A PROSPECTIVE AND RETROSPECTIVE STUDY ON FUNCTIONAL OUTCOME ANALYSIS OF DISTAL HUMERUS FRACTURES TREATED WITH LOCKING COMPRESSION PLATES

Dissertation submitted to

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ORTHOPAEDIC SURGERY

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CERTIFICATE

This is to certify that this dissertation titled "**A Prospective and Retrospective Study on Functional Outcome Analysis of Distal humerus fractures treated with Locking Compression Plates"** is a bonafide record of work done by **DR. J.SHIVAKUMAR ,** during the period of his Post graduate study from May 2012 to April 2015 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2015.

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DECLARATION

I declare that the dissertation entitled "**A Prospective and Retrospective Study on Functional Outcome Analysis of Distal humerus fractures treated with Locking Compression Plates"** Submitted by me for the degree of M.S is the record work carried out by me during the period of June 2012 to September 2014 under the guidance of Prof.A.Pandiaselvan M.S.Ortho., D.Ortho., Professor of Orthopaedics, Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai. This dissertation is submitted to The Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2015.

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Place: Chennai

Date:

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ABSTRACT

INTRODUCTION

Fractures of the distal humerus accounts for 2-6% of all fractures. Motor vehicle accidents are the major cause of distal humerus fractures in young population whereas simple accidental falls are the cause in elderly population. Composite problems in distal humerus fracture management include frequent articular involvement, metaphyseal communition, bone loss and osteopenia. Attempt to achieve painless stable yet mobile elbow requires a systematic approach. We hereby report the functional outcome of a series of distal humerus fractures with articular extension surgically treated with locking compression plates applied orthogonally.

MATERIALS AND METHODS

15 Patients(9 males, 6 females) with type C distal humeral fractures (C1-5 cases , C2 -8 cases and C3-2 cases) were operated with locking compression plates applied orthogonally and functional outcome was observed for a mean duration of 8 months. All fractures were closed injuries. Causes were motor vehicle accidents (10 cases) , accidental falls (4 cases) and assault (1 case). They were operated by chevron olecranon osteotomy(9 cases) , paratricipital (4 cases) , TRAP approach (1 case) and triceps splitting approach (1 case).mean duration of fracture healing was 12 weeks. Functional outcomes were assessed by Mayo elbow performance score system (MEPS).

RESULTS

Excellent and good results were found in 6 cases each. 2 patients had fair outcome and 1 patient had poor result. Complications encountered in our study were paraesthesia along ulnar nerve distribution(2 cases), infection(superficial treated with antibiotics 2 cases), stiffness, heterotopic ossification(2 cases each) and hard ware prominence(1 case).

CONCLUSION

Complications were minimal and outcomes were satisfactory in patients with type C distal humerus fractures who underwent bicolumn locking compression plates fixation applied orthogonally by posterior approach .

KEYWORDS

Orthogonal plating , distal humerus , LCP ,olecranon osteotomy , modified tension band wiring

CONTENTS

INTRODUCTION

Fractures of the distal humerus accounts for 2-6% of all fractures and 1/3 of all humeral fractures. In our society the incidence of distal humeral fractures is increasingly having a bimodal distribution .Motor vehicle accidents are the major cause of distal humerus fractures in young population whereas simple accidental falls are the cause in elderly population. In this era of modern orthopaedics, despite various advances ,distal humeral fractures remain one of the most challenging injuries to treat. Composite problems in distal humerus fracture management include frequent articular involvement, metaphyseal communition, bone loss and osteopenia. The fore mentioned issues along with the complex three dimensional geometry pose great difficulties in internal fixation. Poor outcomes like stiffness is secondary to prolonged immobilization.Nonunion, high failure rate are noted with old internal fixation techniques. Attempt to achieve painless stable yet mobile elbow requires a systematic approach.

The treatment of these fractures is still debated and an ongoing quest for the ideal solution still remains. The chances of functional impairment and deformity are very high following

conservative treatment of distal fractures of the humerus. In the elbow principles of Good anatomical alignment, absolute stabilization and early mobilization are of more importance than in any other joint. ORIF of the fracture allows the surgeon to restore anatomical alignment of the fracture fragments and permit early range of motion exercises which may aid in the return of a functional range of motion of the elbow postoperatively. Various forms of internal fixation have been evolved over time in an attempt to best restore anatomical alignment of the distal humerus. The anatomical location to place the plates on the distal humerus has recently been debated throughout the literature with the majority of authors currently recommending at least two plates be utilized to provide adequate stability and allow for adequate restoration of anatomy.

The guidelines for fixation of distal humeral fractures has been a gold standard till now with 2 plates placed at a 90° angle to one another(orthogonal/perpendicular/90°/90° plating).Using these fixation techniques authors have reported satisfactory outcomes in 80% to 85% of patients due to early mobilisation and stable bicolumn construct.

As a result of ongoing search for a more secure technique later evolved the concept of parallel plating (180°) which involves placing one plate along the medial column of the distal humerus and the other plate along the lateral column with the screws in the distal fragment interdigitating with each other in the distal fragment restoring the *'tie beam arch'* of the distal humerus. The problems encountered during parallel plate technique is extensive soft tissue dissection and chances of neurovascular injuries .

AIM AND OBJECTIVE

To evaluate the functional outcome of distal humerus fractures treated with bicolumn locking compression plates applied orthogonally.

This is a study of patients who presented with closed fractures of distal humerus and underwent internal fixation with bicolumn locking compression plates applied orthogonally in our institute of Orthopaedics and traumatology , madras medical college and Rajiv Gandhi government general hospital , Chennai .

Postoperatively patients were followed up for the functional outcome of distal humerus fractures and the results were analysed.

REVIEW OF LITERATURE

Distal humeral fractures represents a constellation of complex articular fracture, resulting from severe trauma to elbow, which are difficult to treat. The complex three dimensional structure of distal humerus poses a challenging task for reconstruction if fractured. The diversity of views on the subject is an indication of poor quality of results.

Among patients, who sustain a fracture in the distal humerus, there is a bimodal distribution has been noted with respect to age & gender, with the maximum incidence in males aged 12 to 19 years and females aged above 60 years. The proportion of elderly patients who sustain these injuries is increasing, and this trend will continue. With this change in population, come fresh challenges for reconstruction, including poor bone quality, fracture comminution, and reduced capacity for rehabilitation.

Injury to distal humerus occurs from low velocity to high velocity. Low velocity injuries, are simple domestic falls in middle-aged and elderly females, in which the elbow is either struck directly or axially loaded, in a fall onto the outstretched hand . Road-traffic accidents, and sport injuries, are more common cause

of high velocity injury, in younger males. These patients, often have open fractures and other injuries,(17% other orthopaedic injuries and 5%multisystem injuries) . These young population when injured, affects the socio-economical background of the community.

In 1811, Desault(3) was the first one to come to conclusion that, these fractures are the most difficult of all fractures, with treatment options, ranges from essentially no treatment to replacement of joint. In early 20th century, many authors like Hitzrot(1932), Eastwood(1937), Evans(1953) Watson jones(1956), Deplama(1959) and Brown & Morgan(1971) were in favour of conservative approach. But, as the results of conservative approach were incongruous joint, non-union, malunion, and stiff elbow, most condemned conservative management in all type of fractures, and advised surgical management. The goals of treatment are a stable, painless and functionally useful elbow, and this can be achieved by proper anatomical restoration of articulating surface by open reduction, and stable internal fixation followed by early rehabilitation.

It was Van Gordner (1940) and Cassebaum[37] (1952), who first approached these fractures, by posterior means. They emphasized

the advantages of posterior approach over others as, 1. It affords a more adequate exposure of fractured parts. 2. It allows more freedom in the use of implants. 3. It involves dissection of soft parts that contain no major neurovascular structures, the ulnar nerve have been identified and retracted previously. 4. It is the only approach that can give clear view of joint surface. 5. With this not only the posterior surface, but also the borders of distal humerus can be utilised for fixation purposes 6. Less number of cutaneous nerves, when compared to medial and lateral approaches .

The trans-olecranon osteotomy approach, which is considered to be the gold standard, for management of distal humeral fractures was, first employed by Cassebaum[37] in 1952 and achieved good results. Other approaches which are proved useful, include the paratricipital(Alonso-Llames) , triceps-reflecting anconeus pedicle (TRAP) ,triceps-reflecting (Bryan-Morrey) , triceps-splitting(32,33) .

Chen G[38] in 2011, came to conclusion after analysis of 67 patients, that ORIF via the triceps-sparing approach, confers inferior functional outcomes for intercondylar distal humerus fractures in patients over the age of 60 years, for whom the olecranon osteotomy approach may be a better choice. However, for

patients less than 60 years of age, especially those less than 40 years of age, either approach confers satisfactory outcomes.

In 1953, Mervin Evans treated distal humeral fractures by alignment and fixation of articular surfaces, followed by attaching it to the shaft of humerus. Restoration of articular surface is of prime importance, and any residual displacement between the fixed articular fragments and the shaft, will not have great deleterious effects on the ultimate function.

Rehabilitation of the injured elbow, following surgery is equally important, as elbow is prone for stiffness if immobilised for long time. For early rehabilitation, the fractures should be fixed with a stable construct. The stable fixation is achieved by internal fixing the reconstructed articular block, with the shaft by plating on both pillars . Without this dual plate arrangement, stability of fixation can be inadequate, and this has been proven by many studies . These plates can be placed either, posteriorly on lateral side and over ridge, on medial side (perpendicular plating) or over ridges on both sides (parallel plating).

In the last quarters of century, improved outcomes of surgery for distal humeral fractures were reported, AO-ASIF group set out

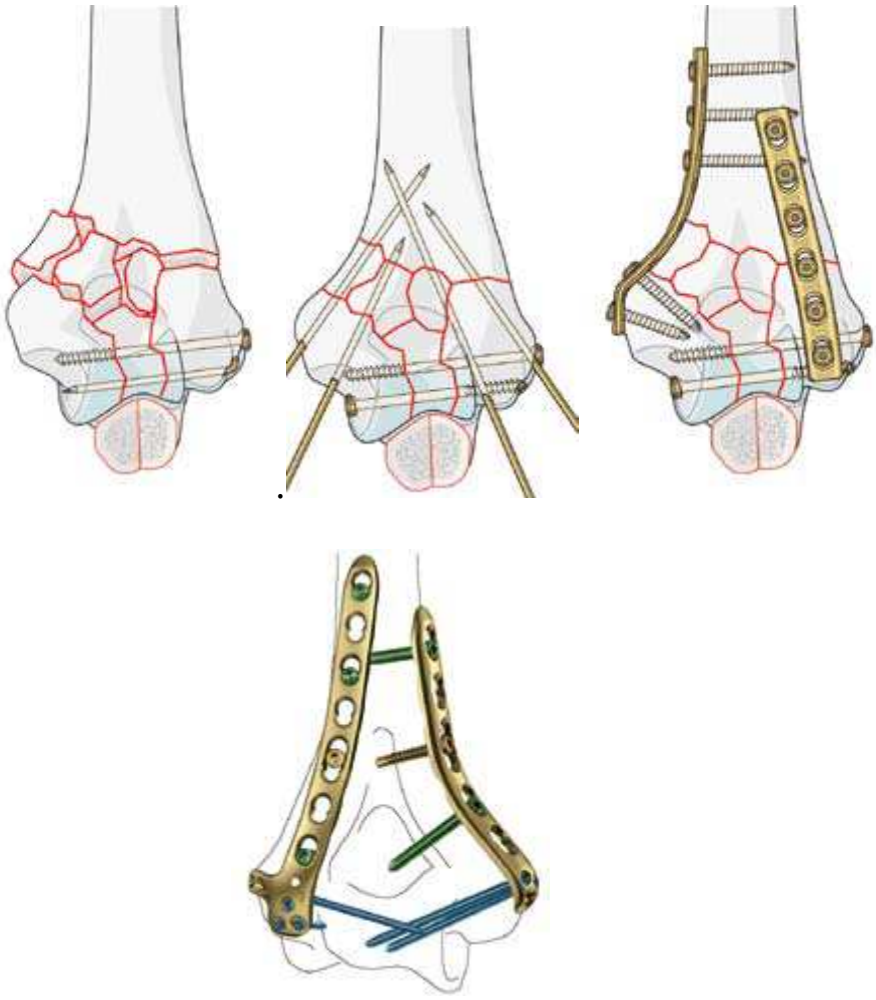
their principles of anatomical articular reduction and rigid internal fixation, through their perpendicular plating techniques. In 1990, Helfet, Hotchkiss[39] did biomechanical analysis of the perpendicular plating technique and added creditability to this technique. A number of subsequent clinical studies, revealed nearly 75–85% good to excellent results with 90–90 plating.

In 2007 ,Doornberg et al[15] concluded from a long term follow-up study of 19yrs , results of Type C fractures of the distal humerus treated with open reduction and internal fixation, are similar to the short term study reported .

Jacobson[27]concluded that perpendicular plate orientation was strongest in the sagittal plane while Korner stated that perpendicular plating had increased stiffness to torsional and anteroposterior bending forces. Schwartz found similar stabilization among both plate orientations.

Wong tested both fixation methods and concluded that both methods may be above the threshold necessary for early motion and predictable fracture healing, rendering the marginal strength of parallel plating clinically unimportant. Kimball found that the risk of delayed union or nonunion increased by the extensive

subperiosteal elevation with parallel plating orientation. Schutzer tested the perpendicular plate orientation with different plate types and concluded that implant choice was not critical in good bone quality. Korner showed that locking plates have a substantial advantage in poor bone quality or if significant metaphysical comminution is present. Otherwise they concluded that there was no difference in plate type and that plate position is critical



After parallel plating concept was introduced, numerous biomechanical studies were conducted between parallel and perpendicular plating for validation of superior one .Zalavras[17] et al (2011)[14] concluded that higher degree of stiffness and higher degree of resistance in torque, cyclical varus loading axial and sagittal loading to failure was exhibited by parallel plating compared to orthogonal plate constructs.

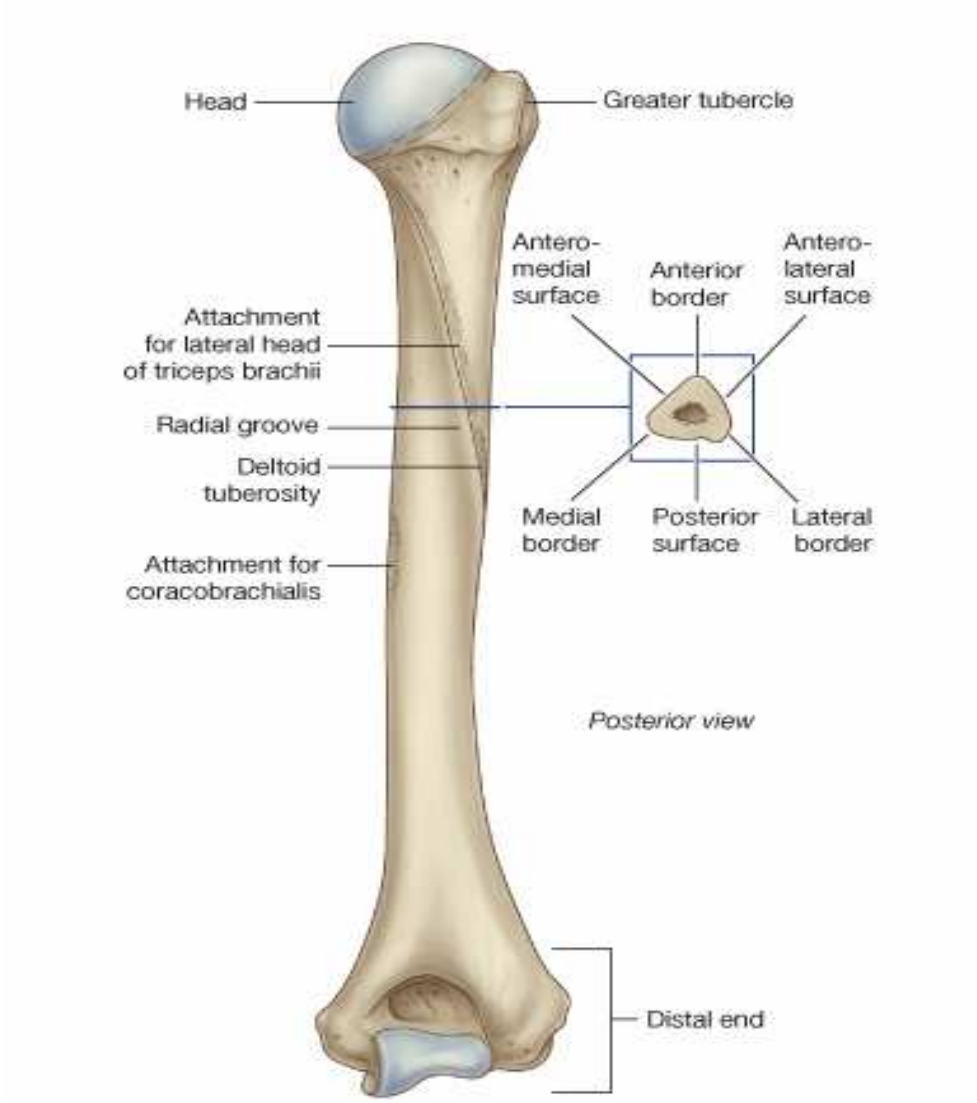
The perpendicular technique requires less soft tissue dissection, technically easy and the reports of non-union, in this technique is stastically insignificant. Though, parallel plating is more biomechanically stable than perpendicular as per cadaveric bone studies, clinical comparison of these two plates in large groups is not available till date.

The Various plates that are available for fixation are Locking compression plates, 3.5 mm reconstruction plates (simple and locking), One third tubular plates, lambda plates and Pre contoured distal humeral plates (parallel and perpendicular). Deshmukh and Deivendran et al in 2010 showed less implant failure with distal humeral locking plates [14]. The pre-contoured geometry allows easier reduction and saves operating time in fixation of complex fractures..A study by Corradi A et al compared the effectiveness

between distal locking compression plates of the distal humerus and reconstruction plates. The results showed no significant differences based on functional outcome and complications of the affected limb.

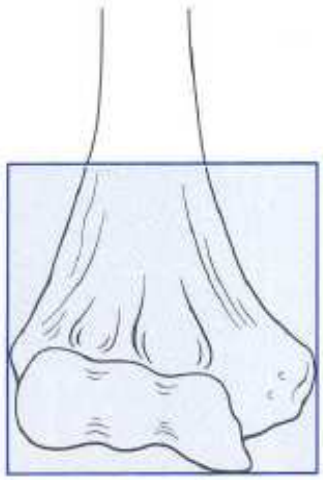
ANATOMY OF HUMERUS

The humerus is a long bone of upper limb which proximally articulates with scapula forming shoulder joint (glenohumeral joint) and distally with radius and ulna forming elbow joint. The humerus has a proximal (upper) end, shaft, distal (lower end). The proximal end consists of head, neck, greater tuberosity and lesser tuberosity. The head of humerus is ball-shaped and articulates with glenoid of scapula. The anatomical neck of humerus is formed by groove separating head from tuberosities . The junction of head and neck with body of humerus is indicated by greater and lesser tuberosities .It provides attachment toscapulo humeral muscles. The greater tuberosity is at lateral margin of humerus, whereas lesser tuberosity projects anteriorly from bone. The inter tubercular groove (bicipital groove) separates tuberosities. The surgical neck of humerus is narrow part distal to the tubercles and the crests descending from them, flanking the inter tubercular groove.[16]



The shaft of humerus has 2 prominences. the deltoid tuberosity which forms attachment for deltoid muscle and oblique radial groove in which the radial nerve and profundabrachii lie as they pass between the medial and long and then the lateral heads of the triceps brachii.

