PROSPECTIVE STUDY ON FUNCTIONAL OUTCOME OF COMMINUTED AND SEGMENTAL FRACTURES OF SHAFT OFHUMERUS TREATED SURGICALLY WITH THE GOLD STANDARD MANAGEMENT PLATE OSTEOSYNTHESIS

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CERTIFICATE

This is to certify that Dr.G.Kaliraj , postgraduate student (2007-2010) in the Department of Orthopaedics, Government Kilpauk Medical College Chennai has done this dissertation on "**PROSPECTIVE STUDY ON FUNCTIONAL OUTCOME OF COMMINUTED AND SEGMENTAL FRACTURES OF SHAFT OF HUMERUS TREATED SURGICALLY WITH THE GOLD STANDARD MANAGEMENT PLATE OSTEOSYNTHESIS**" under my guidance and supervision in partial fulfillment of the regulation laid down by the Tamilnadu Dr. M.G.R Medical University, Chennai for MS (Ortheopaedics) degree examination to be held on March 2010.

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DECLARATION

I, Dr.G.Kaliraj, solemnly declare that the dissertation titled "**PROSPECTIVE STUDY ON FUNCTIONAL OUTCOME OF COMMINUTED AND SEGMENTAL FRACTURES OF SHAFT OF HUMERUS TREATED SURGICALLY WITH THE GOLD STANDARD MANAGEMENT PLATE OSTEOSYNTHESIS"** is a bonafide work done by me, at Government Kilpauk Medical College between 2007-2009, under the guidance and supervision of my unit chief **Prof. Dr.K.NAGAPPAN M.S Ortho., D. Ortho.,** Professor of orthopaedic surgery. This dissertation is submitted to the Tamilnadu Dr. M.G.R Medical University, towards partial fulfillment of regulation for the award of M.S.Degree Branch-II) in Orthopaedic surgery.

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CONTENTS

INTRODUCTION

INTRODUCTION

Fractures of humeral diaphysis constitute 3% of all bone injuries. The anatomy, fracture configuration and the region involved influences the treatment option.(37,22)

The rich muscle sleeve surrounding the bone and good vascularity provided by them helps in fracture healing. The wide range of movements of shoulder accomodates for a minimal degree of angulation and shortening.(27) The limb does not take part in weight bearing or ambulation which allows some shortening to acceptable but not the rotational deformity.

Operative technique for the humeral diaphyseal fracture includes

1) Open reduction and internal fixation with plate osteosynthesis.
2) Open or closed reduction and internal fixation with intramedullary fixation.
3) External fixation using Ilizarov fixators or AO external fixators.(42,21)

Open reduction and internal fixation with plate osteosynthesis supplemented with bone grafting has been the gold standard treatment comparing to others.(27,32)

Advantages are high union rate , low complication rate and rapid return to function.It can be used for fractures with proximal and distal extention.It is safe and effective and no shoulder or elbow morbidity and stable enough to allow early upper limb weight bearing in polytrauma.(17,34)

In large number of series the union rate is 96 to 97%(7,3)

Complications are radial nerve neuropraxial 2-5% , infection 1-2% for closed fractures,2-5% for open fractures and refracture is 1%

AIM OF STUDY

AIM OF STUDY

Prospective study on functional outcome of Comminuted and segmental fractures of shaft of Humerus treated surgically with the gold standard Management plate osteosynthesisat Government Royapettah Hospital, Chennai between January 2008 to June 2009

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The two principles of closed methods of treatment of humerus shaft fractures

1) Thoroco brachial immobilization
2) Dependency traction

Thoroco brachial immobilization:Here the body is the splint. This was achieved by using body strapping or by shoulder arm spica application. This was not reliable due to difficulty in maintaining the alignment of the bone and promotion of bone healing.(42,37,11)

Caldwell promoted Hanging arm cast.These are above elbow cast. They are stipulated weight less than 2lbs., inorder to avoid destruction. These casts are provided with series of loops, which are used to correct angulation deformities.(22,19)

U slabs or co-optation splints were devised based on dependency traction. These are effective methods of treatment but functionally inferior to bracing.

Treatment for humeral shaft fractures was revolutionizes by the introduction of functional bracing by **Sarmiento.** This is a fracture treatment orthosis made up of light weight plastic brace fitted with Velcroe straps.

This has provided excellent long term results with 100% union rate with minimal complications of malalignment, infections or Iatrogenic nerve injury.(41,17)

Various studies have found bracing to be a much superior method of fracture treatment in otherwise normal individual.(16,21)

Operative intervention was found necessary in patients with malalignment. Klenerman et al and Balfour et al in different studies found that a valgus angulation of more than 15% unacceptable cosmetically though they found that this was not having any functional disability.(41,2)

Bell, et al., proposed that humerus fractures must be fixed in cases of polytrauma. Brumback suggested fixation for bilateral fractures of the humerus.

Broad dynamic compression plate was promoted by AO/ASIF for fracture stabilization.

They noted complication rates of 7%hardware failures, 6%infection Kuntscher first proposed intramedullary nailing for management of diaphyseal fractures of the femur, tibia and the humerus during world war II. This was further promoted by Maatz.

Flexible nails in multiple numbers can be inserted into the humerus from both antegrade and the retro grade entry portal. The nails which have been in use areEnders nail

1) Hackethal nail
2) Rush nail

They were found to be having good prognostic outcome with 3% chances of infection,9% chances of nonunion and rarely migration and pseudoarthrosis, fracture at nail tips , distraction at fracture site and high re-operation rate.(17,21)

Biological internal fixation or bio buttress fixation is that one makes sense from biological point of view. Blind subcutaneous or submuscular insertion of an implant like a bone plate via a minimal surgical approach to preserve the vascularity and fixing it by the newer aiming and stabilizing technologies to achieve elastic flexible fixation.(32,47,22)

The operative treatment of bone fractures using plates and screws is a standard successful technique. However problems also are encountered in the fixation of osteoporotic bone. An implant called "**Locking compression plate(LCP)"** was developed , based on many years experience with compression plating and good clinical results obtained with internal fixators,

such as the **Less invasive stabilization systems** (LISS). It combines the two treatment methods (i.e., the compression plating and locked internal fixation methods) into one system.(41,17)

Locked internal fixator plate is designed to preserve biological integrity to enhance fracture healing, and to improve resistance to infection. In the setting of an osteo porotic fractures loss of purchase in the poor quality bone is high and it may be preferable to obtain an initial friction fit and protect this fixation with subsequent locking screws. In-addition a compression screw may be used initially to oppose the plate to the bone in order to optimize reduction.(34,37)

ANATOMICAL CONSIDERATIONS

ANATOMICAL CONSIDERATIONS

DEVELOPMENTAL ANATOMY

Appearance of upper limp bud on the ventrolateral aspect of the body wall opposite to the lower cervical segments at the end of fourth week of embryonic life.(21,27)

One primary centre's and seven secondary centres. The primary centre appears in the middle of diaphysis during the eighth week.

The upper end three secondary centre's one for the head (first Year) one for the greater tubercle (second year) and one for the lesser tubercle (fifth year). Three centre's fused together during the sixth year to form one epiphysis which fuses with shaft during twentieth year.

The lower end ossifies from four centre's which forms two epiphysis. The centre's include one for the capitulum and lateral flange of trochlea (first year), one for the medial flange of trochlea (ninth year) and one for the lateral epicondyle (twelfth year); all three fuse during the fourteenth year to form one epiphysis, which fuses with the shaft at about sixteen years. The centre for radial epicondyle appears during 4-6 years, forms a separate epiphysis, and fuses with shaft during the twentieth year.

ANATOMY OF HUMERUS

OSTEOLOGY(41,21)

The Humerus shaft is rounded in the upper half and triangular lower half. The transition occurs at the mid diaphysis near the insertion of deltoid. It has three borders and three surfaces.

BORDERS:

1. The upper 1/3rd of the anterior border forms the lateral lip of the inter tubercular sulcus. In its middle part, it forms the anterior margin of the deltoid tuberosity. The lower half of anterior border is smooth and rounded.
2. The lateral part is prominent only at the lower end, where it forms the lateral supracondylar ridge. In the upper part it is barely traceable upto the posterior surface of the greater tubercle. In the middle part, it is interrupted by the radial or spiral groove.
3. The upper part of the medial border forms the medial lip of the inter tuberculous sulcus. About its middle it represents a rough strip. It is continuous below with the medial supracondylar ridge.

SURFACES:

1. The anterolateral surface lies between the anterior and lateral borders. The upper half the surface is covered by the deltoid. A little above the middle it is marked by V shaped deltoid tuberosity. Behind the deltoid tuberosity, the radial groove runs downwards and forwards across the surface.(31)
2. The anteromedial surface lies between anterior and medial borders. Its upper 1/3rd is narrow and forms the floor of intertubercular sulcus. A nutrient foramen is seen on this surface near its middle, near the medial border.
3. The posterior surface lies between the medial and lateral borders. Its upper part is marked by a oblique ridge. The middle 1/3rd is crossed by radial groove.

