankar :Chairperson
2. Prof.R.Jayanthi,MD.,FRCP(Glasg)., Dean,MMC,Ch-3 : Deputy Chairperson
3. Prof. Geetha Devadass,MD., Vice Principal(IC),MMC,Ch-3 : Member Secretary
4. Prof.N.Gopalakrishnan,MD,Director,Inst.of Nephrology,MMC,Ch : Member
5. Prof.S.Tito,MD,Prof. Inst. of Int.Med,MMC, Ch-3 : Member
6. Prof.Alli, Prof. Inst. of Gen.Surgery,MMC : Member
7. Prof.Shobha, Prof, Inst.of O&G, Chennai : Member
8. Prof.Rema Chandramohan,Prof.of Paediatrics,ICH,Chennai : Member
9. Prof. Sudha, Prof. Inst. of Pharmacology,MMC,Ch-3 : Member
10. Prof.K.Ramadevi,MD., Director, Inst. of Bio-Chemistry,MMC,Ch-3 : Member
11. Prof.Bharathi Vidya Jayanthi,Director, Inst. of Pathology,MMC,Ch-3: Member
12. Thiru S.Govindasamy, BA.,BL,High Court,Chennai : Lawyer
13. Tmt.Arnold Saulina, MA.,MSW., :Social Scientist
14. Thiru K.Ranjith, Ch- 91 : Lay Person

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary – Ethics Committee

MASTER CHART

SI NO	NAME	AGE	SEX	MODE OF INJURY	SIDE	NERVE PALSY	AO CLASSIFICATION	TIME SINCE INJURY	DURATION OF SURGERY (MIN)	FOLLOW UP (IN WEEKS)	IMPLANTS	TIME TO UNION (IN WEEKS)	UCLA SCORE	MEPS SCORE	COMPLICATION
1	Ansari	37	M	RTA	Left	Nil	12-A2	12	80	20	14 Holed	14	29	95	Nil
2	Ajith	20	M	RTA	Left	Nil	12-B2	16	75	24	12 Holed	12	32	100	Nil
3	Chandran	70	M	Fall	Left	Nil	12-B2	17	70	30	13 Holed	16	29	95	Nil
4	Guganathan	44	M	RTA	Left	Nil	12-B2	12	100	28	12 Holed	15	26	95	Nil
5	Perumal	56	M	Fall	Left	Nil	12-A3	8	80	36	11 Holed	14	26	95	Radial Nerve Palsy
6	Vasanth	18	M	Rta	Left	Nil	12-A3	10	80	36	9 Holed	12	33	100	Nil
7	Sakunthala	72	F	Fall	Left	Nil	12-A3	7	75	28	10 Holed	16	24	90	Nil
8	Devaraj	47	M	RTA	Left	Nil	12-A1	4	85	40	13 holed	14	34	95	Nil
9	Ajith Kumar	22	M	RTA	Right	Nil	12-A3	4	120	42	10 holed	15	35	95	NIL
10	Anandan	51	M	RTA	Left	Nil	12-B1	7	80	40	16 holed	16	29	95	Radial nerve palsy
11	Prabha	56	F	RTA	Left	Nil	12-A3	5	85	16	9 holed	14	25	95	Radial nerve palsy
12	Arul Das	40	M	RTA	Right	Nil	12-A3	15	80	20	9 holed	14	32	95	nil
13	Nalla Sivam	60	M	Fall	Left	Nil	12-B2	8	85	32	10 holed	16	29	95	nil
14	Kandhan	51	M	RTA	Right	Nil	12-B2	4	80	42	10 holed	18	32	95	nil
15	Rajalakshmi	63	F	Fall	Right	Nil	12-B1	9	78	28	9 holed	12	31	95	nil