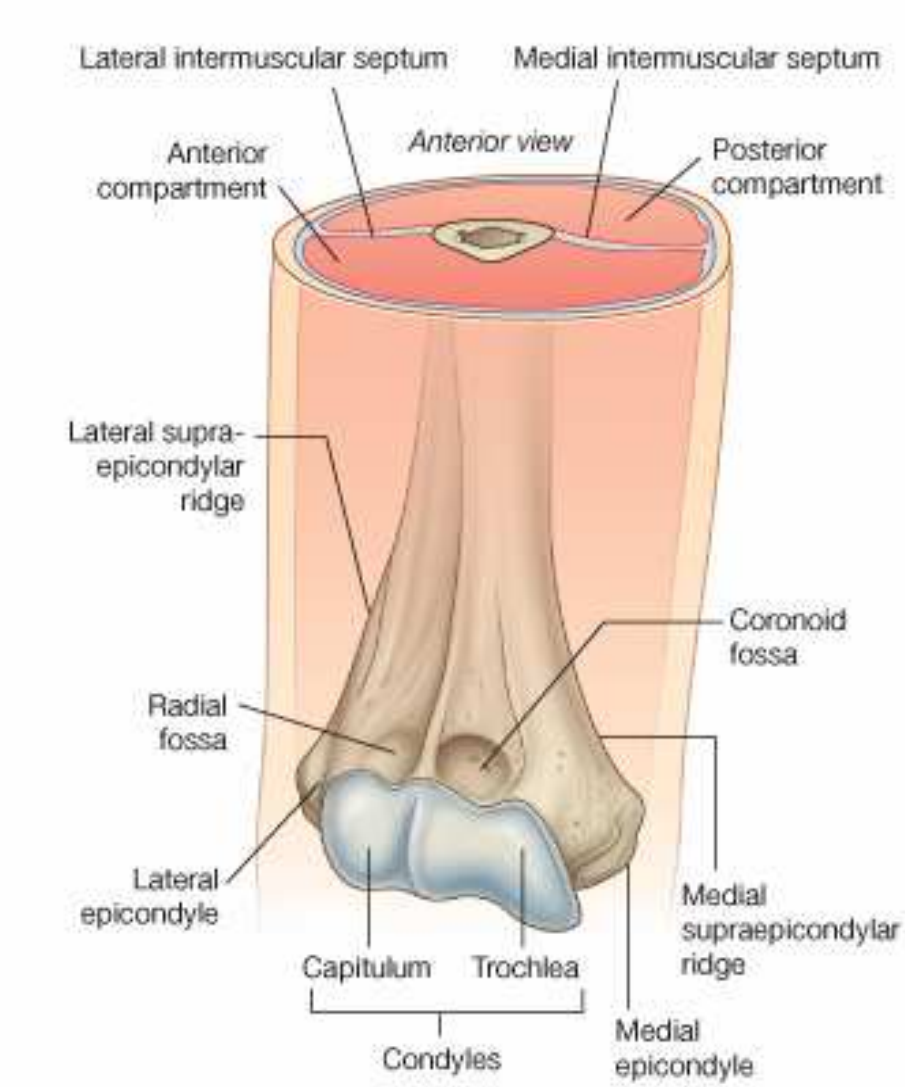
OSTEOLOGY OF DISTAL HUMERUS

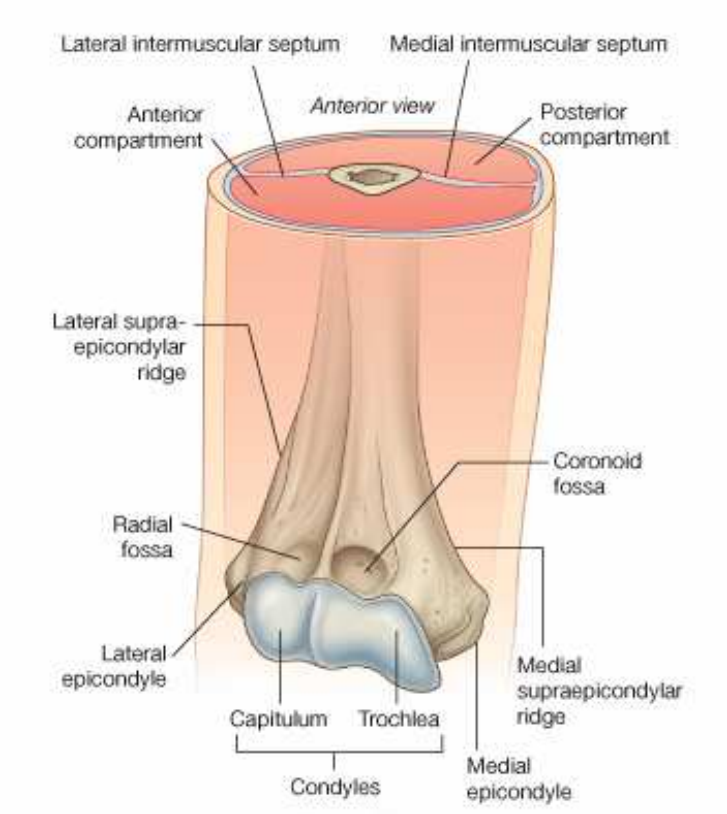


Epicenter described by Muller

The distal humerus is defined as the square of the epicentre between the epicondyles as described by Muller.

The distal humerus consists of two condyles which forms the articular surface of trochlea and capitellum. Proximal to trochlea, **prominent medial epicondyle** serves as an attachment of ulnar collateral ligament and flexor-pronator group of muscles. Laterally, **lateral epicondyle** is located just above capitellum and is less prominent than the former . Lateral collateral ligament and supinator-extensor muscle group originate from flat surface of lateral epicondyle. The posteroinferior aspect gives origin to the anconeus muscle partially .


Lateral intermuscular septum
Medial intermuscular septum
Anterior view
Anterior compartment
Posterior compartment
Lateral supra-epicondylar ridge
Coronoid fossa
Radial fossa
Lateral epicondyle
Medial supraepicondylar ridge
Capitulum
Trochlea
Condyles
Medial epicondyle

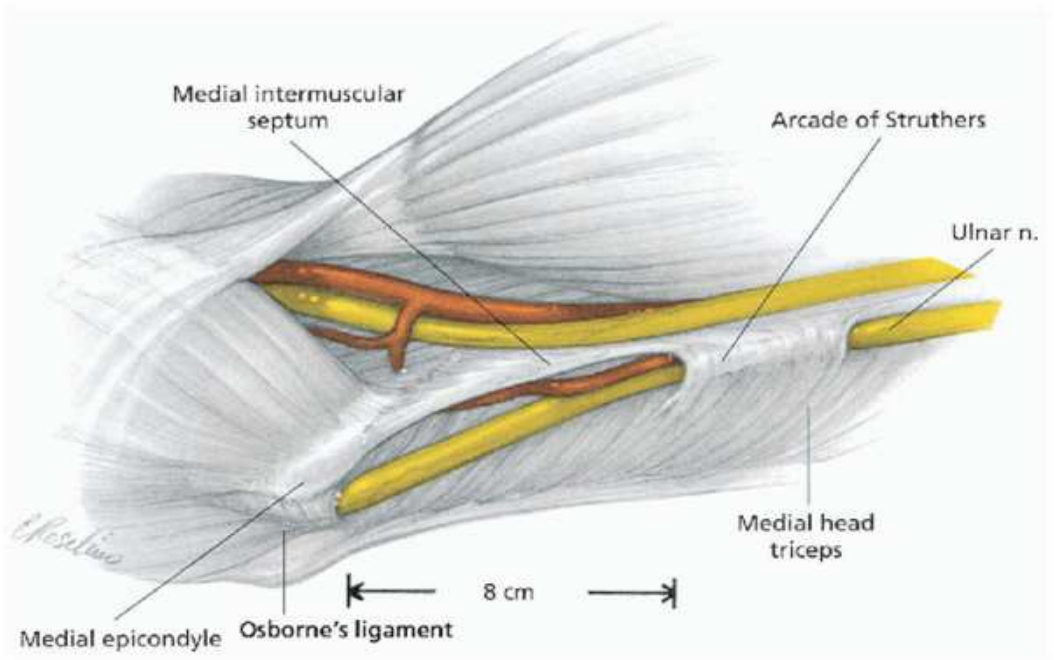


Just above articular surface of capitellum, **the radial fossa** accommodates the radial head during flexion. The coronoid inserts into a **large coronoid fossa** superior to the trochlea. Posteriorly, **the olecranon fossa** serves a similar purpose, receiving the tip of the olecranon during extension.A thin membrane of bone separates the olecranon and coronoid fossae in about 90 percent of individuals, although there is some race and sex variation with this anatomical feature. The coronoid and olecranon fossae are bordered by the strong lateral supracondylar column and a smaller medial supracondylar column. The difference in size of these two structures is important because the smaller medial column may be

vulnerable to fracture during insertion of some designs of humeral components at the time of elbow prosthetic replacement surgery. The posterior aspect of **lateral supracondylar column** is flat, whereas anterior surface is slightly curved. This allows ease of application of contoured plates to the posterior aspect of the lateral column and forms the basis of routine orthogonal plating. The **prominent lateral supracondylar ridge** separates the two surfaces into the so-called safe interval between brachioradialis and extensor carpi radialis longus anteriorly and triceps posteriorly. This serves as an important landmark for many lateral surgical approaches.[18] The radiologic appearance of the various bony landmarks is shown in the picture below

Proximal to the medial epicondyle, about 5 to 7 cm along the medial intermuscular septum, **a supracondylar process** is seen in 1 to 3 percent of individuals. A fibrous band termed the ligament of Struthers might originate from this process and get attached to medial epicondyle. When present, this spur serves as an anomalous insertion of the coracobrachialis muscle and an origin of the pronator teres muscle.Various pathologic processes are associated with supracondylar process such as fracture, median and ulnar nerve entrapment.

NERVES IN RELATION TO DISTAL HUMERUS



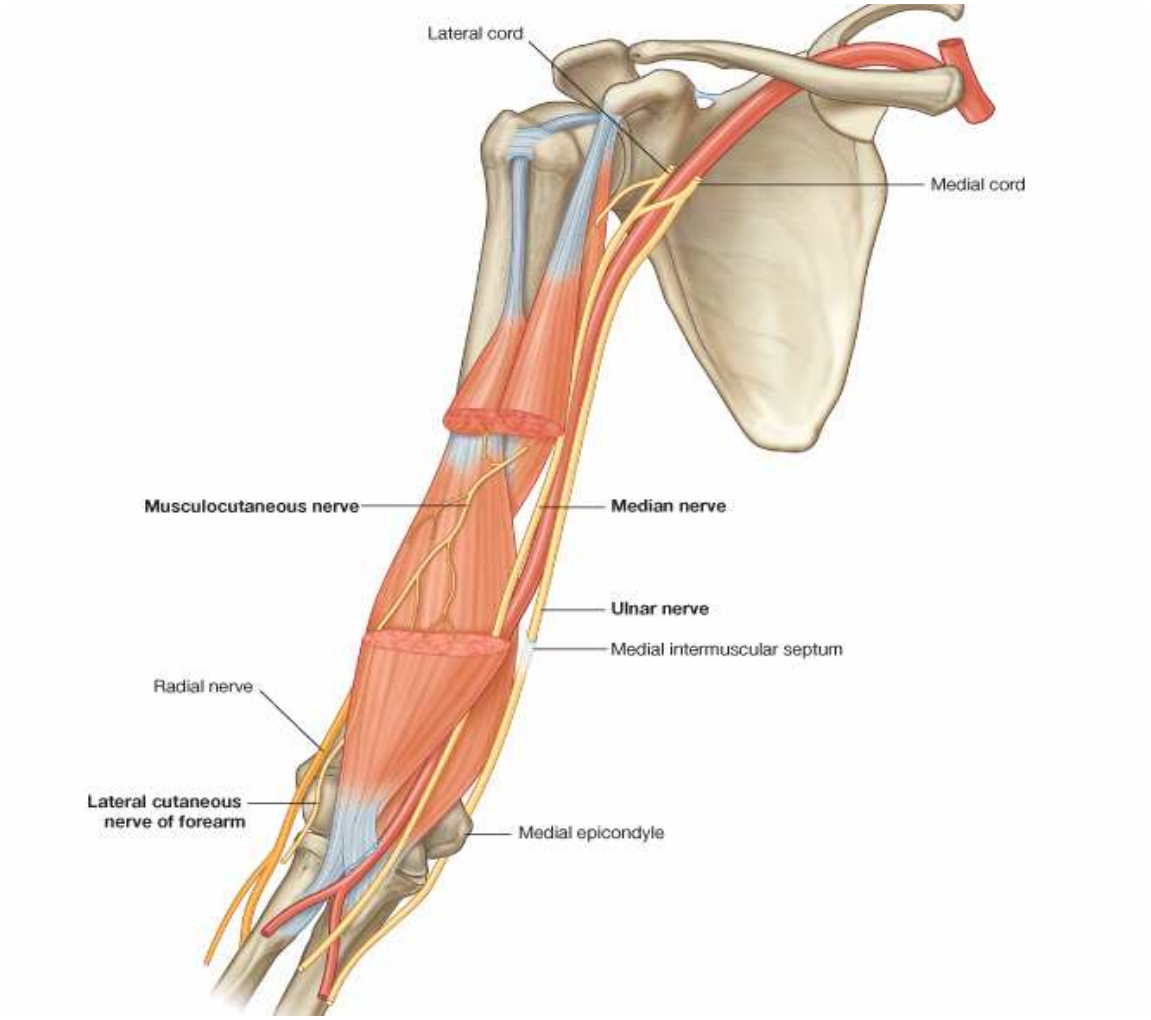
Anatomy of Ulnar nerve:

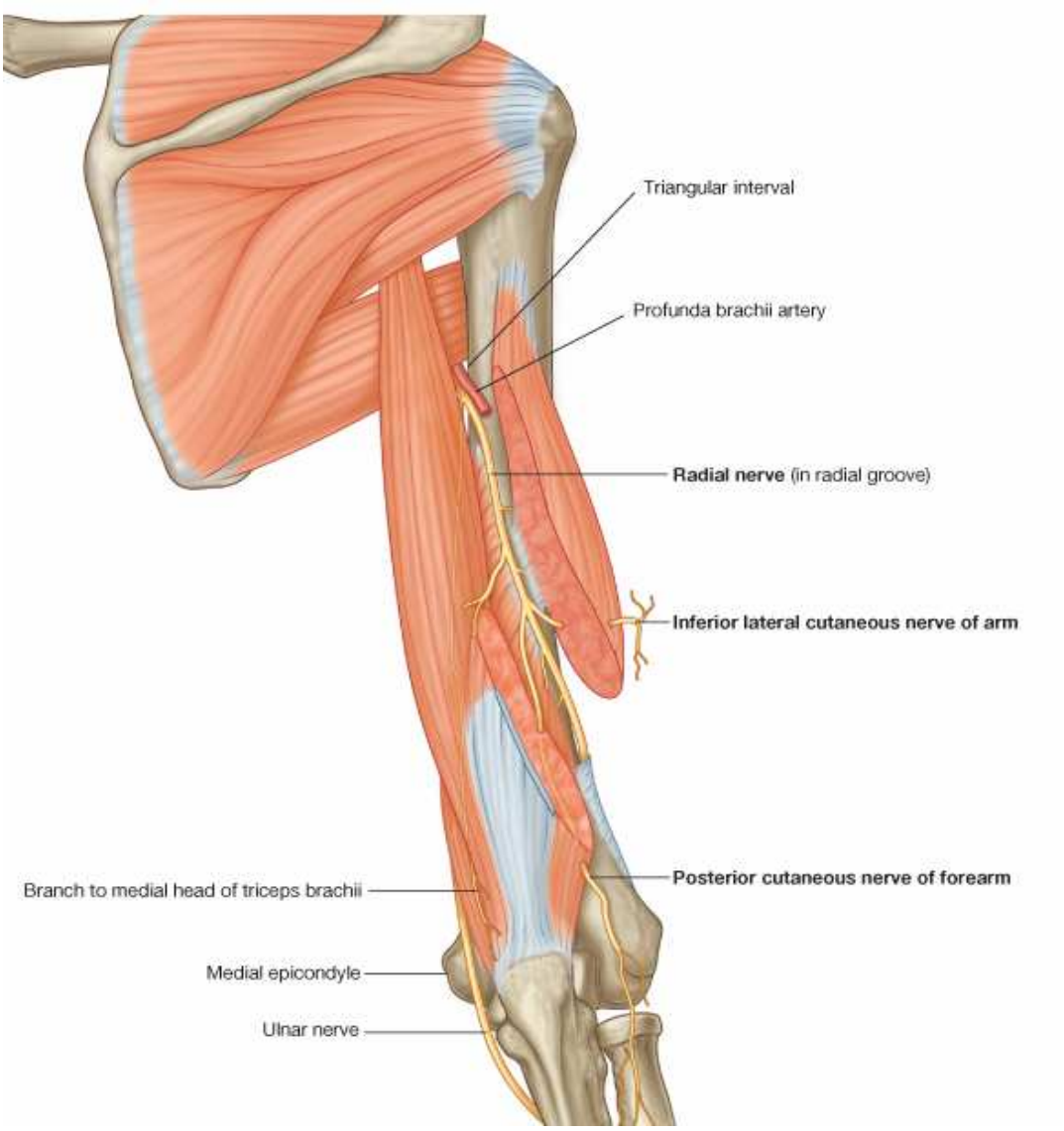
Eighth cervical and first thoracic root forms medial cord of the brachial plexus, which then divides into ulnar nerve and medial cutaneous nerves of arm and forearm. In midportion of arm ulnar nerve lies anterior to the medial head of triceps and posterior to medial intermuscular septum . In 70% of extremities a medial musculofascial arcade, as described by Struthers, covers the nerve. This arcade is located approximately 8 cm proximal to medial epicondyle and is composed of deep fascia of the arm, superficial fibers of triceps, and internal brachial ligament arising from the coracobrachialis tendon. The nerve then passes into a fibroosseous

groove that is bordered anteriorly by the medial epicondyle, posterior and laterally by the olecranon and ulnar humeral ligament, and medially by a fibroaponeurotic band. In this region numerous branches of superior and inferior collateral, posterior ulnar recurrent arteries, as well as several veins, accompany the nerve. Also at this level, a small articular branch leaves the ulnar nerve to innervate the joint capsule. Occasionally, an anomalous muscle called the anconeusepitrochlearis is encountered covering the ulnar nerve. This muscle arises from medial border of olecranon & inserts onto medial epicondyle.

After exiting the fibroosseous groove, the ulnar nerve travels between humeral and ulnar heads of the flexor carpi ulnaris. Osborne described a fibrous band that begins at the fibroaponeurosis of the epicondylar groove and continues to the flexor carpi ulnaris. It is often very thick and is a common cause of ulnar nerve compression. (Synonyms for the ligament described by Osborne are the triangular ligament, the arcuate ligament, and humeral ulnar arch.) In this region medial collateral ligament of elbow lies posterior to ulnar nerve. While lying within the muscle of the flexor carpi ulnaris, the ulnar nerve gives off motor branches to this wrist flexor. Traveling distally, the nerve pierces the flexor

pronator fascia and then lies between flexor digitorumsuperficialis (FDS) and flexor digitorumprofundus (FDP).