DIAPHYSIS

Humerus diaphysis constitutes the middle three-fifths of the bone extending from the upper end of the pectoralis major to the supracondylar region. The proximal half of the diaphysis is broad and circular cross section. It is grooved on its anterior aspect by the long head of biceps. In the distal half the bone flattens out into a triangular cross section. It has an anteromedial and an inferolateral surfaces flanked by medial and lateral supracondylar ridges. It also has a posterior surface. The lower end of the

humerus in its juxta articular region is marked by the fossa to accommodate the olecranon posteriorly and the coronoid and the radial head anteriorly.

The medullary canal follows the contour of the humeral diaphysis. It is circular in its proximal half and is triangular in its distal half. It is broad proximally and tapers downs distally. The medullary canal is straight and is having an anterior offset towards the distal end.

PROXIMAL HUMERAL METAPHYSIS

Proximal humeral metaphysis is the broad globular end of the bone. It has an spheroidal head, which articulates with the glenoid. Apart from this the proximal end also has two bony prominences the greater and lesser tuberosity. These landmarks are separated from each other by the presence of the bicepital groove. A shallow constriction separates the two tuberosities from the articulating surface. The constriction is the anatomical neck of the humerus. This is a significant landmark as the space between the articulating surface and the greater tuberosity forms the entry point for the interlocking nail in antegrade insertion technique.

DISTAL HUMERAL METAPHYSIS

Distal humeral metaphysis broadens mediolaterally and flattens anteroposteriorly. It is made up of the medial epicondyle, the trochlea, the

capitulum and the lateral epicondyle mediolaterally. Between the distal articulating surface and the diaphysis are fossae for accommodating the olecranon posteriorly and the coronoid and radial head anteriorly.

The distal humeral articulating part is angulated anteriorly to the diaphysis by an angle of 40 degree to the diaphysial axis in the sagittal plane.

The diaphysis is supplied by a single nutrient vessel arising from the brachial artery in the mid shaft level.

SOFT TISSUE RELATIONS

The humerus is surrounded by the bulk sleeve of muscle which provides for the better vascularity of the bone. There are three important neurovascular bundles, which weave around humerus, which becomes significant during the exposure of the bone.(27)

MUSCULAR RELATIONS

Humerus is posteriorly related to the triceps, two of whose heads viz, lateral and medial originate from the posterior surface of the bone on either side of the radial groove. Anteriorly it is related to the biceps brachii, which does not have any attachment on to the humerus and the brachialis which originates from the anterior surface of the lower half of the bone. The

deltoid covers the anterior, lateral and posterior aspect of the proximal half of the humerus.

MUSCULAR ATTACHMENTS

To the anatomical neck is attached the shoulder joint capsule and the capsular ligaments. The greater tuberosity gives insertion for the supraspinatus, the infraspinatus, and the teres minor from above downwards. Subscapularis gets inserted onto the lesser tuberosity.

Pectoralis major, the latissimus dorsi and the teres major gain insertion into the biciptial groove from before backwards. The deltoid is inserted onto the deltoid tuberosity on the lateral aspect of the middle of the shaft. Corresponding to the insertion of the deltoid, on the medial aspect is the insertion of the coracobrachialis.

The anteromedial and the anterolateral surfaces in the lower half of the humerus give origin to the brachialis. The posterior surface gives origin to the lateral and medial heads of the triceps above and below the bicepital groove. The medial and the lateral epicondyles are attached to the common flexor and the extensor origin. The lateral supracondylar ridge gives origin for the brachioradialis, extensor carpi radialis longus and brevis.

EUROVASCULAR RELATIONS

Three important neurovascular bundles flank the humerus in its anatomical relations. The axillary nerve runs around the proximal metaphysis of the humerus supplying the deltoid. The radial nerve accompanied by the profunda brachial vessels runs around the posterior aspect of the humerus in the radial groove flanked by the medial and lateral head of the triceps this structure is important in exposure of the humeral diaphysis by the posterior approach. Occasionally it may get entrapped in the fracture ending up with radial nerve palsy. The brachial vessels, the medial cutaneous nerves of the arm and forearm run in the space between the biceps and the brachialis.

CLASSIFICATION

CLASSIFICATION

AOASIF has an elaborate system of classification of the fractures based on the fracture morphology, and the fracture site. This comprehensive system is of prognostic value, in that greater the grade of fractures the higher the energy of injury, implying greater the chances of occurrence of complications during treatment.(29,34,50,2)

AO ASIF CLASSIFICATION OF HUMERAL DIAPHYSEAL FRACTURES

TYPE-A simple fractures Circumferential break in the bone

A1-spiral fractures

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

A2-oblique fractures i.e. fracture lies at 30 degree or more to the diaphysis

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

A3-transverse fractures .i.e. fracture lies <30degree to the diaphysis

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

TYPE-B wedge fractures.

Separate butterfly fragment, but the fracture reduces with contact between the main fracture fragments.

B1-spiral wedge as a result of torsional forces.

- In the proximal zone
- In the middle zone
- In the distal zone

B2-bending wedge as a result of bending stresses.

- In the proximal zone
- In the middle zone
- In the distal zone

B3-bending wedge where the wedge is comminuted.

- In the proximal zone
- In the middle zone
- In the distal zone

TYPE-C: complex fractures.

There are more than two fragments and even after reduction the main fragments do not come in contact.

C1-spiral

- With two intermediate fragments
- With three intermediate fragments
- With more than three intermediate fragments

C2-segmental

- With one intermediate segment
- with one intermediate segment and a butterfly fragment
- with two intermediate segments

C3-irregular fractures

- With two or three intermediate fragments
- With shattering of the bone for a length of <4cms
- With shattering of the bone for a length of >4 cms

MECHANISM OF INJURY

MECHANISM OF INJURY

The predominant causes of humeral shaft fractures include simple falls or rotational injuries in the older population and higher-energy mechanisms in the younger patients including motor vehicle accidents, assaults, falls from a height and throwing injuries.(19,33)

A history of minimal trauma causing fracture in older patient may be the first point to alert the surgeon that the fracture may involve pathologic bone (be it from metastatic disease or severe osteoporosis) and prompt a thorough history (eg.for prior cancer) and possible a systemic work-up.

Discordance between history and fracture type is a hallmark of domestic abuse, and again this may represent an opportunity to intervene in a potentially lethal situation. Alcohol abuse, smoking, and / or illicit drug use are all potential risk factors for negative fracture outcome through repeat injury, non- compliance, or poor biology at the fracture site, and represent an opportunity to improve outcome.

TREATMENT PROTOCOL

Fractures of the humeral diaphysis are commonly associated with other systemic injuries viz, thoracic injuries, facio maxillary and injury to the brachial plexus. These more life threatening injuries must be looked for

and treated immediately. Any neurovascular involvement especially that of radial nerve and the brachial vessels must be checked for. (15)

The humeral diaphyseal fractures are treated with closed reduction and coaptation splinting. This can be the definitive treatment if the reduction is satisfactory and there are no neurovascular complications.(47)

Indications for primary operative treatment of humeral shaft fractures

I. Fracture Indications:

- ❖ Failure to obtain and maintain adequate by closed means of reduction;

  Shortening >3cm.

  Rotation>30 degree

  Angulation >20 degree

- Segmental fracture
- Pathological fractures
- Intra articular extension.

1. Shoulder joint

2. Elbow joint.

II.Associated injuries

- Open wound
- Vascular injury
- Brachial plexus injury

- Ipsilateral forearm fractures
- Ipsilateral shoulder or elbow fractures
- Bilateral humeral fractures
- Lower extremity fractures requering upper extremity weight bearing
- Burns
- High velocity gun shot injury
- Chronic associated joint stiffness shoulder & elbow

III. Patient indications

- Polytrauma
- Head injury(GCS ≤ 8)
- Chest trauma
- Poor patient compliance
- Unfavorable body habitus:

➢ Morbid obesity

➢ Large breast

Surgery is definitive in following situations

- Inability to maintain fracture alignment in normal bracing i.e., more than 15° of angulation or rotational deformity.
- Non compliance
- Poly trauma

- Spinal injury
- Lower extremity injury
- Long bone fractures involving the same limb
- Pathological fractures
- Brachial plexus injury
- Brachial artery injury
- Bilateral humeral fractures
- Segmental fractures

GENERAL PRINCIPLES OF MANAGEMENT

GENERAL PRINCIPLES OF MANAGEMENT

Many times humeral diaphyseal fractures are associated with poly trauma. Hence these systemic problems must be sought after and treated before the definitive management of humeral fractures.(15,17)

AVAILABLE TREATMENT OPTIONS

1. Thoraco brachial immobilization
2. Closed reduction and hanging arm cast
3. Closed reduction and co-aptation splinting
4. Open reduction and internal fixation with

a. Plate osteosynthesis

- Dynamic compression plates
- LC-DCP Plate
- Looking Compression Plates

b) Intramedullary nailing

- Multiple nails
- Flexible nails
- Solid nails

5. Closed reduction and internal fixation with a intramedullary interlocking nailing

6. External fixators application with

a. AO external fixators

Ilizarov ring fixator

BIOMECHANICS OF PLATE OSTEOSYNTHESIS

BIO MECHANICS OF PLATE OSTEOSYNTHESIS

HISTORY:

Pawel	:	Designed tension band principle for plating
Key	:	Principles of axial compression
Charnley	:	Popularise auxilary compression
Eggers et a	:	Contact-compression factor in healing of cortical bone
Danis(Belgium)	:	Active compression by eccentrically placing the last screw
Venable and Stuck	:	Designs similar plate
Bagby and Jones	:	Modified collision plate where tapered screw head when fastened against straight holes produces compression Muller and Algower:Introduce compression plate (22,37)

PLATE OSTEOSYNTHESIS

Plate osteosynthesis simply means fracture fixation with plates and screws. According to functions plates are classified as

Neutralization Plate	Buttress Plate
Compression Plate	Condylar Plat

Neutralization plate : It acts as a bridge transmitting various forces from one segment to other segment without disturbing fracture as a mechanical link. It does not produce any compression. It can be used in conjunction with lag screw in comminuted fractures.

Compression Plate: Produce locking force across fracture site according to Newton's III law. When the plate is pulled across fracture side the tension produced compress the fracture site.(11,12)

- Role of Compression:
- Compression of fragments
- Primary bone healing
- Increased stability so that preserves the blood supply
- Torsional and shearing forces eliminated

Two types of compressions are Static and Dynamic. Methods of compression are

- Self compression plate
- Tensioning device
- Eccentric screw placement

Buttress plates and condylar plates are used in special situations.(25,13)

PRINCIPLES OF PLATE FIXATION

Plate Related Factors:

Strength depends on thickness and stiffness

Distribution of holes

Distribution of the surface

Inclination of screw hole

Screw Related Factors:

How a screw fastened to a plate to bone construct

Design of thread and head

Holding power ratio of pilot hole to depth

Number of screws

Material used

Bone Related Factors:

Mechanical properties

Tension side plating

Bone quality

Holding power of screw

Bone elasticity

Construct Related Factors:

Direction of the load and position of the plate in bone determine strength of construct.

When applied to compression side under bending forces the construct becomes ‘bending open configuration’, a weak construct

When applied to tension side it becomes ‘bending close configuration’ it is 200 times stronger.

When double plating is done at rightangles it is 235 times stronger (27,49)

Strength of the Plate-Bone Construct Depends On

Strength of plate and screw:

Design

Dimension

Material used

Screw purchased

Configuration of the fracture:

Extent of comminution

Placement of the plate

Bone quality

Mechanical properties of the construct:

Working length

Load sharing

Additional principles(4,13,21,39)

Tension band Plate: When the plate is placed on tension side of bone construct is strong. The opposite cortex must be intact. It decreases working length and increases rigidity.

Pre Bending of Plate:When static compression is applied the near cortex gets compressed and the far cortex is opens out. To prevent this the pre bending of plate is done and the innermost screw applied initially.

Obliquity Of Fracture: The plate and screws is placed according to the direction of obliquity.

Double Plating

Plate contouring

Minimum no.of screws is 7 cortical purchase on each fragment

Minimizing the stress concentration

No screw with in 1 cm of the fracture site

Avoiding bicortical purchase of last screws of the plate

LAG principle: Lag principle means achieving interfragmentary compression by applying a screw perpendicular to the fracture plane. Whenever possible a butterfly fragment must be lagged to a principle fragment incase of comminuted and segmental fracture. It improves the stability of the construct. In our study we use lag principle in seven cases

PLATE REMOVAL

The plates should not be removed before 24 months.

DYNAMIC COMPRESSION PLATE

It was introduced in 1969. The success of the plate lies on its screw hold design.It is shaped like an inclined transverse cylinder. Maximal axial compression is gained. The screw hole inclined 25degrees in longitudinal plane and 7 degree in transverse plane. Lag screw can be applied. One dynamic hole provides 1mm of compression.Screw can be applied in extreme load, load, neutral and buttress position. Dynamic compression unit is one in which the screw hole is undercut allows 45degree angulation without impingement.(14,32)

Primary bone healing became a reality in 1960's and early 1970's with the advent of new philosophies in fracture treatment and the advent of semitubular and

compression devices. In the late 1970's the *dynamic compression plate* was introduced which dawned the era of compression at the fracture site with a single implant. It also minimized the use of external compression devices. This invention was then followed by the limited contact DCP (LC-DCP) which was designed with trapezoid cross section, to decrease the damaging footprint of the plate on the periosteum. Surgeons soon came to realize the importance of preserving the bone micro anatomy for achieving better results. The damage caused by violating the periosteum by DCP and to some extent LC-DCP has been shown with many biochemical markers and stains. After 20 yrs of advocating absolute stability, The masters of plate osteosynthesis now are suggesting the concept of biological fixation.(27,32) The new mantra;" **BONE IS LIVING TISSUE"** prompted surgeons to device new techniques. MIPPO –minimally invasive percutaneous plate osteosynthesis 50 came into vogue in late 1980"s, indirect fracture was used. It can tolerate imperfect reduction because fracture was not disturbed . But the screw pullout which was a major problem was to be answered.(27,17)

Richard wagnoer, combined the principles of compression with that of locking plates used in the LISS system to come out with the present day LOCKING COMPRESSION PLATE. It is ideal combination of two well known anchorage concepts; 1)**Compression plate 2) Internal fixator**

Poor bone quality increases the technical difficulty and complications of operative treatment. Plates with screws that lock to the plate [transforming each screw into a fixed blade] are intended to improve the fixation of poor quality bone.(36,45)

The literature demonstrates low rates of nonunion and overall complication rates with locking plates in difficult metaphyseal and diaphyseal fractures.

FEATURES(9,19,21)

- No primary & secondary loss of correction due to stable plate screw Constructs
- Reduced vascular & periosteal damage beneath the plate.
- Reduced screw loosening thanks to the locking screws.
- No thread stripping in cortical bone
- Availability of preshaped plates
- Excellent distribution of forces around screws
- Easy insertion due to tapered plate tip & suited for MIPPO technique- with less damage to tissues and periosteum.

LCP is choice in

- Osteoporotic bones
- Juxta-articular fractures
- MIPPO technique-reduction is made easy
- Badly shattered communited fracture of long bones
- Periprosthetic fractures

Some tips and pearls of LCP fixation are;

- Atleast 3 screws on either side of the fracture
- Screw holes nearest to fracture have to be used without fail
- All the holes need not to be fixed
- Compression screw should be farther away from the fracture and o one side only
- Plate should be in compression mode in transverse or minimally communited fractures
- Use of a longer plate provides better axial stiffness as the working arm is more

SURGICAL APPROACHES AND APPLIED ANATOMY

SURGICAL APPROACHES AND APPLIED SURGICAL ANATOMY

Although number of surgical approach to the humeral shaft have been described , a few approaches we used in our study are

The posterior approach

- The anterolateral approach

Other approaches under special needs

- The direct lateral approach
- The direct medial approach

Anterolateral approach to humerus:

This approach is preferred option for majority of proximal and middle third humeral shaft fractures that require plate fixation.

Position of the patient

Place the patient supine on the operating table with the arm lying on an arm board and abducted about 60 degree

Skin incision is centered over the fracture site and performed longitudinally along the palpable lateral border of biceps brachii.

ANTEROLATERAL APPROACH(5,13)

Landmark: Proximal coracoid process

Distally anterior to lateral supracondylar ridg Proximally, the plane between pectoralis major [Pectoral nerves] medially and deltoid [Axillary nerve] laterally. Take care to identify and protect the cephalic vein.

If required, broad deltoid insertion can be reflected posteriorly to gain access to anterolateral shaft

Mid shaft region: dissection plane between the biceps (Musculocutaneas nerve) and triceps (Radial nerve) exposing the brachialis underneath which is split longitudinally along with lateral portion.Split is roughly in internervous plane.

Distally: dissection along the anterior aspect of the lateral supracodylar ridge between the brachialis medially and brachioradialis laterally. At this point radial nerve is closest to dissection, so it should be identified and protected.

Advantages:

- Favorable position of the patient – for poly trauma cases.
- Incision can be extended proximally to deal with associated shoulder pathology or proximal extension of a fracture.
- Identification of radial nerve distally

Disadvantages:

- Technically difficult to apply a plate distally along the [thin] lateral supracondylar ridge
- Lack of access to any medial column pathology
- **N**oticeable scar results

Posterior approach:

Posterior approach is ideal for fracture that involves distal third of fractures especially that have intraarticular extension or that require exploration and repair of associated radial nerve injury.

Posterior approach:

Position of the patient

Two positions of the patient are possible during surgery; a lateral position on the operating table with the affected side uppermost or a prone position on the operating table with the arm abducted 90 degree. A sand bag should be placed under the shoulder of the side to be operated on, and the elbow should be allowed to bend and the forearm to hang over the side of the table.Skin incision is centered over the fracture site.

Landmark: Proximally posterolateral corner of the acromion.

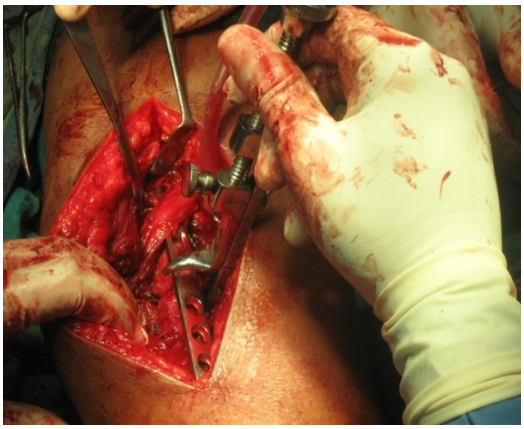
Distally tip of acromion.