Radial nerve winds around from medial to lateral side of the humerus in a groove with profundabrachii artery, between medial and lateral heads of the Triceps brachii. It pierces lateral intermuscular septum approximately 10 cm proximal to the lateral epicondyle and enters the anterior compartment. It later passes between Brachialis and Brachioradialis in front of lateral epicondyle, where it divides into a superficial and a deep branch.

Median nerve descends through arm, it lies at first lateral to brachial artery; about the level of insertion of Coracobrachialis "it crosses the artery usually in front of, but occasionally behind it and lies on its medial side at the bend of the elbow, where it is situated behind the lacertusfibrosus (bicipital fascia), and is separated from the elbow-joint by the Brachialis".

VESSELS IN RELATION TO ELBOW JOINT

The major **blood supply** of distal humerus comes from brachial artery and its anastomosis around elbow.

Brachial artery and its anastomosis provides **blood supply** to distal humerus. The branches anastomosing *in front* of medial epicondyle are:

- anterior branch of inferior ulnar collateral
- anterior ulnar recurrent
- anterior branch of the superior ulnar collateral

Those behind medial epicondyle are:

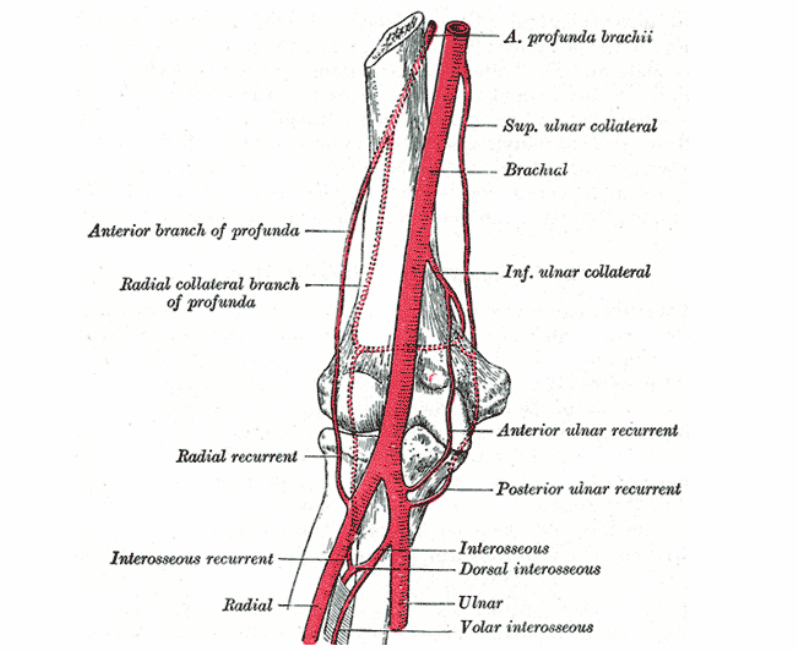
- inferior ulnar collateral,
- posterior ulnar recurrent
- posterior branch of superior ulnar collateral.

The branches anastomosing in front of lateral epicondyle are:

- radial recurrent
- terminal part of profundabrachii.

Those *behind* lateral epicondyle (perhaps more properly described as being situated between lateral epicondyle and olecranon) are:

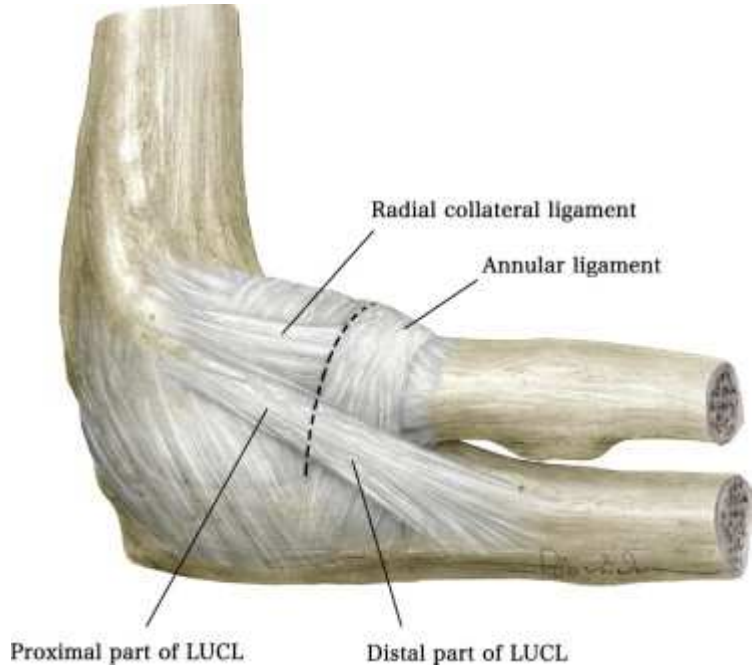
- inferior ulnar collateral
- interosseous recurrent
- radial collateral branch of profundabrachii.
- There is also an arch of anastomosis above the olecranon, formed by the interosseous recurrent joining with the inferior ulnar collateral and posterior ulnar recurrent artery.



LIGAMENTS AROUND THE ELBOW

Lateral collateral ligament (LCL) complex consists of

Radial collateral ligament, Lateral ulnar collateral ligament and Annular ligament.



Annular ligament attaches to anterior and posterior margins of lesser sigmoid notch, whereas radial collateral ligament originates from an isometric point on lateral epicondyle and fans out to attach to annular ligament . The lateral ulnar collateral ligament also arises from isometric point on lateral epicondyle and attaches to crista supinatoris of the proximal ulna. LCL complex functions as an important restraint to varus and posterolateral rotatory instability. The LCL complex is vulnerable to injury during

application of a direct lateral plate; therefore, exposure of the lateral aspect of the distal lateral column should not extend past the equator of the capitellum.

Medial collateral ligament (MCL) consists of an

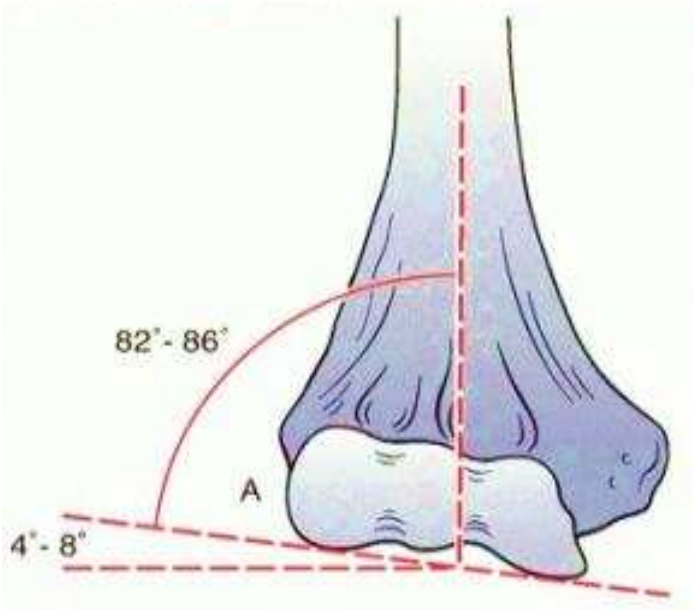
- Anterior bundle,
- Posterior bundle and
- Transverse ligament.

Anterior bundle is of prime importance in elbow stability. It originates from anteroinferior aspect of the medial epicondyle, inferior to the axis of rotation, and inserts on to sublime tubercle of coronoid. MCL functions as an important restraint to valgus and posteromedial rotatory instability. It is susceptible to injury at its origin during placement of a medial plate that curves around the medial epicondyle to lie on to ulnar aspect of the trochlea.

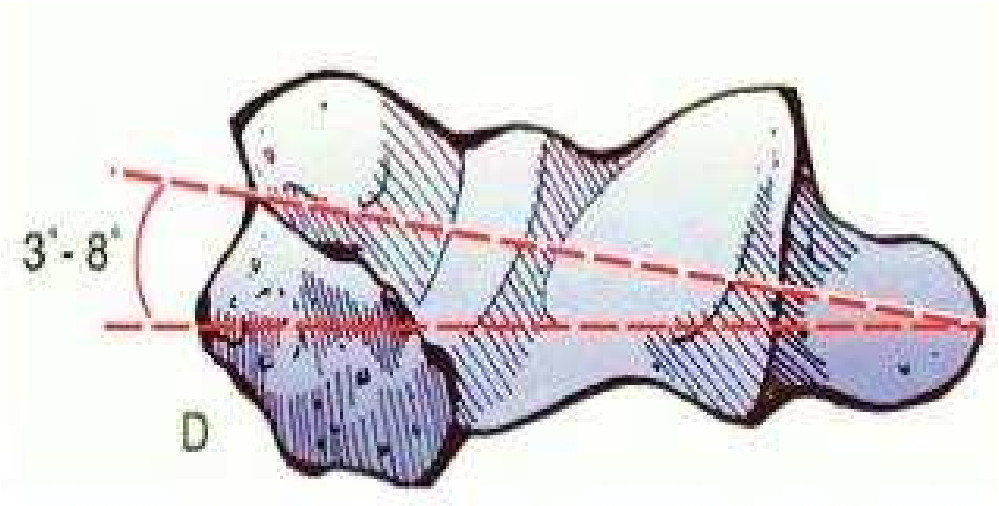
SURGICAL ANATOMY

Elbow is anatomically a trocho-ginglymoid joint, meaning that it has trochoid (rotatory) motion through the radiocapitellar and proximal radioulnar joints and ginglymoid (hinge-like) motion through ulnohumeral joint.

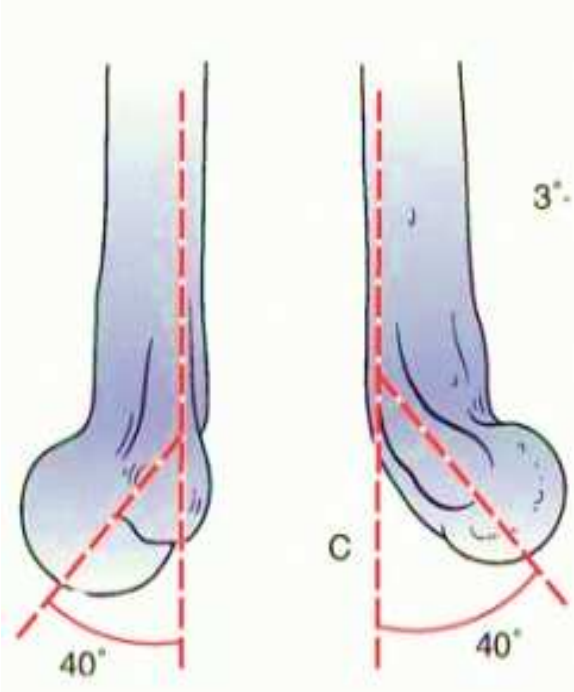
The olecranon of ulna articulates around the trochlea of humerus. **Trochlea** normally is tilted in 5 degree of valgus in males and 8 degrees of valgus in females, thus creating carrying angle of the elbow. A line drawn tangential to the articular surface on the **AP view** of distal humerus makes an angle of 4 to 8 degrees of valgus to shaft axis. . In male, mean carrying angle is 11 to 14 degrees and in female it is 13 to 16 degrees.



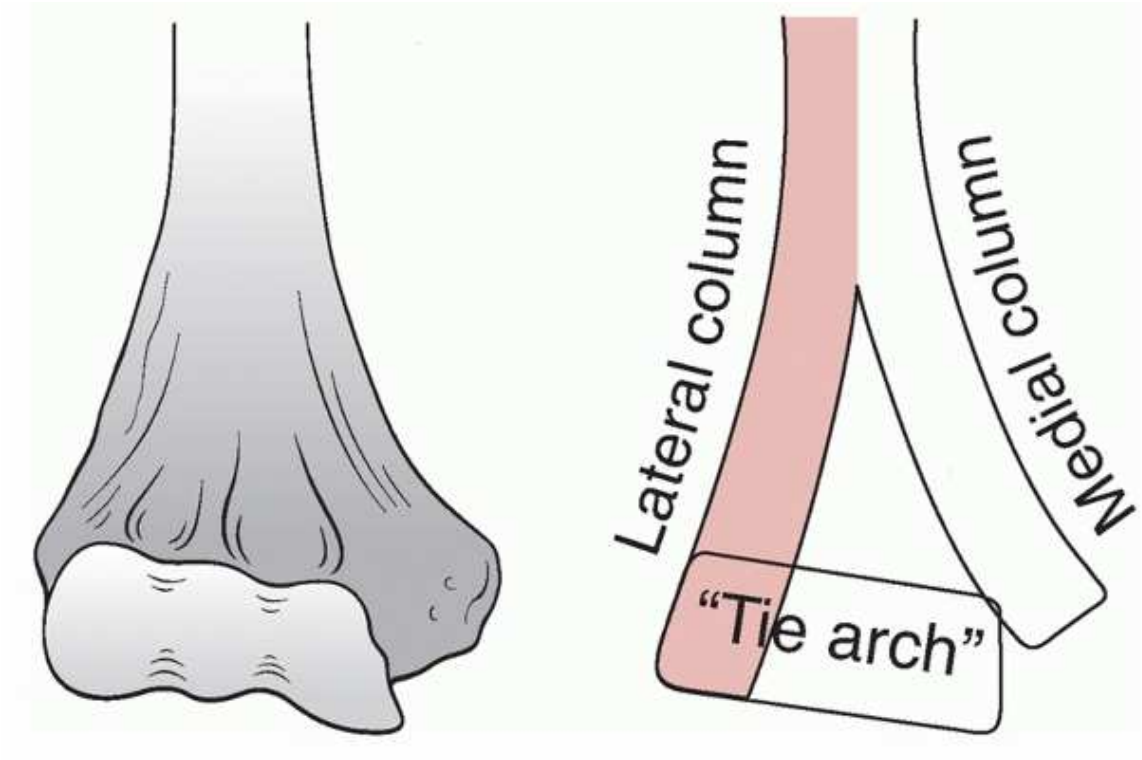
Trochlea is externally rotated 3-8 degrees from a line connecting medial and lateral epicondyles, resulting in external rotation of arm when elbow is flexed to 90 degrees.



The articular segment **juts forward from the line of the shaft at 40 degrees** and functions architecturally at the arch at the point of maximum column divergence distally. It is noted that **medial epicondyle** is on the projected axis of shaft, whereas **lateral epicondyle** is projected slightly forward from axis .



Trochlea must be restored to its normal position, acting as a tie beam between medial and lateral columns of distal humerus and thus acts as a keystone of the arch. This forms **the triangle** of distal humerus, which is crucial for stable elbow motion. Both columns must be securely attached to trochlea. So every attempt must be made to restore the proper valgus and external rotation of the trochlea to allow for stability, full motion and a normal carrying angle.



Medial column diverges from humeral shaft at approximately 45 degrees, continues and ends in medial epicondyle. As nothing articulates anteromedial epicondyle, it's entire surface is available for internal fixation hardware. Care should be taken to protect and transfer ulnar nerve anteriorly.

Lateral column diverges from the humeral shaft at approximately 20 degrees. It is largely cortical bone with a broad flat posterior surface, making it ideal for plate placement.

Coronoid is important to elbow stability and should be reduced and fixed if displaced.

Recessed and thinned bone just cephalad to the waist of the trochlea anteriorly is the coronoid **fossa** and its counterpart posteriorly is the Olecranon fossa. The thin wafer of bone that separates the depth of these fossae may be partially deficient in a small percentage of population. These fossae are designed for the receipt of radial head and coronoid and olecranon processes with full flexion and extension respectively (These are important points to bear in mind in the seating of screws on distal lateral or medial columns for the address of distal humeral fractures). Safe screw placement assures no violation of these fossae. Impingement by a misdirected implant blocks terminal joint motion. If the medial and lateral columns can be securely fixated to the trochlea, early motion should be tolerated.

At **posterior capitellum** cancellous screws must be used to avoid interrupting the anterior capitellar cartilage.

A second range of motion occurs with elbow joint in supination and forearm in pronation; this ROM is allowed by articulation of radial head with capitellum and ulnar notch.

BIOMECHANICS

Ulnohumeral articulation is the cornerstone of osseous Stability and mobility in flexion Extension plane especially the coronoid process.

Coronoid process resists posterior subluxation in extension beyond 30^{o} or greater, depending on the other injuries. The medial facet of coronoid is especially crucial to stability in varus stress. At extremes of ulno humeral motion, the coronoid or olecranon processes may 'lock' into their corresponding fossae, adding additional stability from muscular contraction and with little input from ligaments.

However, most activities in most patients rely on a combination of ligamentous integrity and bony integrity of the articulation.

Anterior band of medial collateral ligament secures medial side of the joint, running from an area just medial and distal to medial epicondyle and to sublime tubercle, slightly distal and medial to the coronoid itself. The brachialis muscle inserts more

distally on the anterior surface of proximal ulna. Fracture near the base of coronoid may compromise these important attachments.

The radial head also contributes to elbow stability by widening the base of support of the forearm, tensioning the posterolateral ligament and acting as an anterior buttress.

Fracture of the coronoid process, radial head, medial epicondyle, os olecranon may be associated with elbow dislocation, making treatment more complex.

Soft tissue structures about the elbow are responsible for as much as 40% of the resistance to valgus stress and 50% of that to varus stress in the extended position. The anterior bundle of the medial collateral ligament may provide one-third to one half of the elbow's resistance to valgus stress depending on the amount of elbow flexion and how "stability" is defined in the experimental setting.

Fracture of coronoid process, a fracture of medial epicondyle, and rupture of medial collateral ligament may completely disrupt the medial components of elbow. The lateral collateral ligament complex inserts onto the annular ligament. Injury to this ligament is responsible for posterolateral rotatory instability that may lead to

recurrent dislocation if not properly protected during the rehabilitation.

Muscles surround the elbow, besides the biceps / brachialis and triceps, theoretically stabilize the elbow as well. However, it is difficult to quantify the importance of the supinator tendon, ECU and the extensor origin.

Except for anecdotal recommendations, repair of these muscles after acute injury has never been documented to be crucial in preventing redislocation, despite certain injury and disruption.

CLASSIFICATION SYSTEMS IN DISTAL HUMERUS FRACTURES

ANATOMICAL CLASSIFICATION:

Supracondylar fractures, transcondylar fractures, intercondylar fractures, fractures of the condyles (lateral and medial), fractures of articular surfaces (capitellum and trochlea) and fractures of epicondyles.