Triceps sharply divided distally taking care to identify and protect the radial nerve[and profunda brachii artery that runs with it] proximally

The radial nerve crosses the posterior aspect of the humerus in the spiral groove roughly equidistant between the tip of olecranon and edge of acromion, and can be identified at the lateral edge of attachment of medial head of triceps.

Proximally it is possible to identify the interval between the long and lateral heads of triceps.

Distally if fixation is anticipated on the medial column of humerus, the ulnar nerve has to be identified and protected.



Advantages:

- Ability to access both lateral and medial column distally.
- Easy to fix a shaft fracture with distal extension.
- Flat posterior surface distally is ideal for plate fixation.

Disadvantages:

- Injury to radial nerve.
- Prone or lateral position of the patient is not favourable in multiply injured patients.
- Humeral head and neck cannot be accessed safely through this approach.

AO PRINCIPLES OF FIXATION

AO/ASIF formulated the following treatment guidelines based on **Lambotte's principles** of surgical treatment of fractures . In **1958** the **AO/ASIF** [Association for the study of internal fixation] formulated four basic principles which have later become the basic principles of internal fixation.(37,40)

1. Anatomical reduction

Exact screw placement utilizing wire sleeves facilitated restoration of articular surface.

2. Stable fixation

Locking screws provide a fixed angle construct providing angular stability.

3. Preservation of blood supply

Tapered end for sub muscular plate insertion improving tissue viability Limited contact plate design reduces plate to bone contact minimizing vascular trauma.

4. Early mobilization

Plate features combined with AO technique create an environment for bone healing expediting a return to optimal function.

MATERIALS AND METHODS

METIRIALS AND METHODS

This prospective study is an analysis of functional outcome of 20 cases of surgically managed severely comminuted and segmental fractures of shaft of humerus undertaken at Department of Orthopaedics and Traumatology Government Royapetth Hospital Chennai from January 2008 to June 2009.

TABLE – 1

SEX DISTRIBUTION

S.NO	SEX	NO.OF.Patients	Percentage
1	Males	14	70
2	Females	6	30

Among the 20 patients 14were males and 6 patients were females. The age of the patients ranged from 20 years to 60 years.

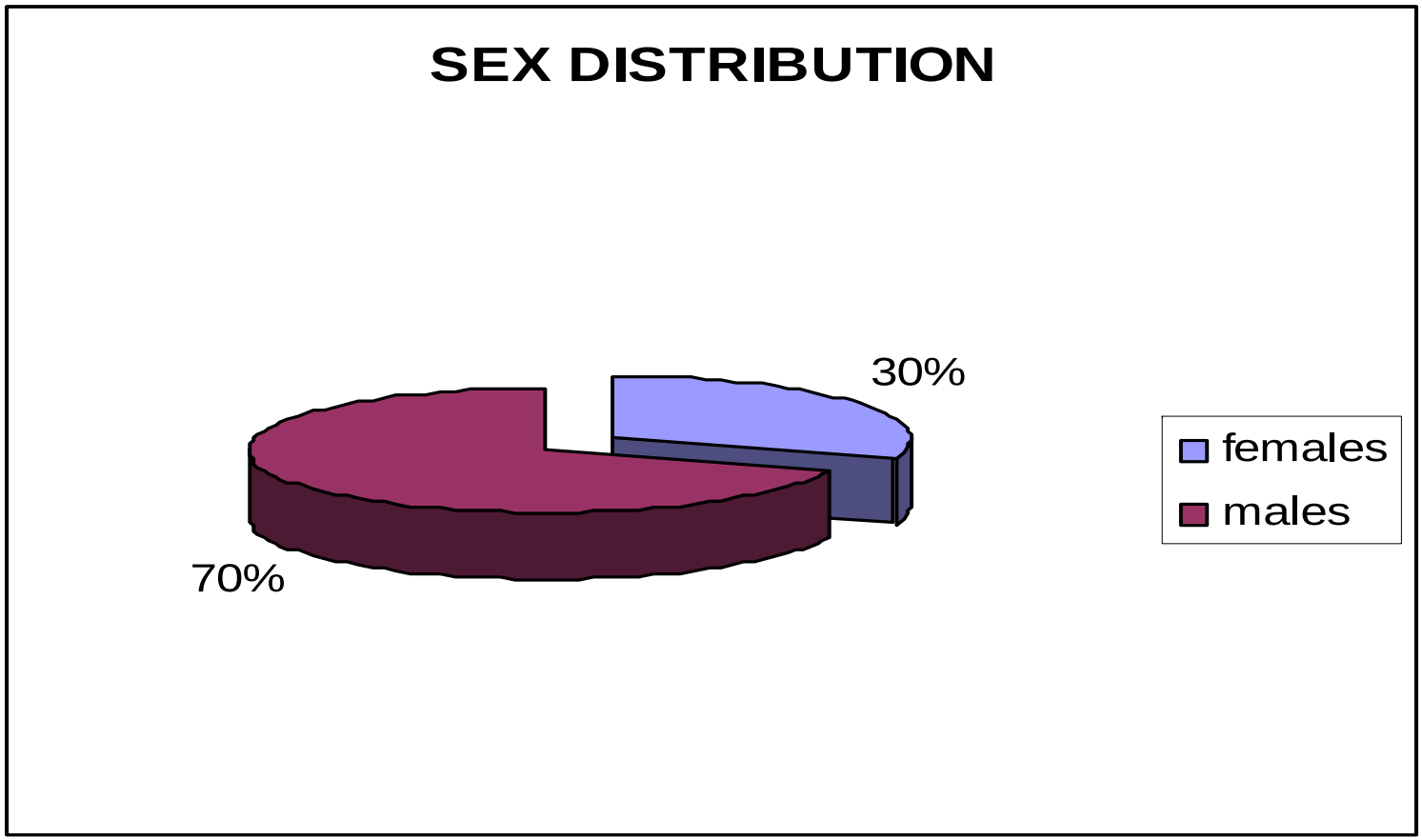

SEX DISTRIBUTION
30%
70%
females
males

TABLE – II

AGE DISTRIBUTION

S.no	AGE GROUP	NO.OF PATIENTS	PERCENTAGE	MALES	FEMALES
1	20-40	9	45	7	2
2	41-50	8	40	6	2
3	51-70	3	15	1	2

The mode of injury was fall at ground level in 5(25%) patients, road traffic accidents in 13(65%) patients, fall from height in 2(10%) patients.

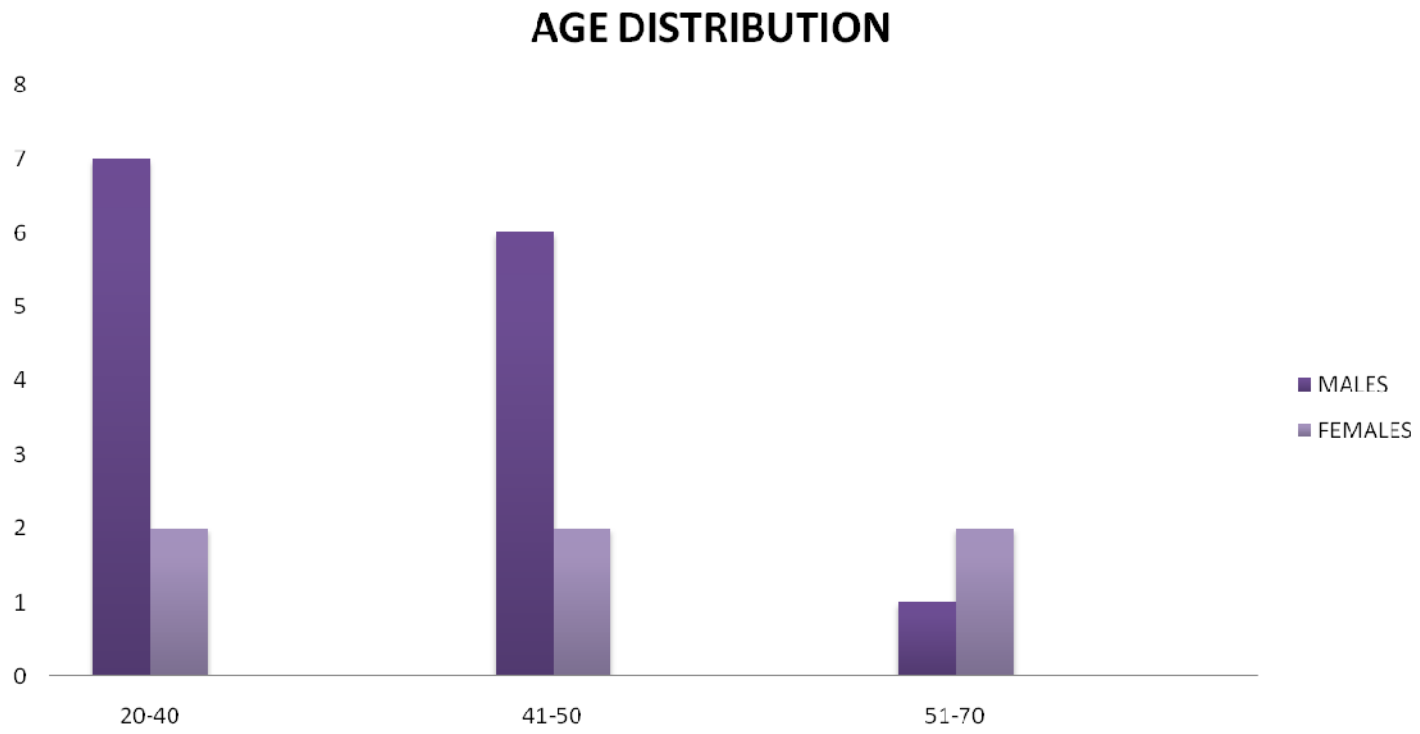

AGE DISTRIBUTION
8
7
6
5
4
3
2
1
0
20-40
41-50
51-70
MALES
FEMALES

TABLE - III

MODE OF INJURY

S.NO.	MODE OF INJURY	NO.OF.PATIENTS	PERCENTAGE
1	Fall at ground level	4	20
2	RTA	12	60
3	Fall from height	4	20

TABLE – IV
OCCUPATION

S.NO.	OCCUPATION	NO.OF.PATIENTS
1	Labourer	10
2	House wife	3
3	Skilled worker	2
4	Professional	2
5	Business	3

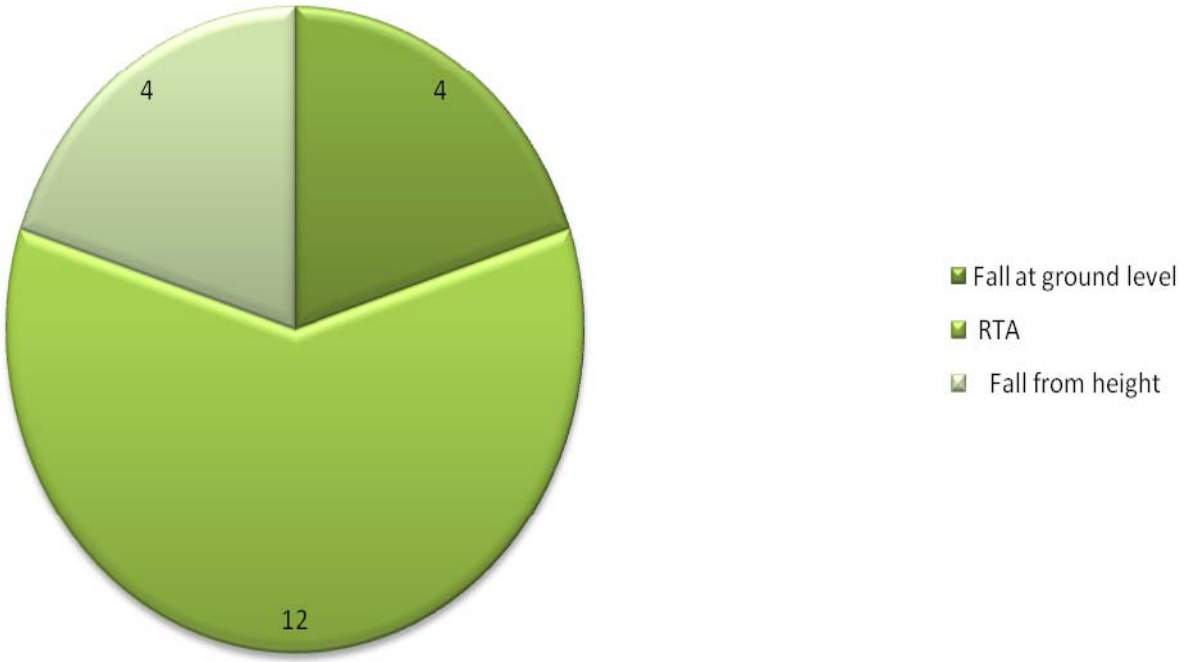

4
4
12
Fall at ground level
RTA
Fall from height

TABLE - V

S.NO.	SIDE	NO.OF.PATIENTS
1	Unilateral	20
2	Bilateral	0

TABLE - VI

SIDE

S.NO.	SIDE INVOLVED	NO.OF.PATIENTS
1	Dominant(right)	15
2	Non-dominant(left)	5

Sixteen patients presented to us within a week after injury and 8 patients had previous treatment either in the form of native splinting, massage or POP cast .

TABLE - VII

PREVIOUS TREATMENT

S.NO.	PREVIOUS TREATMENT	NO.OF. PATIENTS	PERCENTAGE
1	Massage	2	10
2	Splinting	2	10
3	POP Immobilization	1	5
4	No native treatment	15	75

A meticulous clinical examination was made in all patients with care to look for any associated injuries. 5 patients had associated injuries which were concomitantly treated.

TABLE - VIII

S.NO.	ASSOCIATED INJURIES	NO.OF.PATIENTS
1	Fracture distal radius	1
2	Fracture metacarpal	2
3	Fracture neck of femur	1
4	Fracture clavicle	1

Standard anteroposterior and lateral radiographs of the affected humerus were taken in all patients that include the shoulder and elbow joints in each view. Further views ordered depending on the clinical examination and any abnormalities noticed on initial films.

TABLE – IX

TYPE OF FRACTURE

S.NO.	AO-TYPE	NO.OF.PATIENTS	PERCENTAGE
1	B3.1	1	5
2	B3.2	5	25
3	B3.3	3	15
4	C1.1	1	5
5	C1.2	3	15
6	C1.3	1	5
7	C2.1	1	5
8	C2.2	3	15
9	C2.3	1	5
10	C3.2	1	5

Post operative rehabilitation(28,15,6)

In all patients the arm was placed in an arm sling and POP applied if not stable.Prophylactic antibiotics which were started before surgery were continued for 48 and 72 hours post operatively .Sutures were removed by 10^{th} post operative day.

Phase I exercises consisting of active finger movements , and pendulum exercises of shoulder joint were encouraged from the first week.

Phase II exercises consisting of active finger movements range of motion exercises of shoulder and elbow were started by 3 to 6 weeks.

Phase III exercises consisting of advanced stretching and strengthening exercises were started by 3 months. Gradual weight lifting started after 3 months.

OBSERVATIONS

OBSERVATION

- Majority of injured patients were males(70%)
- Highest number of patients were in the 3-4 decade
- RTA was the most common mode of injury.
- There was mostly Unilateralfractures .
- All were right handed persons and the dominant arm was involved in 15 (75%) patients.
- Most patients reported to hospital within a day of injury.
- 30% of patients had undergone previous native treatment either in form of massage or splinting.
- 5 patients had associated fractures. All the patients had closed injuries.
- Post operative immobilization with POP was used in 2 patients.
- Patients were taken up for surgery on an average of 8 days
- Bone grafting was done for all comminuted and segmental fractures.
- Average follow up period was 9 months.
- 50% patients do not have any pain during follow-up.
- Type B had better outcome than Type C fractures.
- 18 of 20 fractures united within a period of 14 weeks.
- The average time of union was 14.5 weeks.
- 95% of fractures united within 16 weeks.
- The functional outcome was more that 90%.

COMPLICATIONS

COMPLICATIONS

Early complications:

Early complications were encountered in 3(15%) patients.

- One with diabetes mellitus had wound gaping requiring secondary suturing after glycaemic control.
- One patient with comminuted humeral shaft fracture developed skin necrosis which resolved after serial wound dressing.
- One patients had Transient Radial nerve palsy after surgery which improved with cock up splint and electrical stimulation of wrist extensors.

SL NO	COMPLICATIONS	NO OF PATIENTS
1	Skin necrosis	1
2	Wound gaping	1
3	Radial nerve neuroprapxia	1
4	Infection	0

Late complications

Late complications were encountered in 3 patients.

- Two patients had shoulder joint stiffness probably because the patients had undergone native treatment with massage and attempted
- Reductions and surgery was performed one month after injury both of them recovered after physiotherapy.

- One patient had delayed union probably because the bone was osteoporotic and associated co-morbid conditions

SL NO	COMPLICATIONS	NO OF PATIENTS
1	Shoulder stiffness	2
2	Elbow stiffness	0
3	Delayed union	1
4	Non union	0
5	Implant failure	0
6	Pseudoarthrosis	0

RESULTS

RESULTS

The patients were followed up at regular intervals i.e., every month during the first 3 months and every 3 months thereafter.The minimum follow up period was 6 months and the maximum follow up period was 15 months. The mean follow up period in this study was 9 months.

1. Pain
2. Range of motion
3. Strength
4. Stability
5. Function
6. Reontgenographic documentation of fracture healing
7. Anatomical restoration

Constant score:

Constant and Murley's score was used to asses the functional outcome of these patients.

The results were graded by using Neer 100 units rating systems.