THE COMPREHENSIVE AO – OTA CLASSIFICATION: (17)

Distal humeral fractures -13

A Extra Articular fracture

A1 : Apophyseal avulsion

A2 : Metaphyseal simple

A3 : Metaphyseal Multifragmentary

B Partial Articular fracture

B1 : Lateral sagittal

B2 : Medial sagittal

B3 : Frontal

C Complete articular fracture

C1 : Articular simple , Metaphyseal simple

C2 : Articular simple , Metaphyseal multifragmentary

C3 : Articular , Metaphyseal multifragmentary

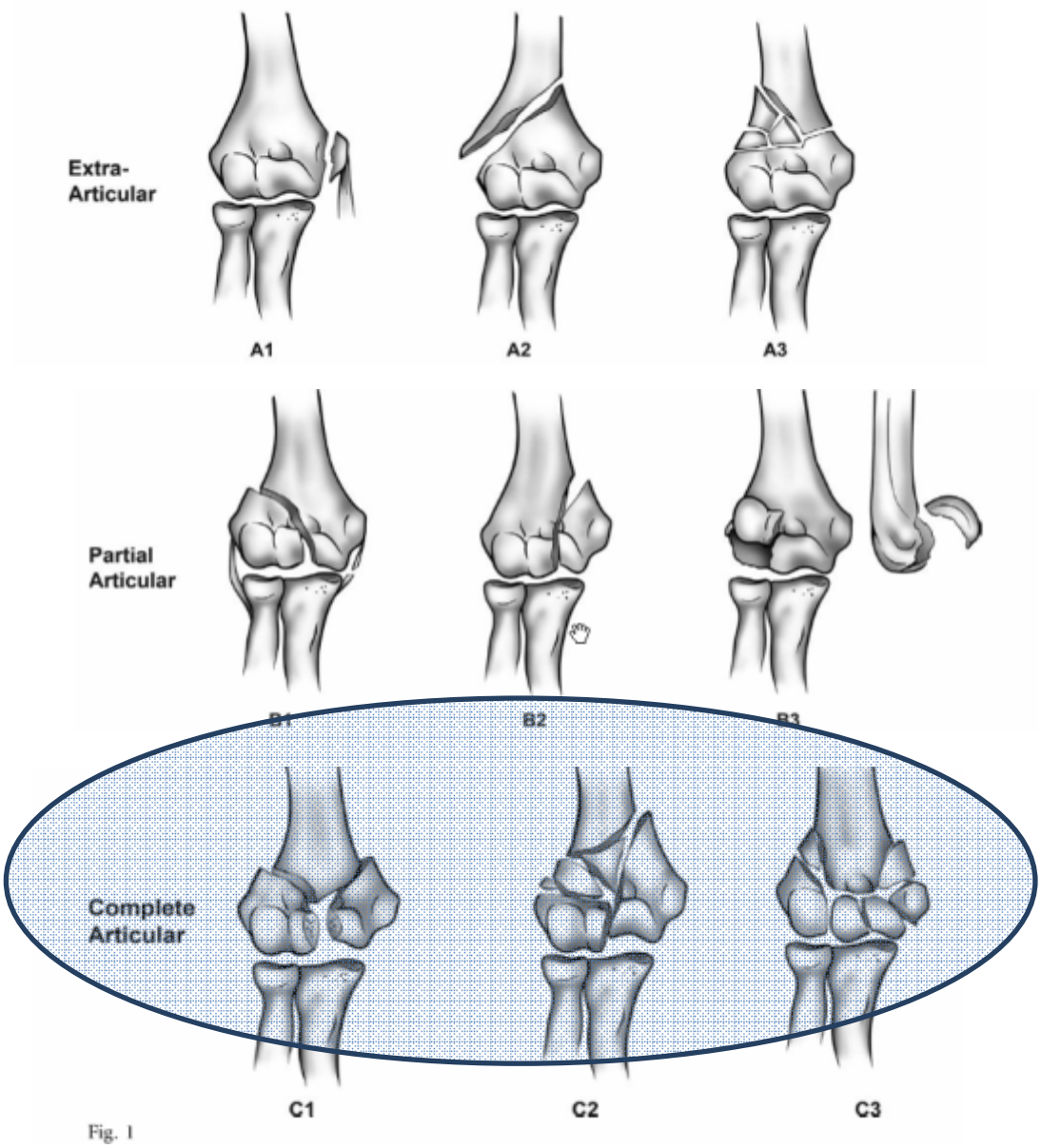
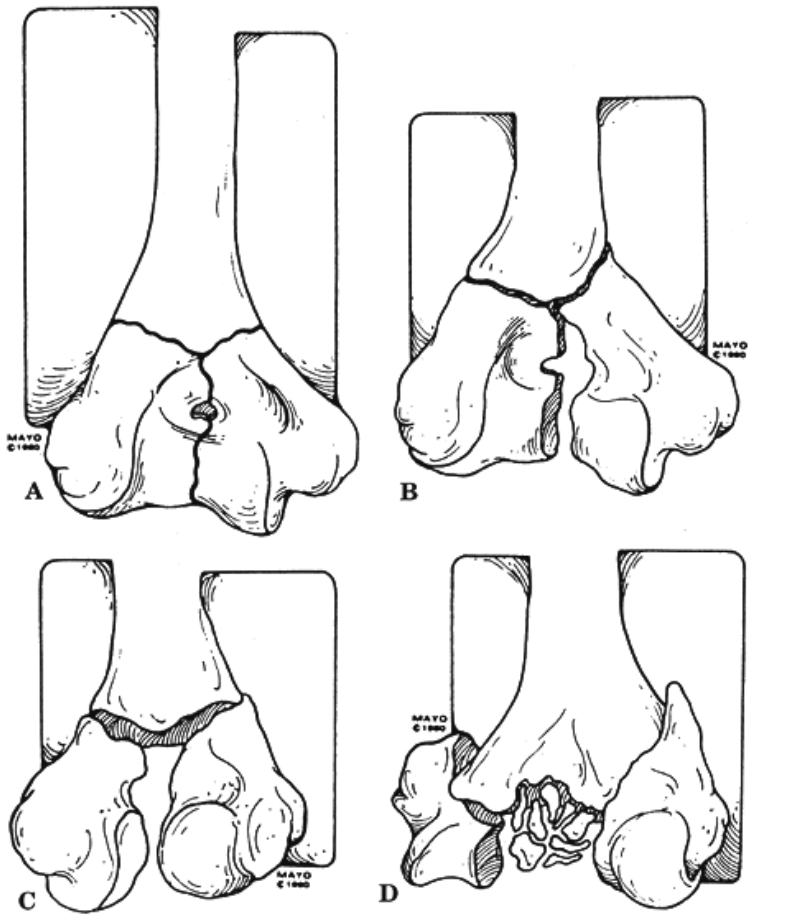


Fig. 1

RISEBOROUGH AND RADIN CLASSIFICATION (18)

Type I	Nondisplaced
Type II	Slight displacement with no rotation between condylar fragments
Type III	Displacement with rotation
Type IV	Severe comminution of articular surface



THE MEHNE AND MATTA CLASSIFICATION: (29)

It is based on, Jupiter's model of distal humerus[29] which is composed of two divergent columns, that support an intercalary articular segment.

1. Intraarticular

a) Single column: high medial, high lateral, low medial, low lateral and divergent single column fracture

b) Bicolumn: high T, low T, Y, H, medial lambda, lateral lambda fractures

c) Articular surface: capitellum, trochlea or both

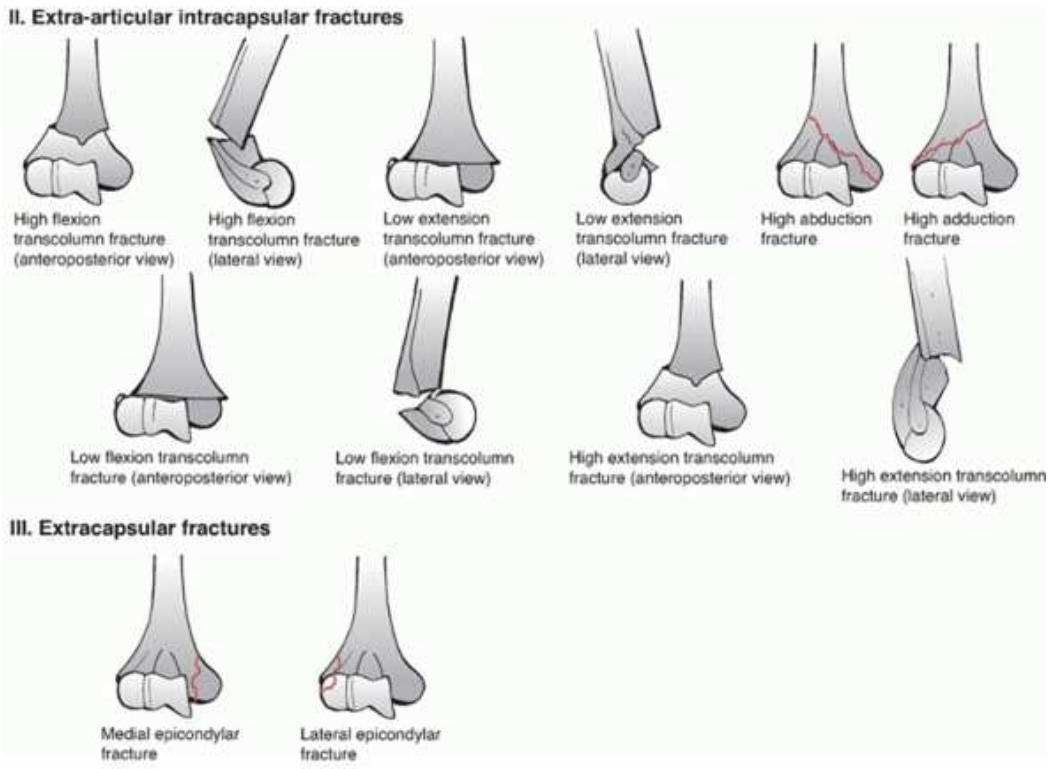
2. Extraarticular intra capsular fractures

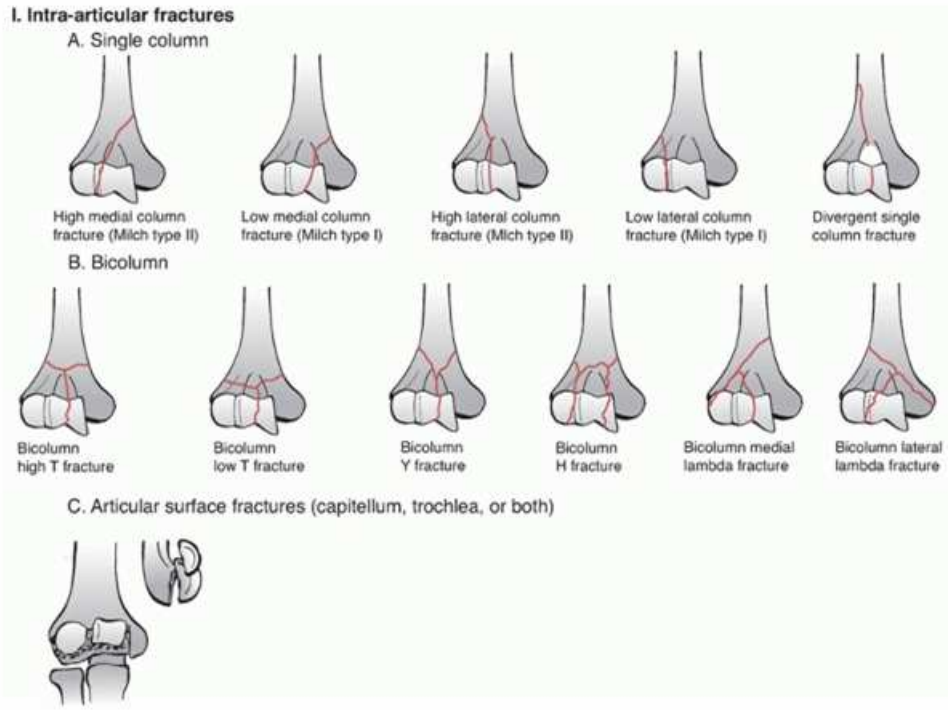
High flexion, low flexion, high extension and low extension, trans column fractures, high abduction and high adduction fractures.

3. Extracapsular fractures

Medial epicondylar and lateral epicondyle fractures

THE MEHNE AND MATTA CLASSIFICATION





MATERIALS AND METHODS

STUDY DESIGN:

A prospective and retrospective study was done to evaluate the functional outcome of distal humeral fractures treated with locking compression plates applied orthogonally and the results were analysed.

STUDY GROUP:

The study group consists of 15 Patients with distal humeral fractures, who underwent osteosynthesis with orthogonal plating technique between June 2012 and Sep 2014 at the institute of Orthopaedics and traumatology , Madras medical college and Rajiv Gandhi Government General Hospital, Chennai. The study was done after getting clearance from Hospital ethical committee. Those who fulfilled the inclusion criteria given below, were invited to participate in the study. Informed consent was obtained from all the patients willing to take part in the study

A. INCLUSION CRITERIA:

1. Intra articular fractures of distal humerus
2. Age >18 years
3. AO Types C1,C2 and C3
4. Closed injuries
5. Consenting to study

b. EXCLUSION CRITERIA:

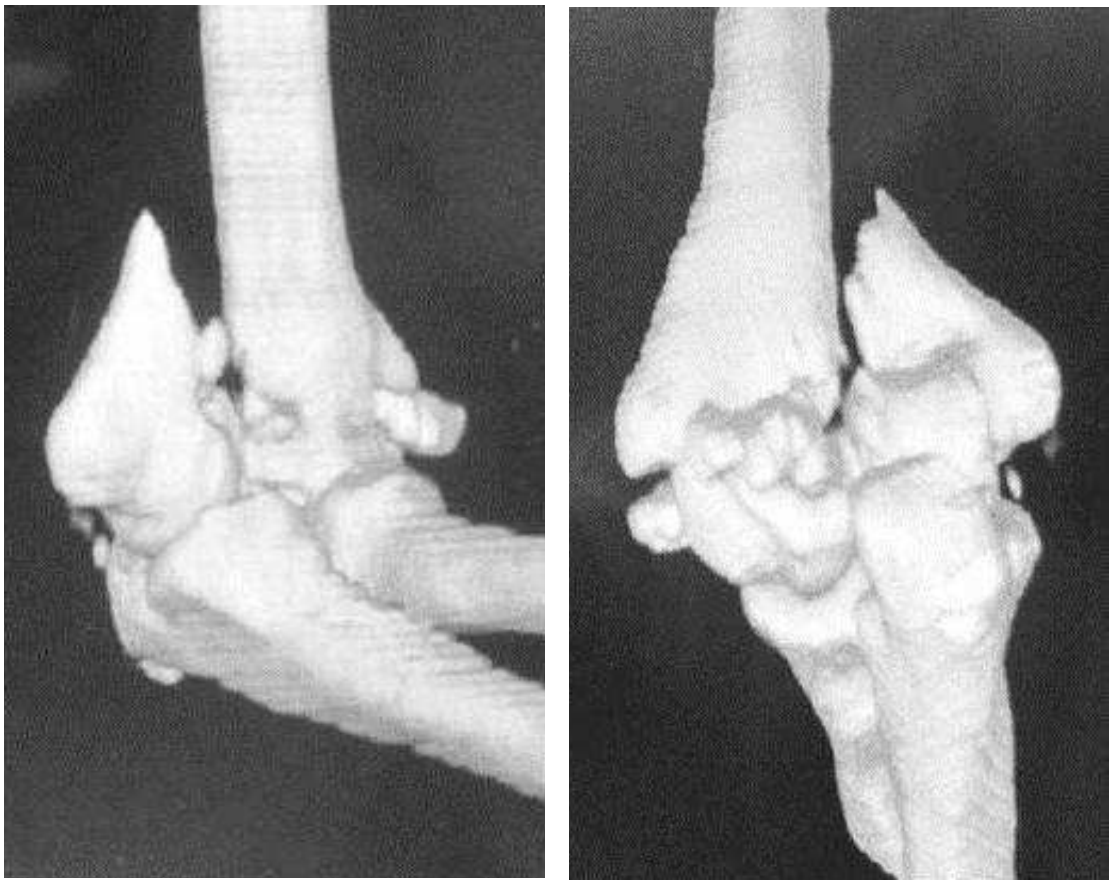
1. With head injuries and vascular injuries
2. Open fractures
3. severe intra articular comminuted fractures in elderly
4. Patients who had medical comorbidities
5. not willing to participate

On admission history was elicited from the patients and attendants to find out the mechanism of injury and associated injuries. A detailed clinical examination and radiological assessment was done to assess the fracture pattern, deformity, neurovascular status associated injuries . Then the injured limb was immobilized in a above elbow plaster slab until surgery.

TREATMENT PROTOCOL

CLINICAL HISTORY AND EXAMINATION:

A primary detailed history regarding name, age, sex, date of injury, mechanism of injury, residential address, occupational status and associated injuries were recorded. Patients general condition, vitals were noted. x rays were taken in both true antero-posterior and true lateral views in slight traction after removing slab if applied previously. 3D reconstruction CT views of elbow joint were taken for evaluating the number of fragments, degree of comminution and displacement if required which aided in planning of surgery, type of implant and placement of screws.

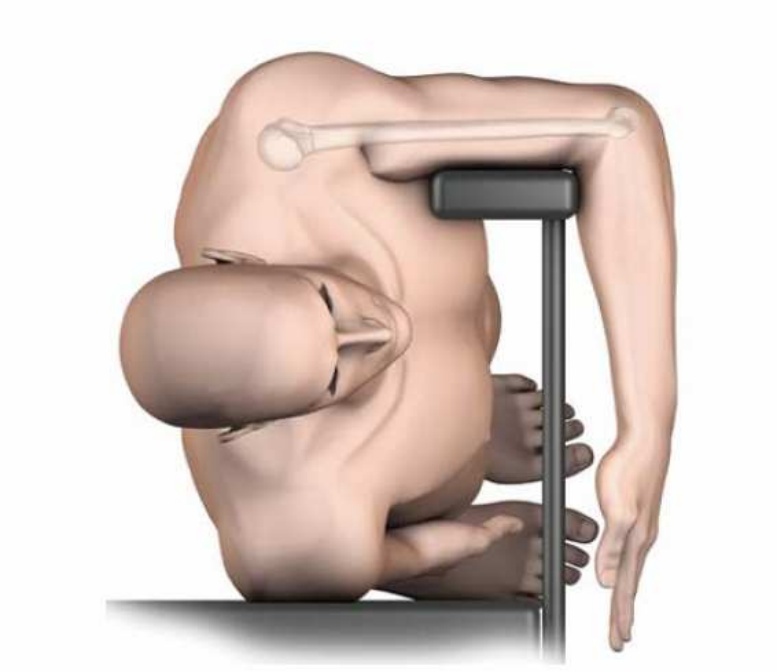


LABORATORY WORK UP:

The patients were submitted to basic investigations required for pre anesthetic checkup. Associated medical comorbidities were dealt with if present.

SURGICAL TECHNIQUE:

The patients were given a general anesthesia or regional anesthesia and were positioned in the lateral position, with the involved limb supported over bolsters in OT table .