The rating system consisting of

35 units for PAIN

30 units for FUNCTION

25 units for RANGE OF MOTION

10 units for ANATOMY

PAIN SCALE	POINTS
No pain	5
Mild pain	4
Pain with unusual activity	3
Pain at rest	2
Marked pain	1
Complete disability	0

13(65%) patients said that they had no pain and 4(20%) patients had only mild pain,3(15%) patents had pain after unusual activity. No patients had disabling pain.

S.NO.	PAIN	NO OF PATIENTS
1	No pain	13
2	Mild pain	4
3	Pain with unusual activity	3
4	Pain at rest	0
5	Marked pain	0
6	Complete disability	0

FUNCTIONS: Function was evaluated with ability to perform day to day activities. Points were according to the following scale.

- 4-normal
- 3-mild compromise
- 2-with difficulty
- 1-with aid

- 0-unable
- NA –not available
- Functional results were graded by following criteria.
- Good functional results 3.5-4.0 points
- Fair 2.5-3.4 points
- Poor<2.5 points

Thirteen 65% patients had good functional results 7(35%) had fair functional results and no patients had poor functional results.

FUNCTIONAL OUTCOME

S.NO.	FUNCTIONAL OUTCOME	NO OF PATIENTS
1	Good	13
2	Fair	7
3	Poor	0

MUSCLE STRENGTH: Muscle strength was evaluated for the muscles around the shoulder and points allotted accorded to strength as follows:

Normal -5

Against resistance -4

Against gravity -3

With elimination of gravity -2

Flicker -1

Paralysis -0

Eighteen (90%) had normal muscle strength in all the muscle groups evaluated and one patient had good muscle strength and one patient had fair Muscle strength.

TABLE—XIX

S.NO	MUSCLE STRENGTH	NO.OF PATIENTS
1	Normal	18
2	Against resistance	1
3	Against gravity	1
4	With elimination of gravity	0
5	Flicker	0
6	Paralysis	0

RANGE OF MOTION:

ROM was evaluated during each follow –up and the improvement progress recorded. The following table shows average ROM observed.

Shoulder joint: Active forward elevation was defined as the angle between the humerus and upper part of thorax in the sagittal plane. External rotation was measured with arm at patient side .Internal rotation was measured as the elbow in a flexed position.

Elbow joint: Active flexion and extension were measured.

TABLE—XX SHOULDER JOINT

S.NO	MOTION	RANGE IN DEGREES	AVERAGE
1	Flexion	130-170	157.5
2	Abduction	140-170	159
3	ER	60-70	64.5
4	IR	60-70	65.5

TABLE—XXI

ELBOW JOINT

S.NO	MOTION	RANGE IN DEGREES	AVERAGE
1	Flexion	120-130	127
2	Extension	0	0

OVERALL RESULTS

The results were accorded to the following criteria:

Maximum number of points - 100

Excellent -90-100

Satisfactory -80-89

Unsatisfactory -70-79

Failure -<70

Of the twenty cases 16(80%) patients had excellent results, 3(15%) satisfactory,and 1(5%) unsatisfactory results.There was no failures in our study.(TABLE—XXII)

TABLE—XXII

OVER ALL RESULTS

S.NO	RATING	NO OF PATIENTS	PERCENTAGE
1	Excellent	16	80
2	Satisfactory	3	15
3	Unsatisfactory	1	5
4	Failure	0	0

In our study internal fixation using locking compression plating techniques achieved union in 19 of 20 fractures (95%) .These results are comparable with those obtained by R.Vander Griend et al open reduction and internal fixation using AO plating techniques (97%).

CASE ILLUSTRATIONS

CASE ILLUSTRATION-1

NAME : VENKATESH IP.NO.: 890152

AGE / SEX: 55 MALE

DATE OF INJURY: 20.01.08

DATE OF SURGERY: 25.01.08

MODE OF INJURY: FALL AT GROUND LEVEL

AO TYPE: C.1. 2

SIDE OF INJURY: RIGHT

ASSOCIATED INJURIES: NIL

PREVIOUS TREATMENT: NIL

PROCEDURE DONE: ORIF AND PLATE OSTEOSYNTHESIS

BONE GRAFTING: YES

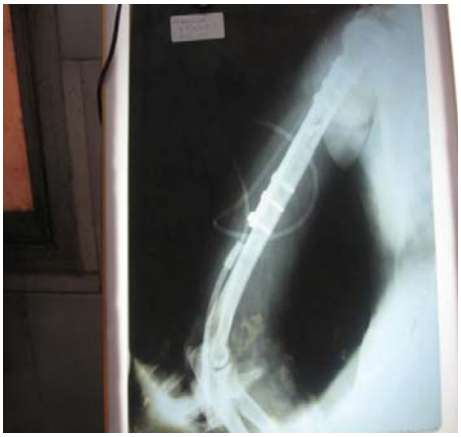
COMPLICATIONS: JOINT STIFFNESS

SECONDARY PROCEDURES: NIL

FUNCTIONAL OUTCOME:

TIME OF UNION	15 WEEKS	
MOVEMENTS OF THE SHOULDER	ABDUCTION	140
	FLEXION	130
	INT.ROTATION	50
	EXT.ROTATION	60
MOVEMENTS OF THE ELBOW	FLEXION	130
	EXTENTION	0
PAIN IN THE SHOULDER	PAIN ON UNLIMITED ACTIVITY	

CASE - 1



CASE – 1

CASE ILLUSTRATION-2

NAME : RANGANAYAKI IP.NO.:896490

AGE / SEX: 57 FEMALE

DATE OF INJURY: 13.04.08

DATE OF SURGERY: 07.05.08

MODE OF INJURY: FALL AT GROUND LEVEL

AO TYPE: B3.2

SIDE OF INJURY: RIGHT

ASSOCIATED INJURIES: NIL

PREVIOUS TREATMENT: MASSAGE AND SPLINT

PROCEDURE DONE: ORIF AND PLATE OSTEOSYNTHESIS

BONE GRAFTING: YES

COMPLICATIONS: NIL

SECONDARY PROCEDURES: NIL

FUNCTIONAL OUTCOME:

TIME OF UNION	**14 WEEKS**	
MOVEMENTS OF THE SHOULDER	ABDUCTION	140
	FLEXION	120
	INT.ROTATION	60
	EXT.ROTATION	70
MOVEMENTS OF THE ELBOW	FLEXION	120
	EXTENTION	0
PAIN IN THE SHOULDER	NIL	

CASE - 2

CASE – 2

CASE ILLUSTRATION-3

NAME : PUSHPA IP.NO.:901896

AGE / SEX: 43 FEMALE

DATE OF INJURY: 04.07.08

DATE OF SURGERY: 23.07.08

MODE OF INJURY: RTA

AO TYPE: C1.2

SIDE OF INJURY: RIGHT

ASSOCIATED INJURIES: NIL

PREVIOUS TREATMENT: SPLINT

PROCEDURE DONE: ORIF AND PLATE OSTEOSYNTHESIS

BONE GRAFTING: YES

COMPLICATIONS: NIL

SECONDARY PROCEDURES: NIL

FUNCTIONAL OUTCOME:

TIME OF UNION	**12 WEEKS**	
MOVEMENTS OF THE SHOULDER	ABDUCTION	160
	FLEXION	160
	INT.ROTATION	70
	EXT.ROTATION	60
MOVEMENTS OF THE ELBOW	FLEXION	120
	EXTENTION	0
PAIN IN THE SHOULDER	NIL	

CASE - 3

CASE -3

CASE ILLUSTRATION- 4

NAME : RGHAVAN IP.NO:909154

AGE / SEX: 44 MALE

DATE OF INJURY: 30.09.08

DATE OF SURGERY: 09.10.08

MODE OF INJURY: RTA

AO TYPE:C1.2

SIDE OF INJURY: LEFT

ASSOCIATED INJURIES : NIL

PREVIOUS TREATMENT: MASSAGE

PROCEDURE DONE: ORIF AND PLATE OSTEOSYNTHESIS

BONE GRAFTING: YES

COMPLICATIONS: NIL

SECONDARY PROCEDURES: NIL

FUNCTIONAL OUTCOME:

TIME OF UNION	**12 WEEKS**	
MOVEMENTS OF THE SHOULDER	ABDUCTION	150
	FLEXION	160
	INT.ROTATION	70
	EXT.ROTATION	60
MOVEMENTS OF THE ELBOW	FLEXION	130
	EXTENTION	0
PAIN IN THE SHOULDER	NIL	

CASE – 4

DISCUSSION

DISCUSSION

In this study we have studied 20 cases of comminuted and segmental fractures of shaft of humerus treated with plate osteosynthesis

There was male preponderance in our study (35). The average age of patients was 44.5yr which was comparable with the reports by R.Ekholm et al and Jadami and S. Ponzer.

RTA was the most common mode of injury.

The OTA classification is most commonly used for humeral diaphyseal fractures. It has wide acceptance for the treatment options and out comes. It has low level of inter and intra observer reliability for subgroup classification.

RATE AND TIME OF UNION :

The rate of union in conservative methods is 97% to 100% and the union rate is 11.5 weeks however it is associated with pain, poor motion and disability , an unacceptable angulation, non union, stiffness, long term morbidity and social problems

Internal fixation in these cases relieve pain prevent soft tissue, fracture disease and fecilitate rehabilitation. The rate of union in intra

medullary nailing is 80 % - 100% and the union time is 18- 24 weeks however it is associated with nonunion, delayed union, impingement syndrome, injury to rotator cuff, shoulder instability and pseudoarthrosis.