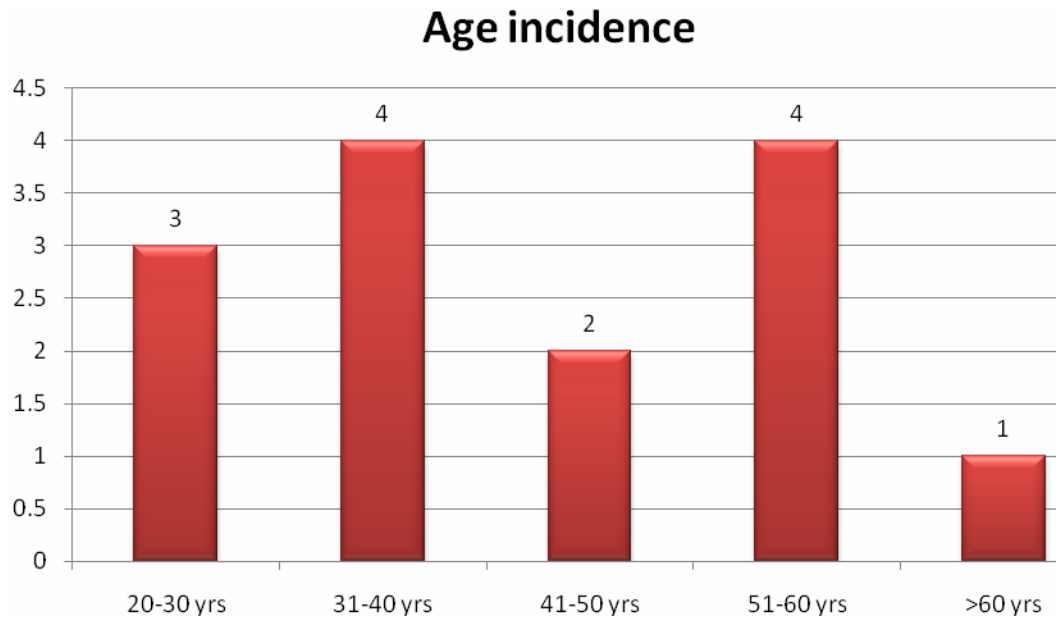


Through a midline posterior skin incision subcutaneous and deep fascia incised and before proceeding further, the ulnar nerve is identified, dissected out and retracted gently with an umbilical cotton tape. Triceps muscle identified and released on either side from the intermuscular septum. In complex articular fractures Chevron V shaped olecranon osteotomy done incompletely with saw and completed with an osteotome to visualize the articular surface. In other types we utilized any of the described approaches like TRAP, paratricipital or Triceps splitting approach .The olecranon osteotomy helps in wide exposure of intra articular fragments in type C fractures

AGE INCIDENCE AND DISTRIBUTION

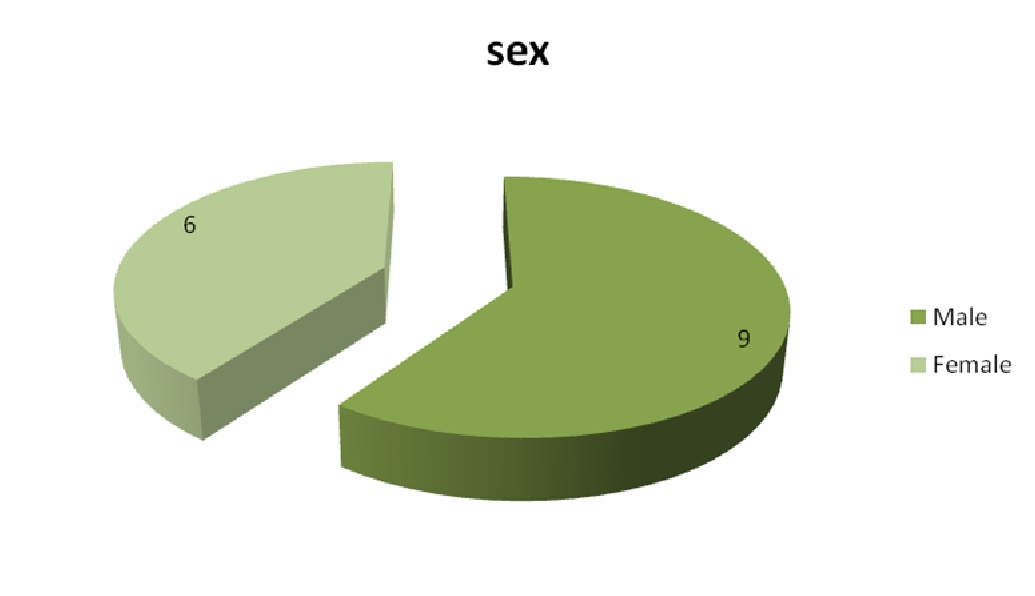
Age	No of Patients	Percentage
20 to 30 Years	3	20%
31 to 40 Years	4	26.6%
41 to 50 Years	3	20%
51to 60 years	4	26.6%
>60 years	1	6.6%

The Mean age of the patients was 36 year ranging from 20 to 65 years.

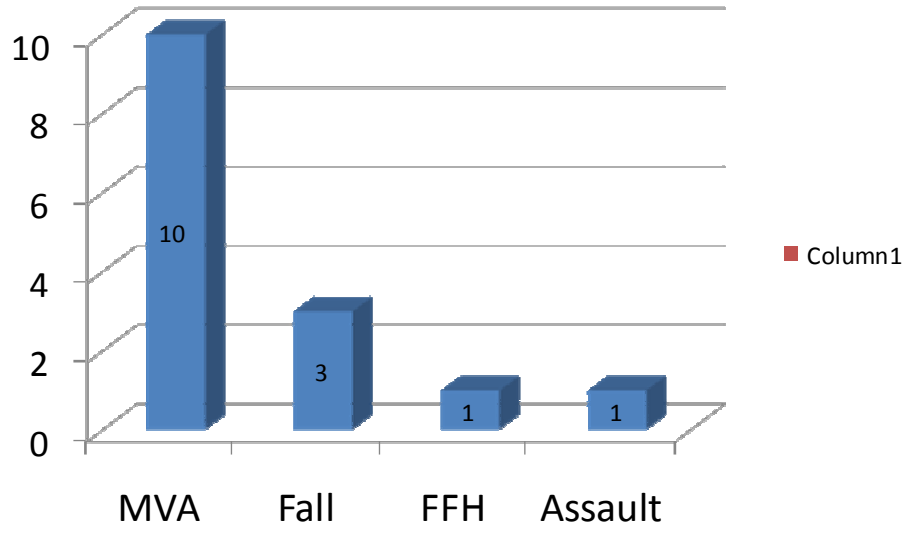


SEX INCIDENCE:

Males dominated in our study .Male: Female ratio was 3:2



MODE OF INJURY:



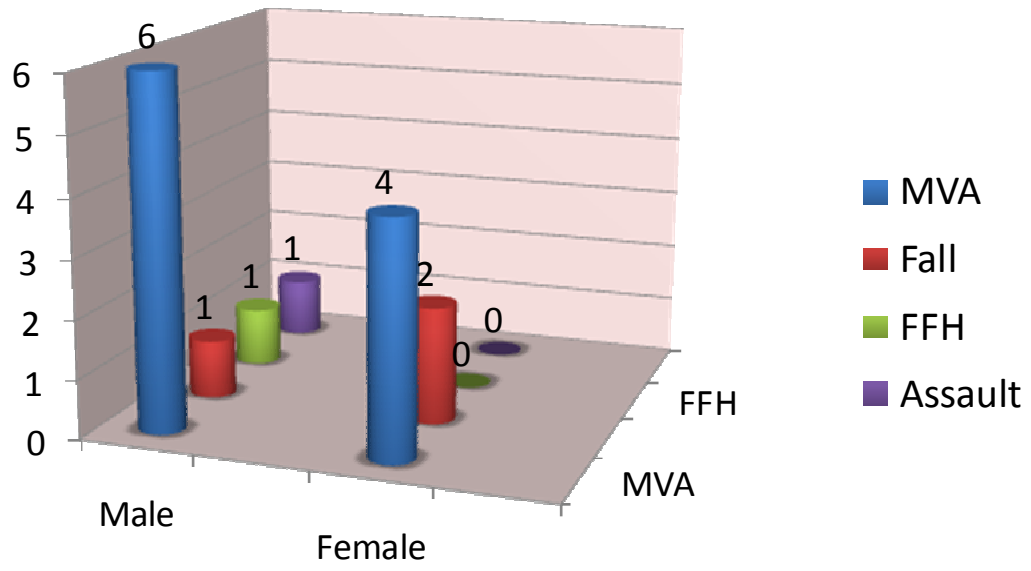
Majority of the patients suffered Motor vehicle Accidents(MVA) . The second most common mode of injury was accidental falls. Other mode of injuries were fall from heights(FFH) and assault.

Mode of injury	**No.of Patient**	**Percentage**
MVA	10	66.5%
Simple Fall	3	20%
FFH	1	6.6%
Assault	1	6.6%

GENDER AND MODE OF INJURY

Males constituted two-thirds of our study. Young males predominantly sustained injury by motor traffic Accidents whereas females predominantly sustained accidental fall .**Male:Female= 3:2**

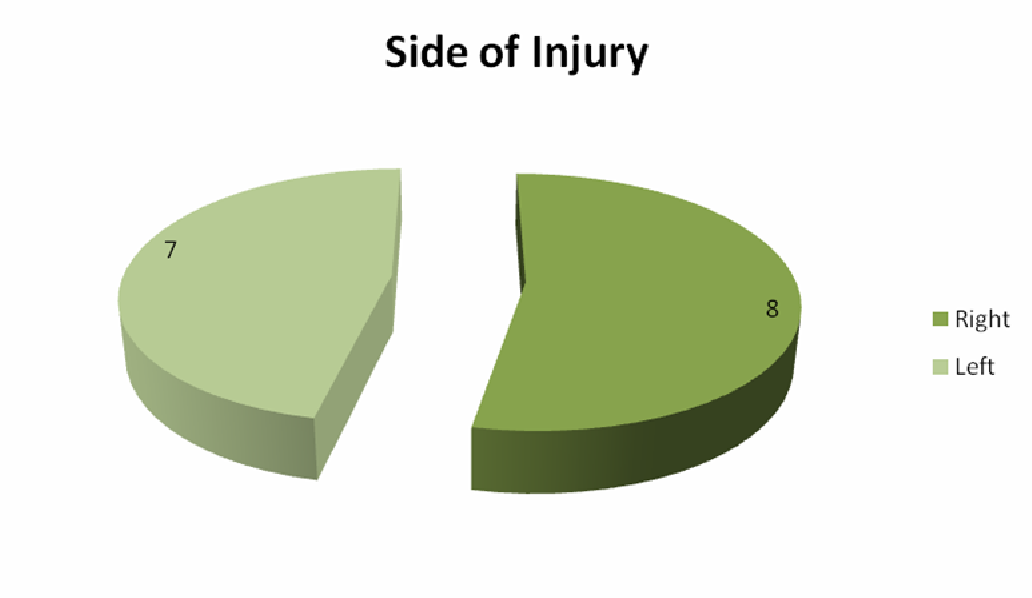
Mode of injury	Male	Female
MVA	6	4
Simple Fall	1	2
FFH	1	-
Assault	1	-
TOTAL	**9**	**6**



Mode of Injury

SIDE OF INJURY

8 patients(53.3%) had fracture of right distal humerus and 7 (46.7%) patients had fracture of left side.

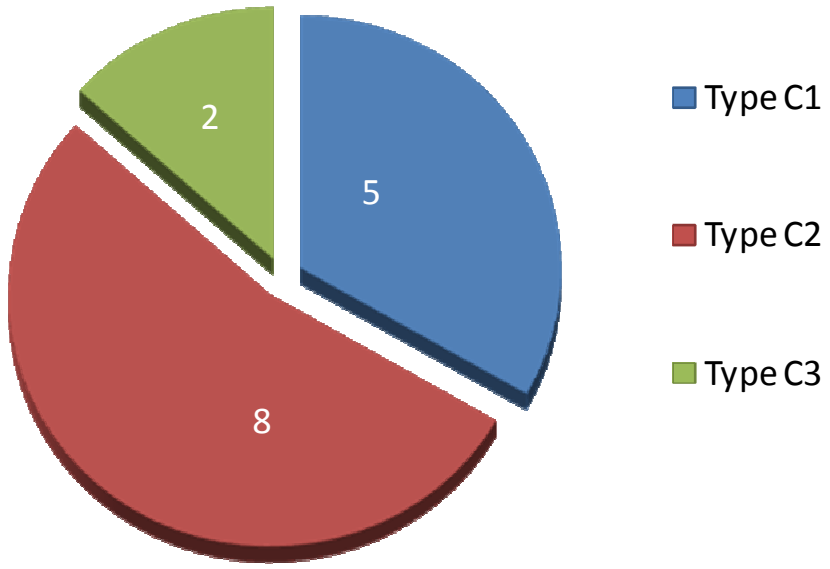


The ratio of right sided injuries to left sided ones reported in our study is 1:1

FRACTURE DISTRIBUTION:

Of all the Intraarticular fractures type C2 constituted the majority with 53.33% , type C1 (33.33%) and type C3 (13.33%)

Fracture type (AO-OTA)	No. of Patients	Percentage
C1	5	33.33%
C2	8	53.33%
C3	2	13.33%



ASSOCIATED INJURIES

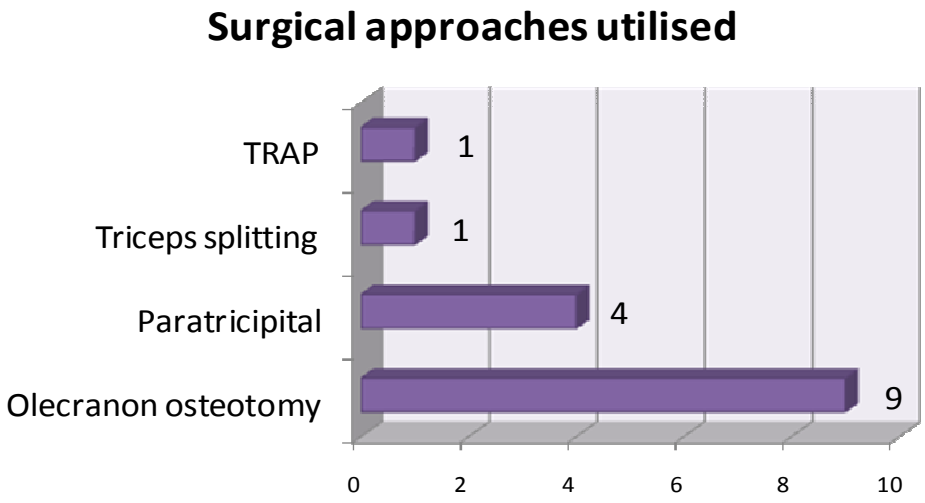
In our study the following associated injuries were noted

Associated injuries	No. of Patients
Fracture of Distal radius	4
Fracture shaft of contralateral humerus	1
Fracture of pubic rami	3
Fracture Metacarpals	2
Median Nerve palsy	1

SURGICAL APPROACHES :

We used chevron osteotomy of the olecranon for fracture fixation in 9 of our cases(60%) .Other approaches used were paratricipital approach in 4 cases(26.66%),triceps splitting approach in 1 case (6.66%) and TRAP approach in 1 case (6.66%).

Procedure	No. of Patients
Olecranon osteotomy	9
Paratricipital	4
Triceps splitting	1
TRAP	1


Surgical approaches utilised
TRAP
Triceps splitting
Paratricipital
Olecranon osteotomy
1
1
4
9
0
2
4
6
8
10

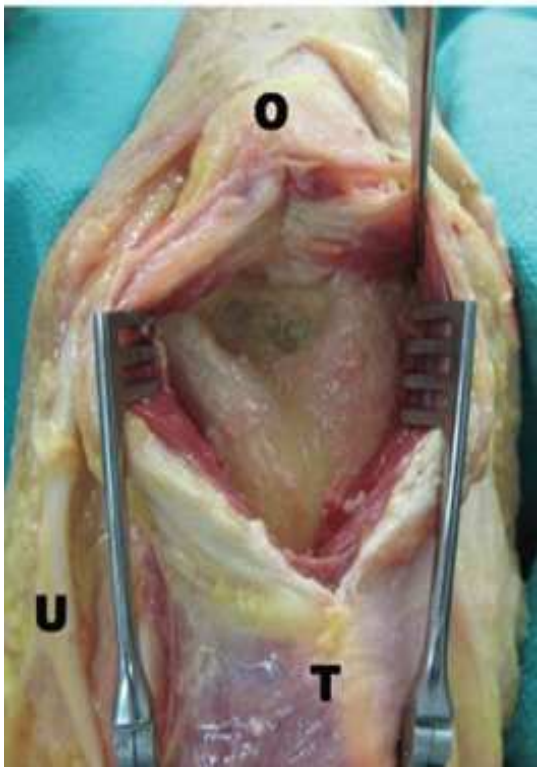
SURGICAL APPROACHES

1.TRICEPS- SPLITTING APPROACH (CAMPBELL): (19)

Involves splitting the triceps longitudinally through the midline of the triceps aponeurosis down to bone followed by sub-periosteal elevation of the triceps medially and laterally.

Triceps split extends distally onto the olecranon and proximally, the radial nerve limits the extent of dissection.

This approach does not provide proper exposure of the distal articular surface.

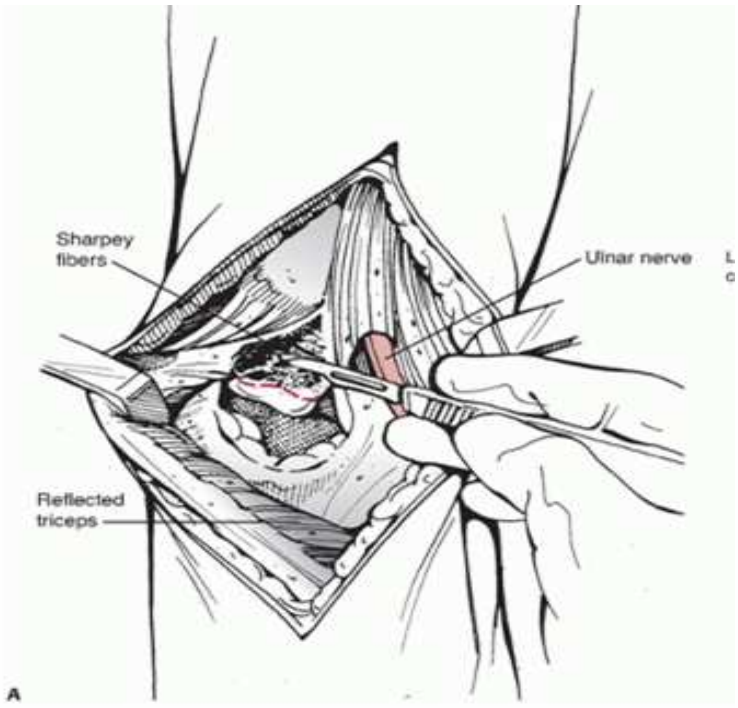


2.TRICEPS- REFLECTING APPROACH (BRYAN-MOOREY): (20)

The extensor mechanism comprising the triceps tendon, forearm fascia, and periosteum are reflected as one unit from the medial to lateral off the olecranon

The triceps may be removed along with a thin wafer of bone to facilitate bone-to-bone rather than tendon-to-bone healing at the triceps insertion site.

Now the entire triceps muscle with the posterior capsule is reflected upwards and laterally, and the elbow is flexed to expose the joint.

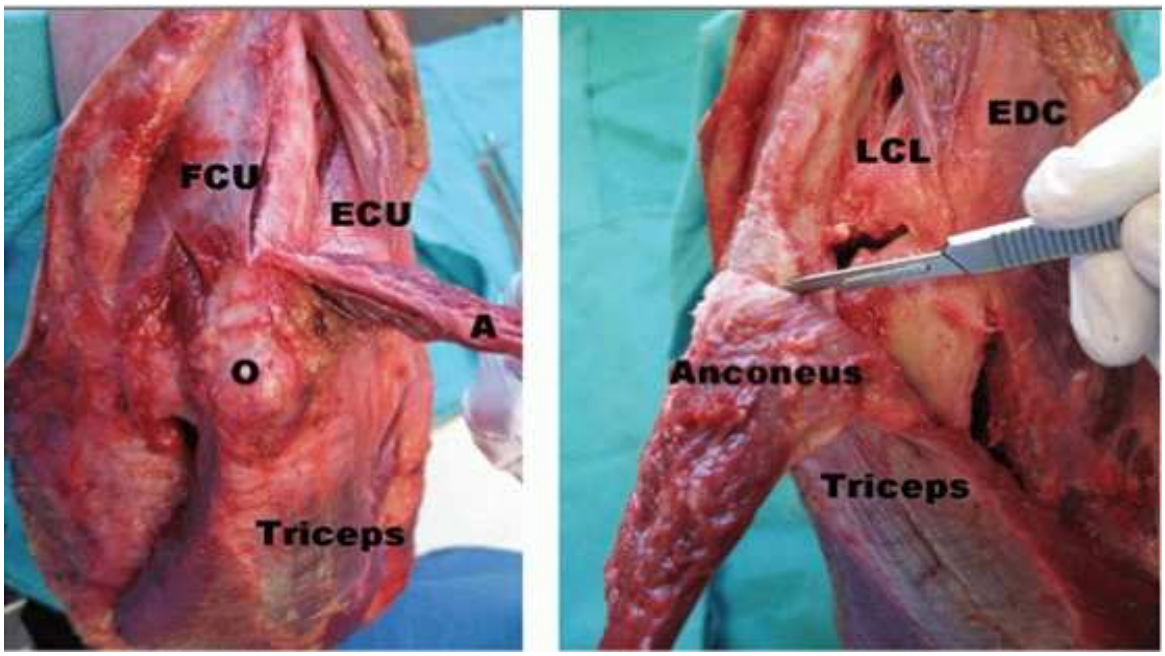


3.TRAP APPROACH (0'DRISCOLL): (17)

It usually begins laterally by preserving the lateral collateral and annular ligament, where the anconeus is elevated subperiosteally from the proximal ulna, which is separated from the capsule of the elbow.

The anconeus is first exposed distally; the exposure is developed proximally and the muscle is reflected upwards

The medial exposure consists of the triceps-reflecting approach of Bryan- Morrey.

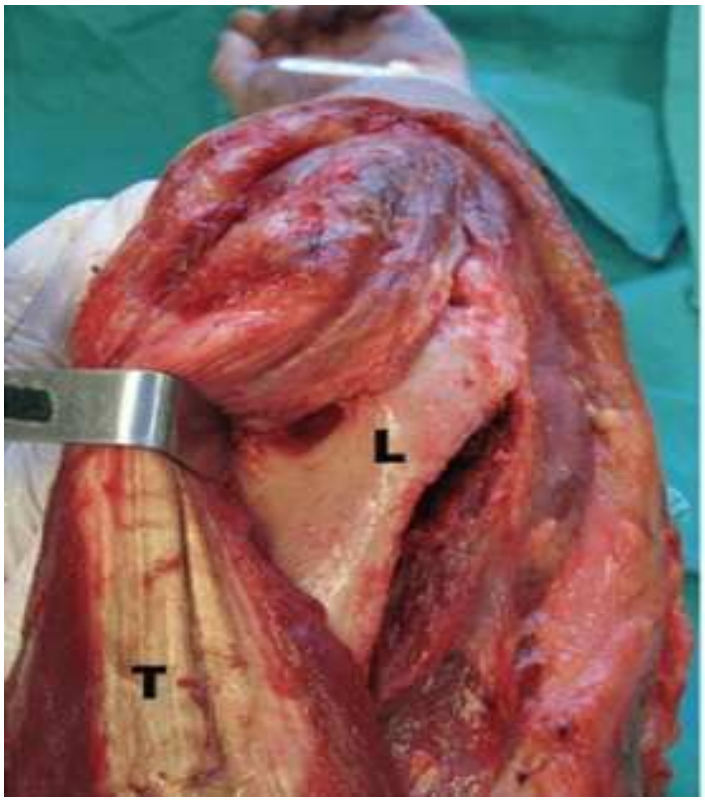


4. PARA- TRICIPITAL APPROACH (ALONSO- LLAMES): (22)

Sub-periosteal elevation of distal triceps off the posterior aspect of the humerus

Develop “windows” along medial and lateral borders of triceps without injuring triceps aponeurosis and its insertion into olecranon

This approach is commonly used for irreparable distal humerus fractures in elderly patients for whom a Total Elbow Arthroplasty may be planned in future.



5.OLECRANON- OSTEOTOMY APPROACH: (23)

The olecranon osteotomy could be either extra-articular or intra-articular, both of which expose the distal articular surfaces properly

A transverse intra-articular osteotomy is inherently unstable and can be difficult to reposition accurately.

In contrast, a chevron-shaped osteotomy, particularly one that has been cracked at articular surface of olecranon, facilitates repositioning and has inherent rotational and translational stability due to interlocking of the fragments.

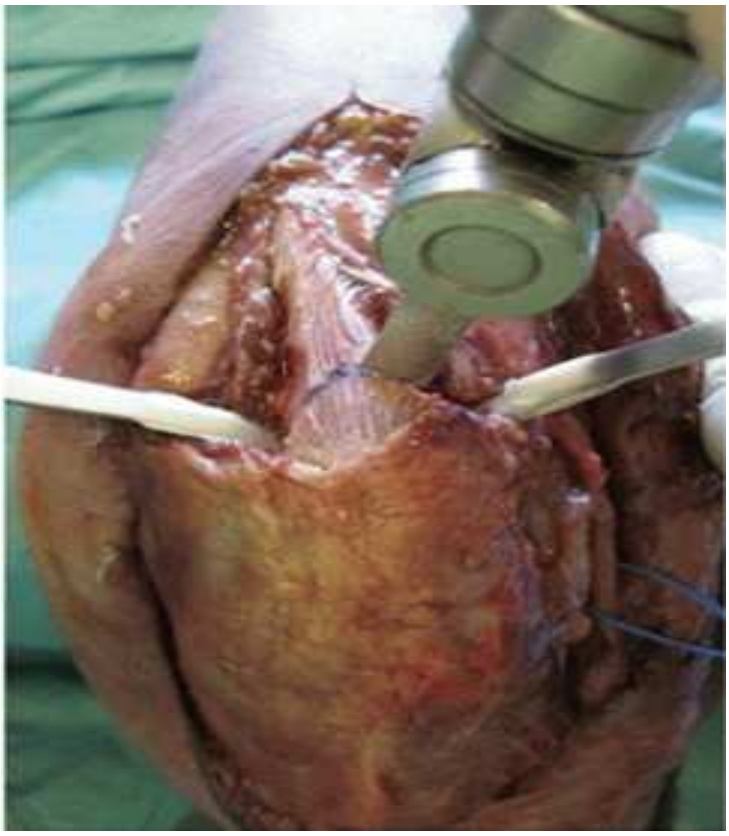


PLATE FEATURES

- The dorsolateral and medial plates allow implant to be placed based on fracture pattern .
- The plates are precontoured to get anatomicaly fit .
- The choice of various lengths of each plate eliminates the need to cut the plate
- The dorsolateral plate has the provision for fixation of capitellum with 3 distal screws
- Increased stability can be obtained from 2 plate fixation of distal fracture humerus
- The 2 plate construct creates a girder like structure which strengthens the fixation
- The dorsolateral plate function as a tension band during fixation of the elbow
- The medial plate supports the medial side of distal humerus .
- The shaft holes accept 3.5mm locking screws/ 3.5mm cortex screws

ADVANTAGES OF DISTAL HUMERUS LOCKING COMPRESSION PLATES

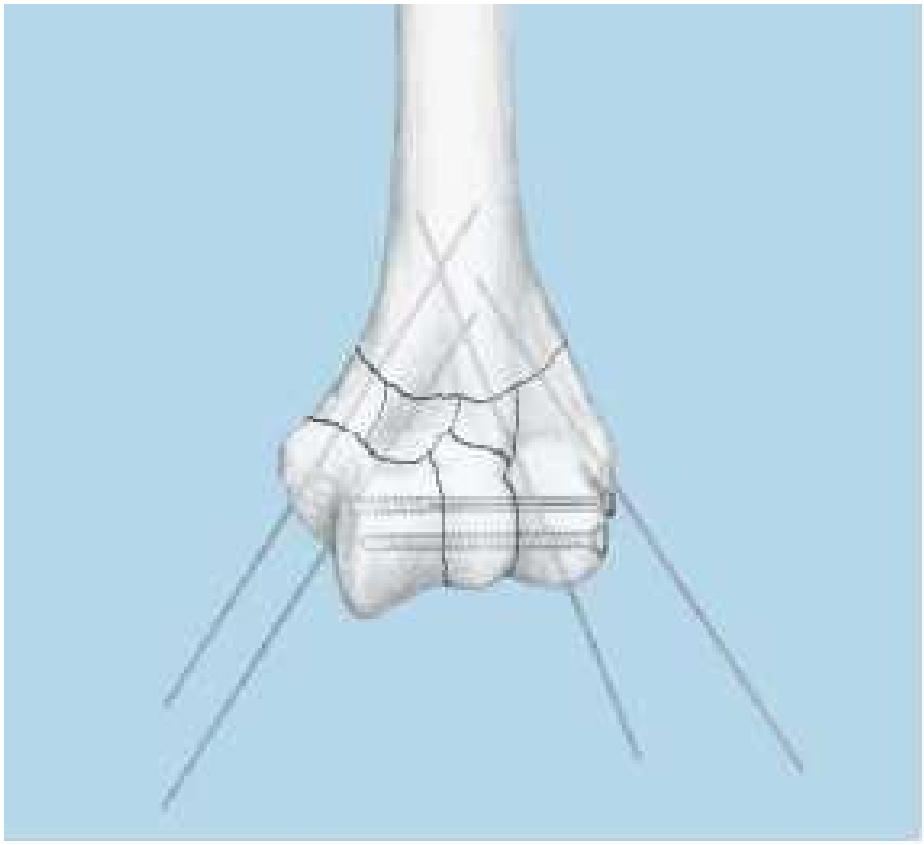
- Primary displacement does not occur since the plates are precontoured
- There is no loss of secondary reduction as the screws do not slide or get displaced
- Applying locking screws provides angular and axial stability which makes the construct more stable
- These plates are more useful in osteoporotic bones
- These plates are noncontact plates hence no damage to periosteal blood supply .
- Since these plates are precontoured operating time is shorter .

ORTHOGONAL PLATING TECHNIQUE:

Step1: Reduce the fracture and fix temporarily

Initially the articular fragments are aligned and provisionally fixed using k wires.

Also temporarily fixing the distal fragment with k wires in both columns to ensure anatomy of distal humerus is restored .



Step 2: Determine the plate length and type

The plate lengths are chosen that offer sufficient fixation proximal to the fracture lines.

To prevent excessive diaphyseal stress, medial and dorso lateral plates are placed of different lengths .

For e.g: 5 holed medial plate is used with 8 holed dorsolateral plate

Step 3: Application of Dorsolateral plates

Initially the dorsolateral plates are applied and non locking 3.5 cortical screw is inserted to fix the plate to the bone

The screws are all directed from posterior to anterior

Additional screws are inserted in a lateral to medial direction for the condyles

Confirm screw placement and length with image intensifier during movement of the elbow to ensure screws are not in the joint.

Step 4: Application of medial plate

Position the medial plate on medial ridge and slightly dorsal to intermuscular septum with distal tip reaching down to insertion of medial collateral ligament .

The longest possible screws are inserted in distal fragment.

After fixing the fracture segments, Tension Band Wiring of osteotomized olecranon was carried out either with two K wires or a 6.5mm Cancellous screw. Meticulous repair of soft tissues was done in layers and closed with a suction drain.

POST OP PROTOCOL

- Patients are placed in a well-padded plaster extension splint which is applied anteriorly and the limb kept elevated for first 3 days.
- Active finger movements and wrist movements started from day 1.
- Intravenous antibiotics given for 3 days; Oral antibiotics given for 5 days.
- Drain removal done at 48 hours ; Suture removal on 12th postoperative day
- Indomethacin prophylaxis for heterotopic ossification was given for the first postoperative month (75 mg/day)
- Elbow range of motion was started between days 3 and 7 postoperatively, as tolerated by the patient.
- Generally, active-assisted and active range of motion are encouraged (flexion, pronation, and supination) of elbow.
- Passive supported (gravity assisted) extension is reserved for patients that underwent an extensor mechanism disrupting approach.

- At 6 months patients were allowed to do their routine full activities
- Active extension Strengthening exercises are avoided for 12 weeks .It is started when radiographic union is evident.
- Follow up at 3^{rd} , 6^{th} , 12^{th} week . At each follow up patients were evaluated clinically and the functional outcomes were measured in terms of Mayo elbow performance score (MEPS).

MAYO ELBOW PERFORMANCE (MEPS) :

MAYO ELBOW PERFORMANCE SCORE

Adapted from: Gill DR, JBJS 1998;80A:1327

Criteria	Points	Patient Score
Pain (45 points)		= 45
None	45	
Mild	30	
Moderate	15	
Severe	0	
ROM		
>100 degrees	20	= 20
50-100 degrees	15	
<50 degree	5	
Stability (10 points)		= 10
Stable	10	
Moderate instability	5	
Gross instability	0	
Daily function (25 points)		= 25
Combing hair	5	
Feeding oneself	5	
Hygiene	5	
Putting on shirt	5	
Putting on shoes	5	
	Patient Score=	100

> 90 points = excellent, 75 to 89 points = good, 60 to 74 points = fair, and less than 60 points = poor

Stable = no apparent varus-valgus laxity clinically, moderate instability = less than 10 degrees of varus-valgus laxity, and gross instability = at least 10 degrees of varus-valgus laxity.

MAYO ELBOW SCORE :

Score greater than 90 : excellent
Score 75 to 89 : good
Score 60 to 74 : fair
Score less than 60 : poor

CASE ILLUSTRATIONS

CASE 1

NAME	:	MR . KUMARAN
IP NO	:	78129
AGE	:	32 yrs
OCCUPATION	:	tractor driver
DIAGNOSIS	:	fracture of distal humerus right side
AO/ASIF	:	Type 13 C2
ASSOCIATED INJURIES	:	Nil
PROCEDURE DONE	:	Orthogonal Plating
COMPLICATIONS	:	Nil
SECONDARY PROCEDURE	:	Nil

TIME OF UNION	12 weeks
MOVEMENT OF ELBOW	flexion 10-135 deg
MAYO SCORE	95
FUNCTIONAL OUTCOME	Excellent

PREOP

POSTOP

12 MONTHS FOLLOW UP

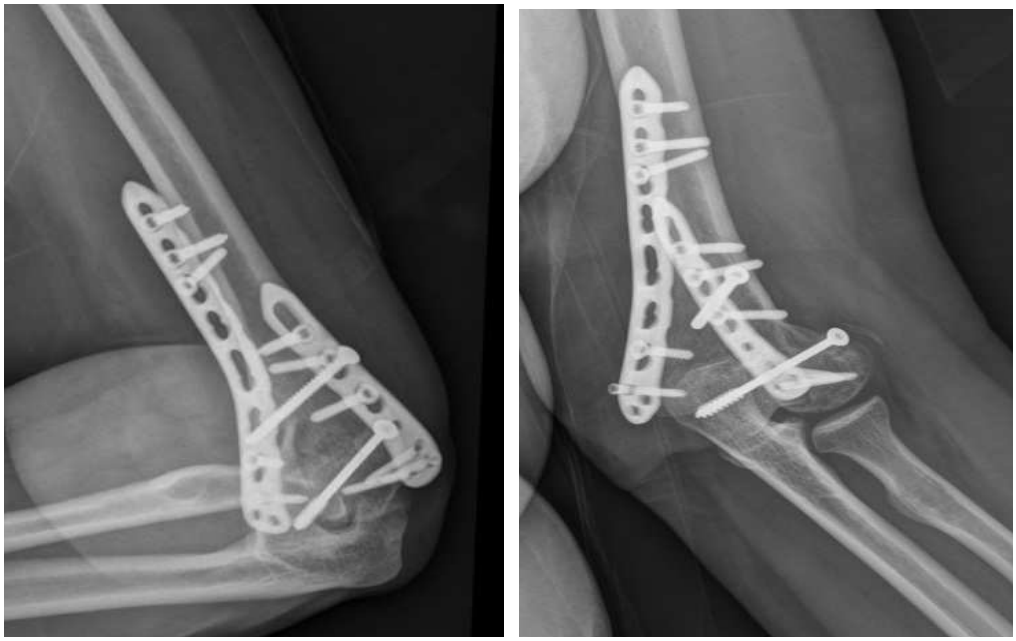
CASE 2

NAME	:	MRS . SARALA
IP NO	:	54189
AGE	:	65/F yrs
OCCUPATION	:	House wife
Diagnosis	:	Osteoporotic communited fracture of distal humerus LEFT
AO/ASIF	:	Type 13 C3
ASSOCIATED INJURIES	:	Nil
PROCEDURE DONE	:	ORIF with orthogonal plating
COMPLICATIONS	:	Nil
SECONDARY PROCEDURE	:	Nil

Time of union	12 WEEKS
Elbow movements	Flexion 10-110 Deg
MAYO SCORE	85
OUT1COME	Good

PREOP

POSTOP



8 MONTHS FOLLOWUP

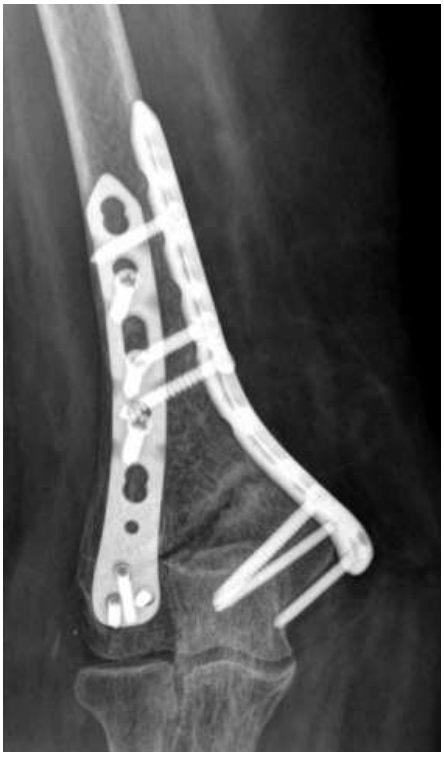
CASE 3

NAME	:	MRS . RANI
IP NO	:	90218
AGE	:	34/Fyrs
OCCUPATION	:	cook
Diagnosis	:	Fracture of distal humerus Right
AO/ASIF	:	Type 13 C2
PROCEDURE DONE	:	Orthogonal Plating
COMPLICATIONS	:	NIL

Time of union	14 weeks
Elbow movements	Flexion10-120
MAYO score	90
Outcome	Excellent

PREOP

POSTOP



8 MONTHS FOLLOW UP

CASE 4

NAME	:	MR .DINAKARAN
IP NO	:	90927
AGE	:	42/M yrs
OCCUPATION	:	Driver
Diagnosis	:	Fracture of distal humerus left
AO/ASIF	:	Type 13 C2
PROCEDURE DONE	:	Chevron osteotomy with orthogonal plating
COMPLICATIONS	:	Nil

Time of union	12 weeks
Elbow movements	Flexion10-120
MAYO score	90
Outcome	Excellent

PREOP

POSTOP

10 MONTHS FOLLOWUP

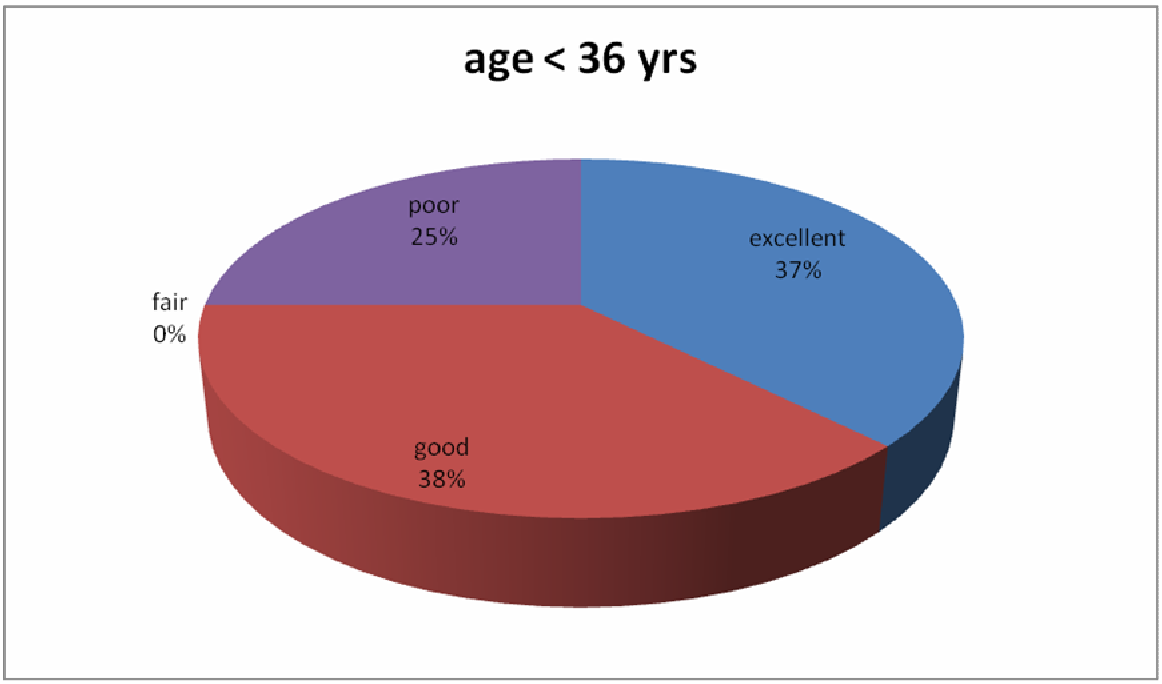
OBSERVATION AND RESULTS

The following observations were made in our study. Good to excellent outcomes were treated as successful .