The rate of union in plate osteo synthesis is 93% - 100% and time of union 3 - 4 months and not exceeding 18 weeks.

Vander Griend et al reported union in 35 out of 36 cases

Bell et al reported union in 37 out of 39 cases. Tingstad et al in 78 of 83 cases. In large number of series the union rate is more than 96%

Complications are too few such as radial nerve neuropraxia, infection, refracture.

In our study we had one superficial infection, one neuropraxia and no case of nonunion or Infection.

Finally a prolonged closely monitored and well defined program of rehabilitation was necessary to obtain the best functional results. Bette results were obtained in more educated rehabilitation program with an active involvement of patient.

We have followed the three phase rehabilitation protocol of **Hughes and Neer** in all our patients and this has provided good results. We had range of motion in shoulder and elbow joint in more than 90% of cases.

Plate fixation according to the Muller's technique is a reliable osteosynthesis method with few initial failures or malunions as evidenced by data in the literature.

Infection is also rare. Although the radial nerve risk makes this technique rather difficult, excellent functional results can be achieved.

In our study internal fixation using plate osteosynthesis achieved union in 19 of 20 fractures (95%).

These incidence of operative and post operative complications was low and return of fuction was good accept in patients with associated injuries.

The functional outcome of the patients were accessed by Constant and Murley's scoring system. The score was more than 90%.

CONCLUSION

CONCLUSION

Fractures of shaft of humerus is best treated by plate osteosynthesis even in situations like severely comminuted fractures and segmental fractures. The functional outcome is best with plate osteosynthesis. In severly communited fractures and segmental fractures where restoration needs soft tissue dissection, plate osteosynthesis can be done by. MIPPO technique, locking compression plate, Less invasing stabilization system(LISS).

In osteo porotic fractures, plate Osteosynthesis can be done using LCP.

To conclude plate Osteosynthesis gives good function outcomes segmental and comminuted fractures, and equally good results comparing to other modalities besides less morbidity.

BIBLIOGRAPHY

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1. Ahmad M, Nanda R, Bajwa AS, Candal-Counto J, Green S, Hui AC. Biomechanical testing of the locking compression plate: when does the distance between bone and implant significantly reduce construct stability.? **Injury 2007 Mar 38(3)358-Fall;15(3):173-6**
2. Anand J Thakur. **The Elements of fracture fixation. 2**nd **edition; pp96-124.**
3. Andrew Jawa,Pearce MCcarty, Jobdoornberg.Extra articular distal third diaphyseal fractures of the humerus.**The journal of bone and joint surgery.2006;vol 88A.pp2343-47.**
4. B.Livani, W.D.Belangero,R.castro de Medeirios. Fractures of distal third of humerus with palsy of the radial nerve.**J bone and joint surgery.2006;88-B:1625-8.**
5. Ben kibler W,Bernen Livingstone, Robin bruce Current conceptsbin shoulder rehabilitation; **Advances in operativeorthopaedics: 1995:Mosby Year Book Inc.**
6. Chapman JR,Henley MB,Agel J,Benca PJ.Randomised prospective study of humeral shaft fractures fixation :Intramedullary nailing vs plating **J.Orthop.Trauma 2000:14:162-6.**

7. Cordey J.Boregeaud M,Perren SM,Force transfer between plate and bone:relative importance of the bending stiffness of the screws friction between plate and bone.**Injury 2000;31supp3:c21-8.**
8. Edmud Y.Schao,Nozomu Inoue,Terry K.K.Koo and Y.H.Kim; Biomedical considerations of fracture treatment and Bone quality maintanence in elderly patients with osteoporosis. **Clinical orthopaedics and related research;2004.number 425,pp 12-25.**
9. **Egol KA,Kubaik EN,Fulkerson E,Kummer FJ,Koval KJ.** Biomechanics of locked plate and screws,**J orthop trauma.2004;18;488-93.**
10. Eijer H,Hauke C,Arens S,PrintzenG,Schlegel U,Perren SM.PC-fix and local infection resistance-influence of implant design on post operative infection development.clinical and experimental results.**Injury.2001;32supp2: B38-43**
11. Eric Fulkerson,Kenneth A.gol,Erik N Kubaik.A biomedical comparison of Locked and conventional plating techniques.**The Journal of trauma surgey.2006;pp830-835.**
12. Erik N Kubaik,Erik Fulgerson,eric Strauss,and Kennet A.Egol.The evolution of locked plates.**The journal of bone an joint surgery.Vol88A;2006pp189-199.**

13. Flinkkila T,Hyvonan P,Siira P,Hamalainen M.Recovery of shoulder function after humeral shaft fractures.A comparative study between antegrade intramedullay nailing and plate fixation.**Arch.Orthop.Trauma surgery 2004 Oct 124(8);537-41.**
14. Frigg R.locking compression plate .An osteosynthesis plate based on the dynamic compression plate and the point contact fixator plate.**Injury;2001:32 supp12:63-66.**
15. Gardner MJ,Griffith MH,Demerakapoules P,Brothy RH,Grose A,Helfet DL,Launch DG.Hybrid locking plating of osteoporotic fractures of he humerus.**J Bone and Joint Surg.Am.2006 Sep:m88(9);1962-7.**
16. Goesling T,Frenk A,Appenzeller A,Garapathi R,Marti A,Krettek C.LISS PLATE;deign mechanical and biomedical characteristics. **Injury. 2003:34suppl 1:A11-5.**
17. Griewe RM,Archdecon MT.Locking plate technology:current concepts.**J.Knee Surg;2007 Jan;20(1)50-5.**
18. Hall JA,Phieffer LS,McKee MP.Humeral shaft split fracture around proximal humerus locking plates.**J.Orthop.Trauma 2006 Nov Dec:20(10);710-4.**
19. Hernanz GanZalez Y,Diaz Martin A,Jara Sanchez F,Resinern Erasun C.Early results of the new internal fixation system LCP&LISS,A

prospect study (113 pts)76 women 37 men Age 53.1 A.**Orthop.Belg.2007 Feb;73(1):60-9.**

20. Kesemenli CC,Subasi M,Arsalan H,Necmioglu S,Kapukaya A.comparative between the results of intermedullary nailing & compression plate fixation in treatment of humerus fractures. **Acta. Orthop.Traumatol.Ture 2003; 37(2):120-5.**
21. Kosler W,Strohm PC,sudcamp NP.New technique for bone osteosynthesis on the humerus.**Chirurg.2002 Oct;73(10):969-77.**
22. Kroptl A,Naglik H,Neider Weiser B,Hertz N et.al,unreamed antegrade humeral nailing.**Unfall chirurg.2000:103(5):348-54.**
23. Lange CH,Foster RJ.Skeletal Management of humeral shaft fractures associated with forearm fractures.**Clin.Orthop.Related Research.1985 May(195);173-7.**
24. Luo CF,Locking compression plating;a new solution for fractures in rheumatoid patients.**Mod.Rheumatol.2005;14(3);169-72.**
25. Martinez AA;Cuenca J,Herrara A,treatment of humeral shaft nonunion.plating vs nailing.**Arch Orthop Trauma.2004:124:92-5.**
26. Mattew W Lawless MD,American Academy of Ortho Surgery.July 12,2004.**Emedicine.Mid shaft humeral fractures.**
27. Mc CorMade RG,Bren ,Mc Kee MD,Powell J ,Schemutch EH.Fixation of Fractues of shaft of humerus by dynamic compression plate or

intermedullary nailing.A prospective randomized trial.**J Bone Joint Surg.Br.2000 Apr;82(3):336-9.**

28. Meekers FS,Broos PL Operative treatment of humeral shaft fractures.The Lauven Exp.**Acta.Orthop.Belg.2002 Dec;68(5);462-70.**
29. Metin Manisah,Dinc Ozaksoy,and Neshlihan Kabakct,Quantitative computed tomography BMD Reference.2006;**Clinical orthopaedics and related research.443,pp.109-112.**
30. Michael J Gardner, Mathew H,Griffith,Robert H Brophy,and Dean G.Lorich.hybrid locked plating of osteoporotic fractures of humerus.**Journal of bone and joint surgery.2006;vol 88-A;1962-67.**
31. Niall DM,O Mahony J.McElwainJP.Plating of Humeral Shaft of Fractures.Has the pendulum swung back?.**Injury 2004Jun;35(6):580-6.**
32. O.Sahap Atik,Tzge Gunal,and FezaKorkusuz.Burden of osteoporosis. **Clinical orthopaedics and related research.2006;number443,pp.19-24.**
33. Paris H,Tropiano P,Cloulet D'OrvallB,Chaudet H,Piotout DG.fracture shaft of humerus.Systematic plate fixation;Anatomic & Functional results of 156cases & a review of literature.**Rev.chir.orthop. Reparatric** Appa. Mot.2000Jun;86(4):346-59.
34. Peter LW,Warwick R,Nyson M,Bannirter LN et.al.**Gray's Text book of anatomy.**