The Mean age of the patients was 36 years ranging from 20 to 65 years .

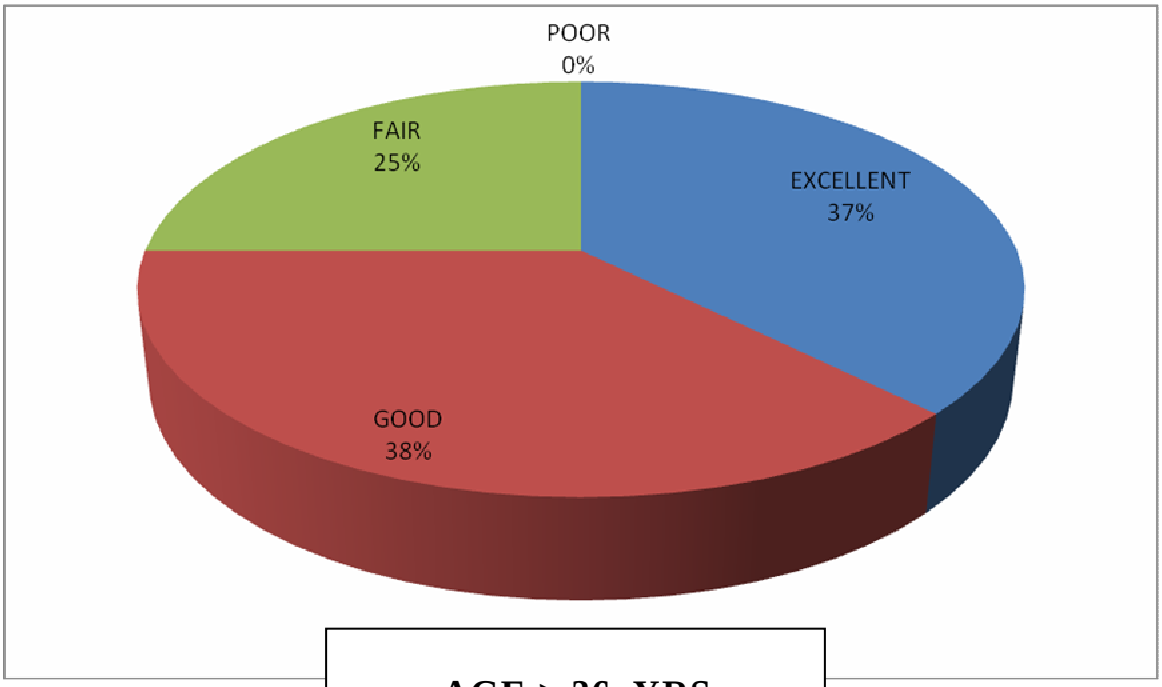
Results among Age group < 36 yrs: Success rate : 87%

Excellent	Good	fair	Poor
3	3	0	1



Results among age group >36 yrs success rate – 75%

Total (n)	Excellent	Good	Fair	poor
8	3	3	2	0

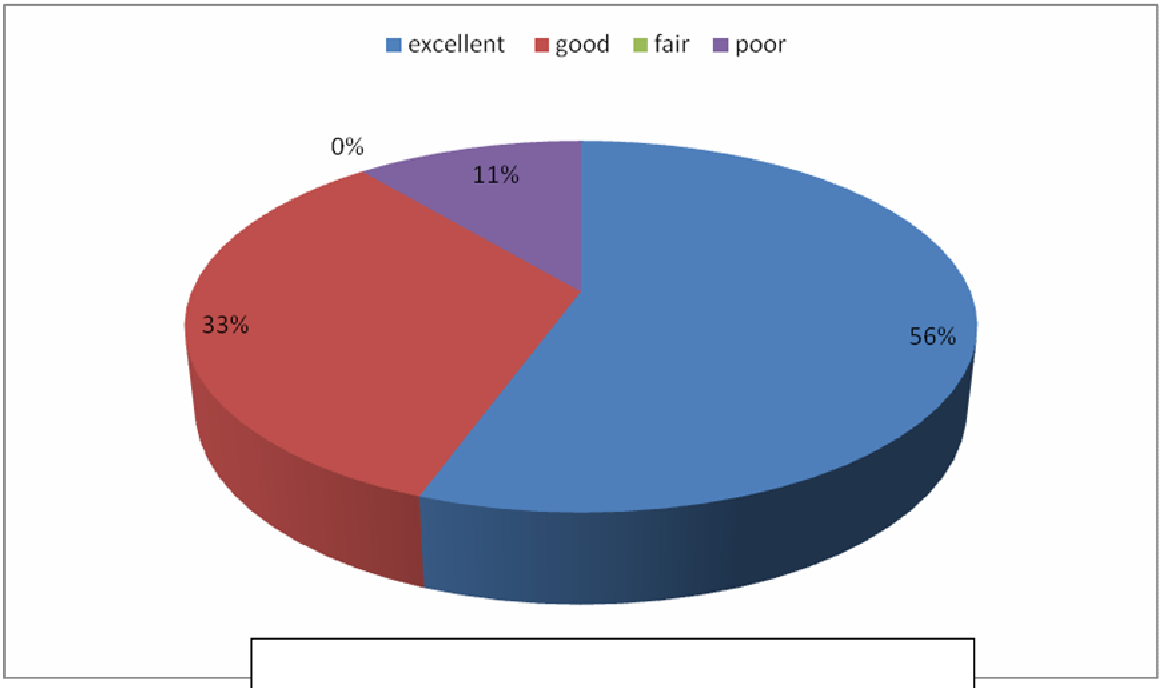


AGE > 36 YRS

MALES DOMINATED IN OUR STUDY GROUP WITH A RATIO OF 3:2

Results among males success rate- 88.9%

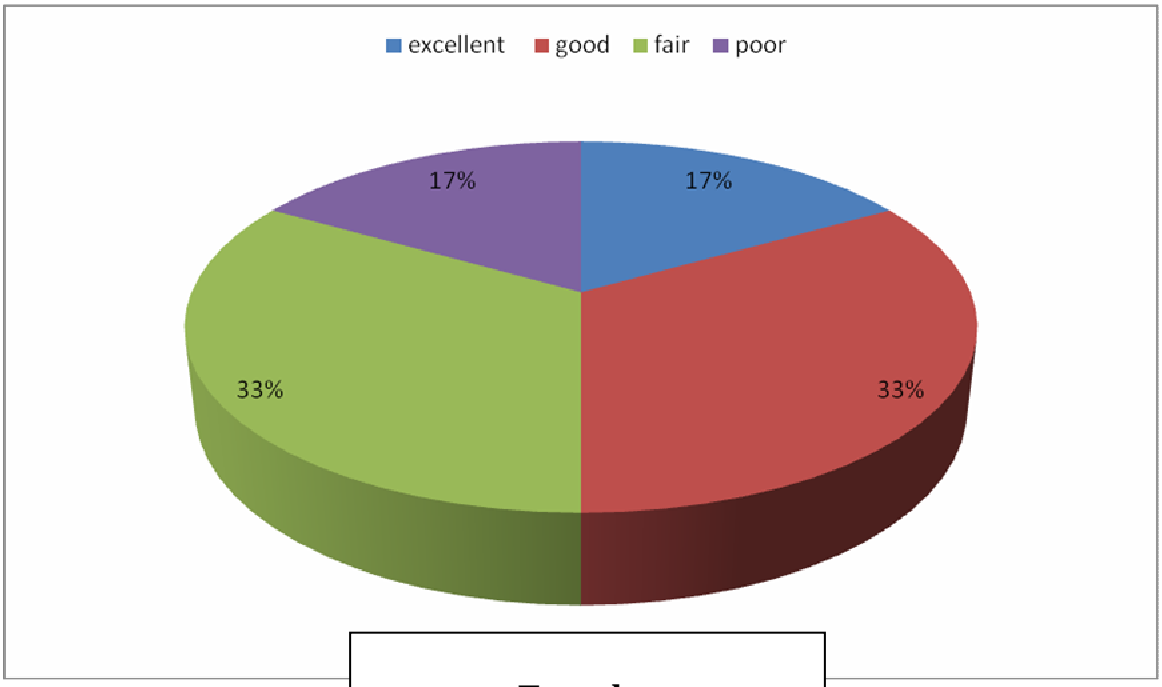
Total (n)	Excellent	Good	Fair	poor
9	5	3	0	1



Males

Results among females success rate – 50%

Total (n)	Excellent	Good	Fair	poor
6	1	2	2	1



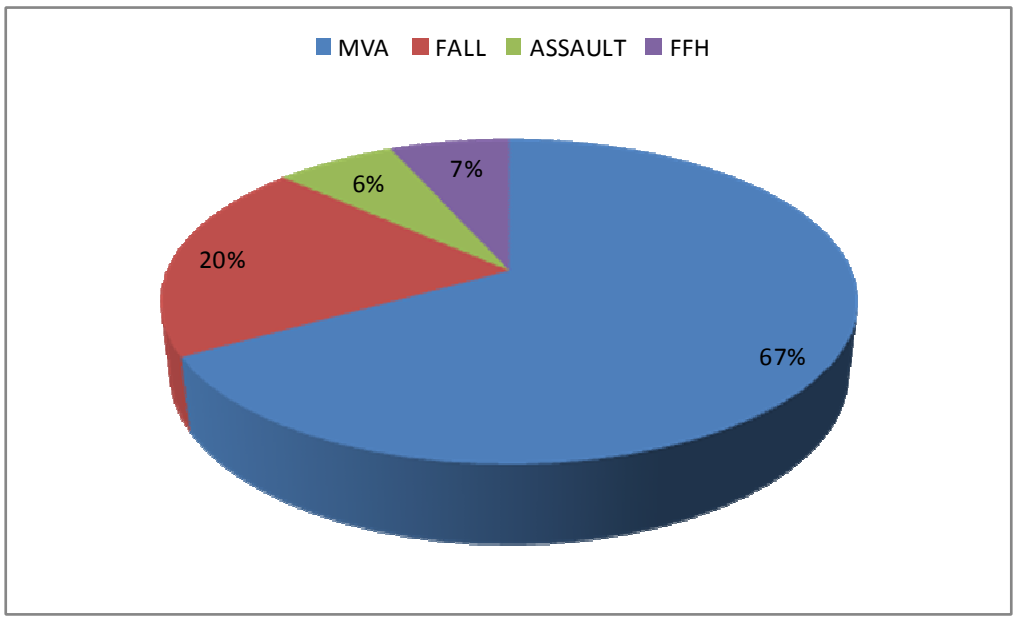
Females

Right limb injuries were more common than left limb injuries.

Incidence of right limb injuries – 8/15 (53.33 %)

Incidence of left limb injuries – 7/15 (46.67%)

In our study Motor vehicle accidents and accidental falls were the common mechanisms of injury.



Motor Vehicle accidents was most common mode of injury in younger males whereas simple accidental falls from standing height had been the most common mode of violence in elderly females.

All fractures had an intra articular extension. Of the complete articular types, the order of most common types were C2 (53.33%) > C1(33.33%) > C3(13.33%)

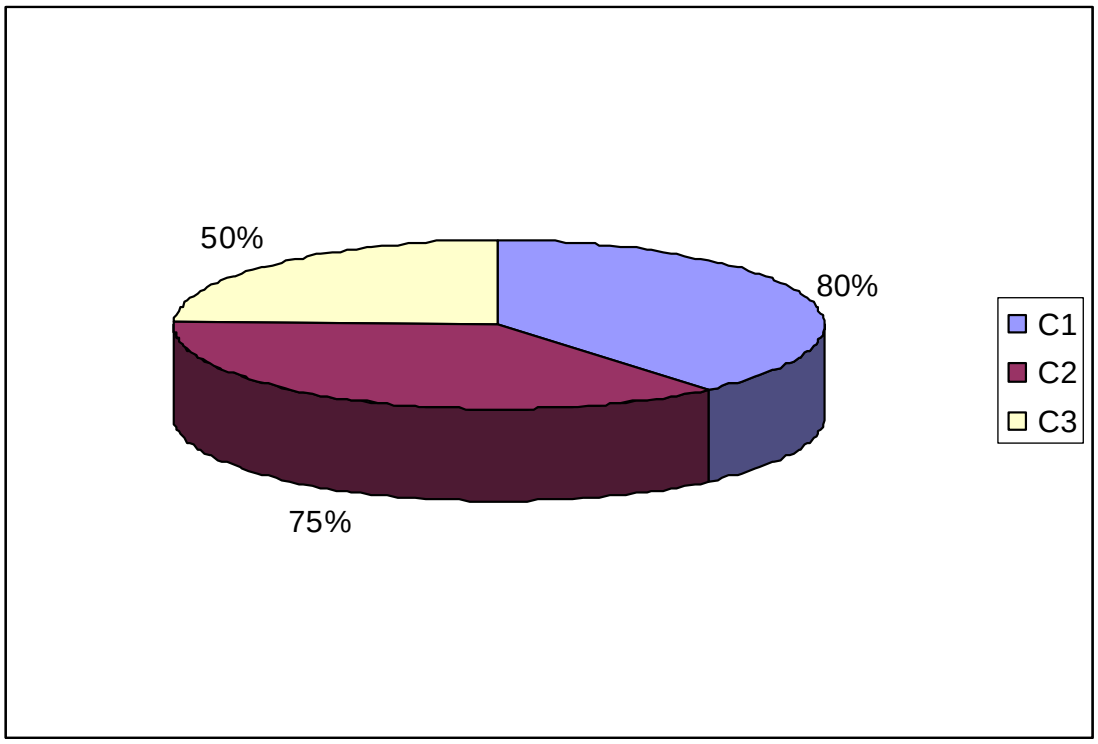
Results among types

Success rates

C1 – 80%

C2 -75%

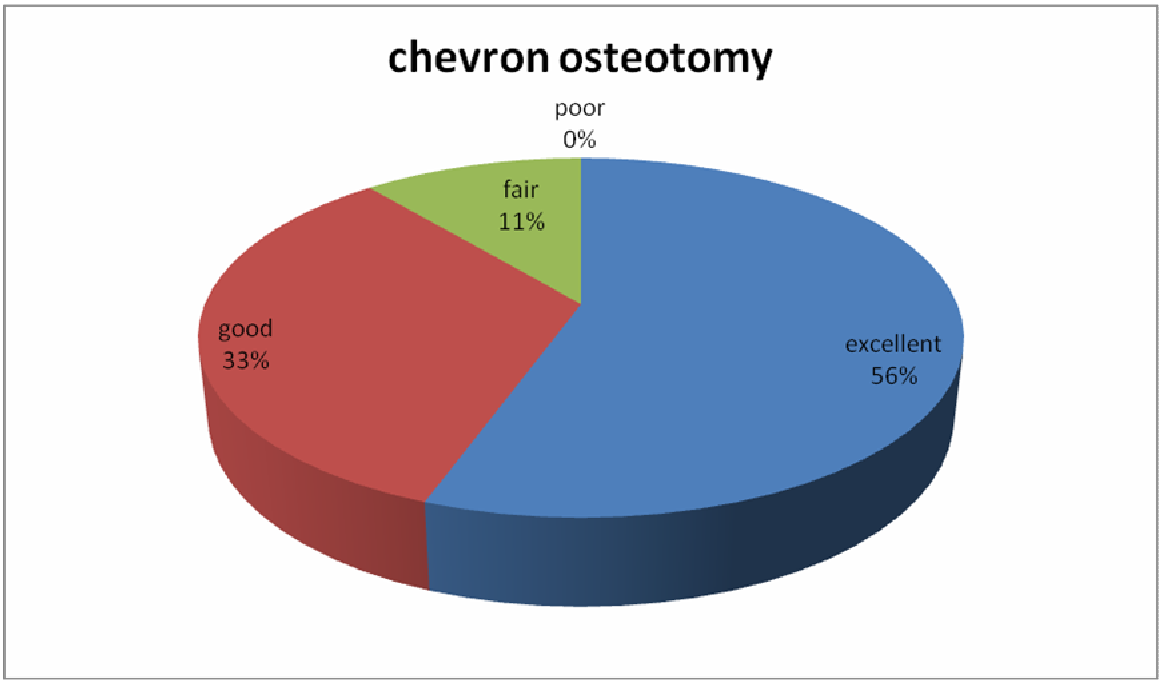
C3 – 50%



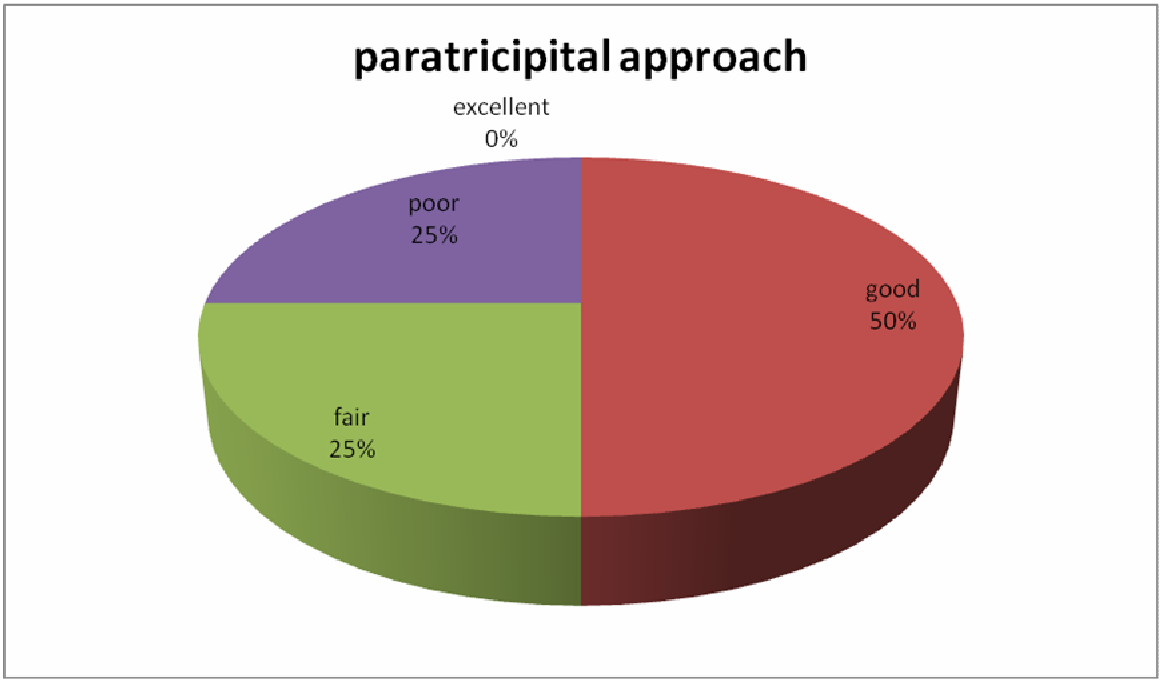
Ten patients had associated skeletal injuries. One patient had preoperative median nerve palsy.