35. Pohler strumann F.Characteristics of stainless steel,**Manual of internal fixation.AO/ASIF 1991.**

36. R.Ekholm,J.Adami;J.tidermark.fractures of he shaft of humerus.An epidemiological study of 401 fractures.**Journal of Bone and Joint surgery.2006;88-B;1469-73**

37. Ring D.kloen P,Kadziel Ski J,Helfet [n],Jupiter JB.Locking compression plates for osteoporotic non unions of the diaphyseal humerus.**CORR 2004 aug(425)50-4.**

38. Robert W.Bucholz,James d.Heckmen,Charles M.court-Brown.**Rockwood and Green's Fractures in adults.6th edition;pp1117-1136.**

39. Sarmiento Zagaroski JB,Zych DO,Latta LL,Capps et.al.Functional bracing for treatment of fractures of humeral diaphysis.**Journal of bone and joint surgery.2000 A:476-80.**

40. Schemitch EH,Bhandari M,Fractures of diaphseal humerus in Browner BD,Jupiter JB,Lavine AM,Trafton PG,eds.**Skeletal trauma.WB Saunders 2001;1481-1511.**

41. Schutz M.Sudkamp NP,Revolution in plate osteosynthesis;new internal fixator systems.**J orthop science.2003;8:252-8.**

42. Seibert HR,Beck A.Trauma surgery in Elderly.**Churg.2005 Feb:76(2);139-50**

43. Shoa MC,Harwood P,Grotz MR,Limb D,Giannoudiu PV.Radial nerve palsy associated with humeral shaft fractures.A systematic review.**JBJS 2005 Dec 87(12)1647-52.**

44. Stanley Hoppenfeld Piet de Boer.Surgical Exposures in Orthopaedics;3rd edition.

45. Stoffel K,Dieter U,Stachowaik G,Gachter A,Kuster MS.biomehanical tesing of LCP-how can stability be in a locked fixator plate controlled.**Injured 2003;34Supp2:B11-9.**

46. Tingstad EM,Wolinskey PR,Shyry Johnson KD.Effect of immediate weight bearing on plated fractures of humeral shaft.(83 #) **J.Trauma 2000** Aug;49(2):278-80.

47. Vander Grend R,Tamasch J,Ward EF.OR&If of humeral shaft fractures.Results of AO plating techniques 36 pts.**J.Bone & Joint Surgery Am 1986 Mar;68(3) 430-3.**

48. Wagner M,Frank A,Frigg R.New concepts of bone fracture treatment and the LCP.**Surg.Technol.Int.2004;12;271-7.**

49. Yang T,Liu S,Liu Y.Minimally invasive LCP to treat complex humeral shaft fractures.**Zhongguo Xiu Fu Chang Jian wai Ke Za Zhi 2007 Aug:21(8)817-9.**

50. Zhiguan A,Bing Fang Z,Yeming W,Chiz,Peiyan H.Minimally invasive plate oseosynthesis(MIPO) of middle and distal third of humeral shaft fractures.**J.Orthop.Trauma 2007 Oct;21(9)628-33.**

MASTER CHART

S.NO	Name & IP no.	Age	Sex	Occupation	D.O.I	D.O.A	D.O.S	MOI	AO TYPE	SIDE	AI	Prev. Treatment
1	Prakash 888764	39	M	labour	29.12.08	01.01.08	18.01.08	RTA	B3.1	R	mcb	
2	Venkatesan 891710	40	M	business	08.01.08	08.01.08	20.01.08	RTA	C3.2	R		
3	Venkatesh 890152	55	M	labour	20.01.08	23.01.08	25.01.08	FAG	C1.2	R		
4	Vijaya 893071	45	F	housewife	27.02.08	04.03.08	07.03.08	FAG	B3.3	R		
5	Chinnamal 893387	40	F	housewife	01.03.08	08.03.08	14.03.08	RTA	B3.3	R		
6	Hero kumar 893411	29	M	Labour	08.03.08	09.03.08	16.03.08	RTA	B3.2	R	mcb	msg
7	Meet bahadur 893673	40	M	Labour	12.03.08	12.03.08	18.03.08	RTA	C2.3	R	clav	
8	Jeyarani 895151	58	F	housewife	03.04.08	03.04.08	09.04.08	FAG	C1.1	L		
9	Vijayan 896152	42	M	Profession	17.04.08	17.04.08	21.04.08	RTA	C2.2	L	sof	
10	Ranganayagi 896490	57	F	Skilled	13.04.08	22.04.08	07.05.08	FAG	C3.2	R		splint
11	Rukmangathan 900614	40	M	Business	12.06.08	18.06.08	28.07.08	FFH	C1.3	L		
12	Puspha 901896	43	F	Labour	04.07.08	04.07.08	23.07.08	RTA	C1.2	R		
13	Rajendran 902965	45	M	Labour	16.06.08	20.07.08	22.07.08	FFH	B3.2	R	Radi	splint
14	Anadan 903440	40	M	Labour	22.06.08	26.07.08	30.07.08	RTA	B3.3	R		
15	Thanikachalam 906140	46	M	Labour	01.09.08	02.09.08	17.09.08	RTA	C2.1	R		
16	Md bakrudeen 907137	44	M	Business	16.09.08	16.09.08	19.09.08	FFH	C2.2	R		
17	Ragavan 909154	44	M	Labour	30.09.08	09.10.08	09.10.08	RTA	B3.2	L		msg
18	Nazeer 910136	22	M	Skilled	20.10.08	23.10.08	03.11.08	RTA	B3.2	R		
19	Nishanthi 910413	21	F	Labour	23.10.08	28.10.08	01.11.08	RTA	C2.2	L	radi	
20	Veerasamy 912857	48	M	profession	12.10.08	27.11.08	01.12.08	FFH	C1.2	R		Pop

S.No.	Name &IP no	I- S	App	FU	ABD	F LE	IR	ER	EFL	EEX	PAIN	SN	WG	JS	RNP	INS	UIW	CMS
1	Prakash 888764	20	AL	12	160	150	60	70	130	0	MP						24	90
2	Venkatesan 891710	12	P	12	170	160	70	60	120	0							14	94
3	Venkatesh 890152	5	P	11	140	130	50	60	130	0	PUA			Y			15	88
4	Vijaya 893071	10	P	11	170	170	60	70	130	0							16	96
5	Chinnamal 893387	13	P	10	160	160	70	60	130	0	MP						12	89
6	Hero kumar 93411	8	P	10	170	170	70	60	120	0							16	97
7	Meetbahadur893673	6	P	10	170	170	70	60	130	0							14	97
8	Jeyarani 895151	6	AL	9	170	160	60	70	120	0			Y				15	94
9	Vijayan 896152	4	P	9	160	150	60	70	130	0	PUA						12	86
10	Ranganayagi 896490	20	AL	9	140	120	50	60	120	0				Y			14	91
11	Rukmangath 900614	16	P	8	170	170	70	70	130	0	MP						15	92
12	Puspha 901896	19	AL	8	160	160	70	60	120	0							12	95
13	Rajendran 902965	7	AL	8	160	170	60	70	120	0		Y					13	95
14	Anadan 903440	8	P	8	170	160	70	70	130	0							16	96
15	Thanikachala906140	16	P	7	150	150	70	60	130	0	PUA						15	88
16	Md bakrudee 907137	3	AL	7	160	160	60	70	120	0							13	96
17	Ragavan 909154	18	P	7	150	160	70	60	130	0							12	95
18	Nazeer 910136	13	P	7	170	150	70	70	120	0	MP				Y		14	90
19	Nishanthi 910413	7	P	7	160	150	60	60	130	0							16	94
20	Veerasamy 912857	50	P	6	160	160	60	70	120	0							12	94

D.O.I : Date of injury

D.O.A :Date of admission

D.O.S: Date of surgery

M.O.I: Mode of injury

R.T.A: Road traffic accident

FAG: Fall at ground

FFH: Fall from height

Radi :radius

Clav: clavicle

Sof :shaft of femur

MCB:metacorible bone

AI :Associated injury

Msg: Massage

I-S: Inteval between injury and surgery

App:approach

Fu:follow up

ABD:abduction shoulder

FLE: flextion shoulder

IR: internal rotation

ER:external rotation

EEX:elbow extension

Efl:elbow flexion

MP: mild pain

PUA:pain on unusual activity

SN: skin necrosis

WG:wound gaping

JS:joint stiffness

RNP: radial nerve palsy

UIW:union in weaks

CMS:Constant and Murley’s score

PROFORMA

PROFORMA

CASE ILLUSTRATIONS

NAME : IP NO :

AGE / SEX:

DATE OF INJURY:

DATE OF SURGERY:

MODE OF INJURY:

AO TYPE:

SIDE OF INJURY:

ASSOCIATED INJURIES:

PREVIOUS TREATMENT:

PROCEDURE DONE:

BONE GRAFTING:

COMPLICATIONS:

SECONDARY PROCEDURES:

FUNCTIONAL OUTCOME:

TIME OF UNION		
MOVEMENTS OF THE SHOULDER	ABDUCTION	
	FLEXION	
	INT.ROTATION	
	EXT.ROTATION	
MOVEMENTS OF THE ELBOW	FLEXION	
	EXTENTION	
PAIN IN THE SHOULDER		