Most of the patient were operated by Chevron olecranon osteotomy approach (9 Patients). Four patients were operated by paratricipital approach. TRAP approach and triceps splitting approach were used each in one patient.

Results among chevron osteotomy success rate -88.9%



Results among paratricipital approach -Success rate 50%



- In our study the average surgical time delay was 4 days ranging from 3 to 11 days.
- The average surgical time was 100 minutes ranging from 70 minutes to 150 minutes.
- Complications encountered in our study were paraesthesia along ulnar nerve distribution , infection, stiffness, heterotopic ossification and hard ware prominence.
- Two patients had infection. One patient was treated conservatively with antibiotics. One patient who had a wound gapping on the 8th day over the olecranon healed by secondary intention and Split skin grafting. 2 patients reported numbness

and paraesthesia along ulnar border of little finger which was treated conservatively .Both patients showed recovery after 6 months .

- Heterotopic ossification with reduced elbow ROM and stiffness was observed in 2 patients.
- No patient died during treatment or follow up.
- Fifteen patients of distal humeral fractures were treated surgically with orthogonal plating technique using LCP and analysed with average follow up of 8 months (3 months – 2 years).
- In our study, solid radiologic union was achieved primarily in all patients. Hardware failure did not occur in any patient.
- The mean flexion-extension arc was 107°. The mean MEPS score was 86. The results were excellent for 6 elbows, good for 7, fair for 2, and poor for 2 patients.

DISCUSSION

The treatment of distal humerus fractures with intraarticular extension by bicolumn locking compression plates applied orthogonally is studied in detail. The options for articular fractures are wide and are continuously refined over time. The treatment is difficult because of complex three dimensional geometry. Poor functional outcomes like stiffness , non-union and implant failure makes these fractures challenging to treat . In our study we focussed on functional outcome of these patients strictly adhering to principles of good anatomical alignment, absolute stabilisation and early mobilisation.

The mean age of patients in our study is 36 yrs which is comparable to the study conducted by Shin et al[4]. whose average age is 42 yrs. The younger age group had more successful outcomes (88%) than the elderly group. This may be attributed to the poor bone quality and non-compliance of patients leading to poor functional outcome like stiffness.

The male patients had a better success rate than a female patient in our study which is comparable to the study proposed by Liu et al. due to better bone quality and active postoperative

mobilization exercises. Of the various approaches we have used in our study, Chevron olecranon osteotomy was widely used which produced a very good success rate (88.9%) and paratricipital approach with a success rate of 50%. A study by Elmadaget al[9] showed olecranon osteotomy provided better outcome than paratricipital approach in their study of 54 patients.

Anterior transposition of ulnar nerve was done in all 15 patients in our study, out of which 2 patients had ulnar neuropraxia which recovered completely in 6 months which is comparable with the study conducted by Wang et al in 70 patients out of which only 2 patients developed ulnar nerve paraesthesia.

In a study by Ring et al[1], the complications of olecranon osteotomy reported were bursitis, hardware prominence, broken or migrated k wire. In our study we encountered 1 case of hardware prominence.

In the study by Qi-X et al[5], 21 cases of distal humerus fractures were operated using paratricipital approach one case of myositis ossificans was reported. In our study out of the four cases, one case developed stiffness due to heterotopic ossification.

In the study by Babhulkaret al[3], 80 cases of intraarticular fracture were operated through orthogonal plating and had excellent outcome in 86 % of cases. Kaiser et al[2]study showed 22 patients treated with orthogonally applied LCP plates. The mean MEPS score was 84.7 .The complications reported were ulnar sensory neuropathy which recovered incompletely in 1 case. All patients had achieved stable reduction and union during follow up.

In the study by Holub et al[11] the outcomes of conventional reconstruction plates and LCP were compared , excellent results were achieved with the use of locking compression plates particularly in intraarticular distal humerus fractures . The average operating time was 123 minutes using conventional plates. Our study had an average time of 100 minutes which may be attributed to the anatomically fit precontoured plates which does not need any contouring to fix with the bone.

Lee et al[6]compared the outcomes of parallel and orthogonal plating technique using distal humerus LCP and no significant difference in outcomes of both techniques were noted. Stoffel et al[8] reported the same result in their study of parallel versus perpendicular locking plate systems in comminuted distal humerus fractures. No intergroup differences noted in terms of operating

time, time to union and functional recovery were reported . Ian et al[10] too had reported no difference in MEPS score , flexion extension arc and operating time .Athwal et al[7] studied the outcomes of 37 patients treated by distal humerus LCP by parallel plate technique and 5 patients out of 24 had postoperative nerve injuries (16%) . in our study nil postoperative nerve injuries were seen. This may be attributed to the safe and easier dissection required in orthogonal plating technique compared with parallel plating technique .

CONCLUSION

Incidence of complex distal humerus fractures among younger population is on the rise due to increasing motor vehicle accidents.

Absolute stability of the system allows early post operative rehabilitation and thence a better functional outcome.

Good to excellent functional outcome was achieved in >80% of the study group in terms of arc of motion and stability.

Absence of implant failure and non-union may be attributed to the highly stable construct system achieved by locking compression plates.

It provides a greater stability in osteoporotic and comminuted bones.

Locking compression plates applied orthogonally can be a successful technique for internal fixation of these complicated fractures when its principles are strictly adhered to.

In the management of complex articular fractures orthogonally applied locking compression plates provide results

comparable with locking compression plate using parallel plate technique .

We conclude that Distal humerus fractures with intraarticular extension can be successfully treated with locking compression plates applied orthogonally. However a long term follow up and a larger sample study is needed to further validate our findings.

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INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr.J.Shiva Kumar ,
Postgraduate MS (Orthopaedics),
Institute of Orthopaedics and Traumatology ,
Madras Medical College,
Chennai – 600 003.

Dr.J.Shiva Kumar ,

The Institutional Ethics Committee has considered your request and approved your study titled **"Prospective and Retrospective Study on Functional Outcome Analysis of Distal Humerus Fractures treated with Locking Compression Plates "** No.11072014.

The following members of Ethics Committee were present in the meeting held on 01.07.2014 conducted at Madras Medical College, Chennai-3.

1.	Dr.C.Rajendran, M.D.,	: Chairperson
2.	Dr.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
3.	Prof.B.Kalaiselvi, M.D., Vice-Principal, MMC, Ch-3	: Member Secretary
4.	Prof.R.Nandhini, M.D., Inst.of Pharmacology, MMC	: Member
5.	Dr.G.Muralidharan, Director Incharge, Inst.of Surgery	: Member
6.	Prof.Md.Ali, M.D., D.M., Prof & HOD of MGE, MMC	: Member
7.	Prof.K.Ramadevi, Director i/c, Inst.of Biochemistry, MMC	: Member
8.	Prof.Saraswathy, M.D., Director, Pathology, MMC, Ch-3	: Member
9.	Prof.Tito, M.D., Director i/c, Inst.of Internal Medicine, MMC	: Member
10.	Thiru S.Rameshkumar, Administrative Officer	: Lay Person
11.	Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
12.	Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

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

Sd/ Chairman & Other Members

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.

2/7/14

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003.

INFORMATION SHEET

Title : **"A Prospective and Retrospective Study on Functional Outcome Analysis of Distal humerus fractures treated with Locking Compression Plates"**

Principal Investigator :

Name of the Participant :

Site :

We are conducting a study on " Analysis of functional outcome of distal humeral fractures treated with locking compression plates – A prospective cum retrospective study" among patients attending the Institute of Orthopedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai and for that your specimen may be valuable to us.

The purpose of this study is to evaluate and analyze the functional outcome of distal humeral fractures treated with locking compression plates.

We are selecting certain cases and if you are found eligible, we may be using your radiographs of the spine to evaluate the outcome of surgery which in any way do not affect your final report or management .

The privacy of the patients in the research will be maintained throughout the study In the event of nay publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary, You are free to decide whether to participate in this study or to withdraw at any time: your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator Signature of Participant

Date :

Place :

PATIENT CONSENT FORM

Study Detail : **"A Prospective and Retrospective Study on Functional Outcome Analysis of Distal humerus fractures treated with Locking Compression Plates"**

Study Centre : Rajiv Gandhi Government General Hospital, Chennai.

Patient' s Name :

Patient's Age :

Identification Number :

Patient may check (✓) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my question and doubts have been answered to my complete satisfaction.

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected.

c) I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw form the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study.

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms.

e) I Understand that my identity will be kept confidential if my date are publicly presented

f) I understand that my identity will be kept confidential if my date are publicly presented

g) I herby give permission to undergo detailed clinical examination, Radiographs & blood investigations as required.

h) I have had my questions answered to my satisfaction.

i) I hereby consent to participate in this study.

Signature / thumb impression **Signature of Investigator**

Patient's Name and Address **Study Investigator's Name**

சுய ஒப்புதல் படிவம்

ஆய்வு தலைப்பு : " ஹ்யூமரஸ் எலும்பு முறிவுக்கு தட்டு வைத்து அறுவை சிகிச்சை செய்வதன் பயன்பாடு குறித்து ஓர் ஆய்வு "

பெயர்	:	தேதி	:
வயது	:	வெளி நோயாளி எண்	:
பாலினம்	:	ஆராய்ச்சி சேர்க்கை எண்	:
முகவரி	:		

நான் ..... இந்த படிவத்தில் உள்ள தகவல்களை படித்தேன். (அல்லது எனக்கு படித்து காட்டப்பட்டது). நான் இந்த மருத்துவ ஆராய்ச்சி பற்றி எந்த தயக்கமும் இன்றி தகவல்களை கேட்டு பெற்றுக்கொண்டேன். நான் 18 வயதை கடந்தவர் என்றும், இந்த ஆராய்ச்சியில் முழு சுதந்திரத்துடன் பங்கேற்க சம்மதம் என்றும் தெரிவித்துக் கொள்கிறேன்.

1. நான் இந்த ஒப்புதல் படிவத்தை படித்து இதில் உள்ள தகவல்களை நன்கு புரிந்துகொண்டேன்.
2. எனக்கு இந்த ஒப்புதல் ஆவணம் பற்றி நன்றாக விளக்கப்பட்டது.
3. எனக்கு இந்த ஆய்வின் தன்மையை பற்றி விளக்கப்பட்டது.
4. என்னுடைய உரிமை மற்றும் பொறுப்புகள் ஆராய்ச்சியாளர்களால் விளக்கப்பட்டது.
5. நான் இந்த ஆராய்ச்சியில் இருந்து எந்த நேரமும் பின் வாங்கலாம் என்பதையும் அதனால் எந்த பாதிப்பும் ஏற்படாது என்பதையும் புரிந்து கொண்டேன்.
6. இந்த ஆய்வின் மூலம் பெறப்பட்ட என்னுடைய முடிவுகளை வெளியிட விளம்பரதாரர் கட்டுப்பாட்டு அதிகாரிகள், அரசு அதிகாரிகள், நன்னெறி குழு(IEC)க்களுக்கு அனுமதி அளிக்கிறேன்.
7. என் ஆய்வு விவரங்களை பொதுவாக வெளியிடும் பொழுது என்னை பற்றிய அடையாளங்கள் ரகசியமாக வைக்கப்படும் என்பதையும் புரிந்துகொண்டேன்.
8. என் சந்தேகத்திற்கு உரிய பதில்களை திருப்தியுடன் பெற்றுக்கொண்டேன்.
9. நான் இந்த ஆராய்ச்சியில் பங்கு பெற முடிவு செய்திருக்கிறேன்.

எனக்கு இந்த ஆய்வின் போது எழும் சந்தேகங்களை ஆராய்ச்சியாளரிடம் கேட்டு தெரிந்து கொள்ளவேண்டும் என்பதை அறிவேன். நான் இந்த படிவத்தில் கையொப்பம் இடுவதன் மூலம், இந்த ஆய்வை பற்றி எனக்கு நன்றாக விளக்கப்பட்டது எனவும் ஒப்புதல் அளிக்கிறேன். எனக்கு இந்த ஒப்புதல் ஆவணத்தின் நகல் வழங்கப்படும்.

.....	.....	.....
நோயாளியின் பெயர்	கையொப்பம் / கைரேகை	தேதி
.....	.....	.....
சாட்சியின் பெயர்	கையொப்பம் / கைரேகை	தேதி
.....	.....	.....
ஆராய்ச்சியாளரின் பெயர்	கையொப்பம்	தேதி

ஆய்வு தகவல் தாள்

ஆய்வு தலைப்பு : **" ஹ்யூமரஸ் எலும்பு முறிவுக்கு தட்டு வைத்து அறுவை சிகிச்சை செய்வதன் பயன்பாடு குறித்து ஓர் ஆய்வு "**

ஆராய்ச்சியாளரின் பெயர்:

சென்னை மருத்துவக்கல்லூரி மற்றும் மருத்துவமனையில் **" ஹ்யூமரஸ் எலும்பு முறிவுக்கு தட்டு வைத்து அறுவை சிகிச்சை செய்வதன் பயன்பாடு குறித்து ஓர் ஆய்வு "**செய்து வருகிறோம். அதற்காக நோயாளிகளை தேர்வு செய்கிறோம்.

இந்த ஆய்வில் பங்கேற்க விரும்பும் நோயாளிகளுக்கு, இடைநிலை திருகுகளை பயன்படுத்தி தட்டு வைத்து அறுவை சிகிச்சை செய்து அதன் பயன்பாடு பற்றி கண்டறிவதே இந்த ஆராய்ச்சியின் நோக்கம் ஆகும்.

இந்த ஆராய்ச்சியில் பங்கேற்கும் நோயாளிகளின் விவரங்கள் ஆய்வு முடியும் வரை ரகசியமாக வைக்கப்படும். ஆராய்ச்சியின் முடிவு பற்றிய பதிப்புகள் மற்றும் வெளியீடுகளில் யாருடைய தனிப்பட்ட விவரங்களும் பகிர்ந்து கொள்ளப்பட மாட்டாது.

இந்த ஆராய்ச்சியில் பங்கேற்கும் உங்கள் முடிவு தன்னிச்சையானது. இந்த ஆராய்ச்சியில் இருந்து எந்த நேரத்திலும் விலகிக்கொள்ள உங்களுக்கு வாய்ப்பு உள்ளது. உங்களின் இந்த தீர்மானத்தினால் உங்களுக்கு இம்மருத்துவமனையில் வழங்கப்படும் பயன்களில் எவ்வித மாற்றமும் இருக்காது.

இந்த சிறப்பு ஆய்வின் முடிவுகள், ஆய்வின் முடிவில் அல்லது ஆய்வின்போது ஏற்படும் எதிர்மறையான விளைவுகளை நோயாளியின் நலன் கருதியோ அல்லது சிகிச்சை அளிக்கும் பொருட்டோ நோயாளிக்கு தெரிவிக்கப்படும்.

ஆராய்ச்சியாளரின் கையொப்பம் நோயாளியின் கையொப்பம்

தேதி:

ABBREVIATIONS

#DR	-	Distal radius
K wires	-	Kirschner wires
LCP	-	Locking compression plate
#MT	-	Fracture Metatarsal
MVA	-	Motor vehicle accident
ORIF	-	Open reduction and internal fixation
POP	-	Plaster of paris
ROM	-	Range of motion
#SOH	-	Fracture shaft of humerus
TBW	-	Tension band wiring

MASTER CHART

S.No	IP No.	Age/Sex	R/L	Mode of injury	AO type	Treatment	Approach	Associated injuries	ROM	Pain	MEPI rating	MEPS	Complications
1	92115	26/M	R	MVA	C2	ORIF with orthogonal plating	Olecranon osteotomy	-	10-135	-	Excellent	95	-
2	66223	31/M	L	MVA	C2	ORIF with orthogonal plating	Triceps splitting	Median N. palsy	0-125	mild	poor	55	Superficial infection settled with antibiotics for 3 weeks
3	23531	60/F	L	Fall	C3	ORIF with orthogonal plating	Olecranon osteotomy	-	10-130	-mild	fair	70	- decreased ROM due to heterotopic ossification
4	54189	26/M	R	MVA	C1	ORIF with orthogonal plating	Olecranon osteotomy	-distal radius #	30-100	-	good	85	hardware prominence
5	78129	32/M	R	MVA	C2	ORIF with orthogonal plating	Olecranon osteotomy	-#metacarpals	10-135	-	Excellent	95	
6	54189	65/F	L	Fall	C3	ORIF with orthogonal plating	Olecranon osteotomy	-	20-120	-	Good	85	- Parasthesia in Ulnar N sensory area
7	92883	45/F	R	MVA	C1	ORIF with orthogonal plating	Paratricipital	Contralateral shaft of humerus #	30-95	mild	fair	70	decreased ROM due to heterotopic ossification
8	22154	35/M	R	MVA	C2	ORIF with orthogonal plating	Paratricipital	Right superior and inferior pubic rami #	10-110	mild	Good	80	stiffness
9	90927	21/M	L	MVA	C2	ORIF with orthogonal plating	Olecranon osteotomy	-	20-130	-	Excellent	95	-

S.No	IP No.	Age/Sex	R/L	Mode of injury	AO type	Treatment	Approach	Associated injuries	ROM	Pain	MEPI rating	MEPS	Complications
10	77715	52/M	L	Fall from height	C2	ORIF with orthogonal plating	TRAP	-	10-135	-	Excellent	90	-
11	62421	41/M	L	MVA	C1	ORIF with orthogonal plating	Paratricipital	-	20-120	-	Good	85	
12	78133	54/M	R	Assault	C2	ORIF with orthogonal plating	Olecranon osteotomy	Right superior Pubic rami #	0-120	-	Excellent	90	Parasthesia in Ulnar N sensory area
13	27457	36/F	R	MVA	C2	ORIF with orthogonal plating	Paratricipital	# inf pubic rami	30-90	mild	poor	55	
14	20933	65/F	R	fall	C1	ORIF with orthogonal plating	Olecranon osteotomy	#distal radius	10-110	-	Good	80	Superficial infection settled after debridement
15	90218	48/F	L	MVA	C1	ORIF with orthogonal plating	Olecranon osteotomy	-	20-90	mild	Excellent	90	

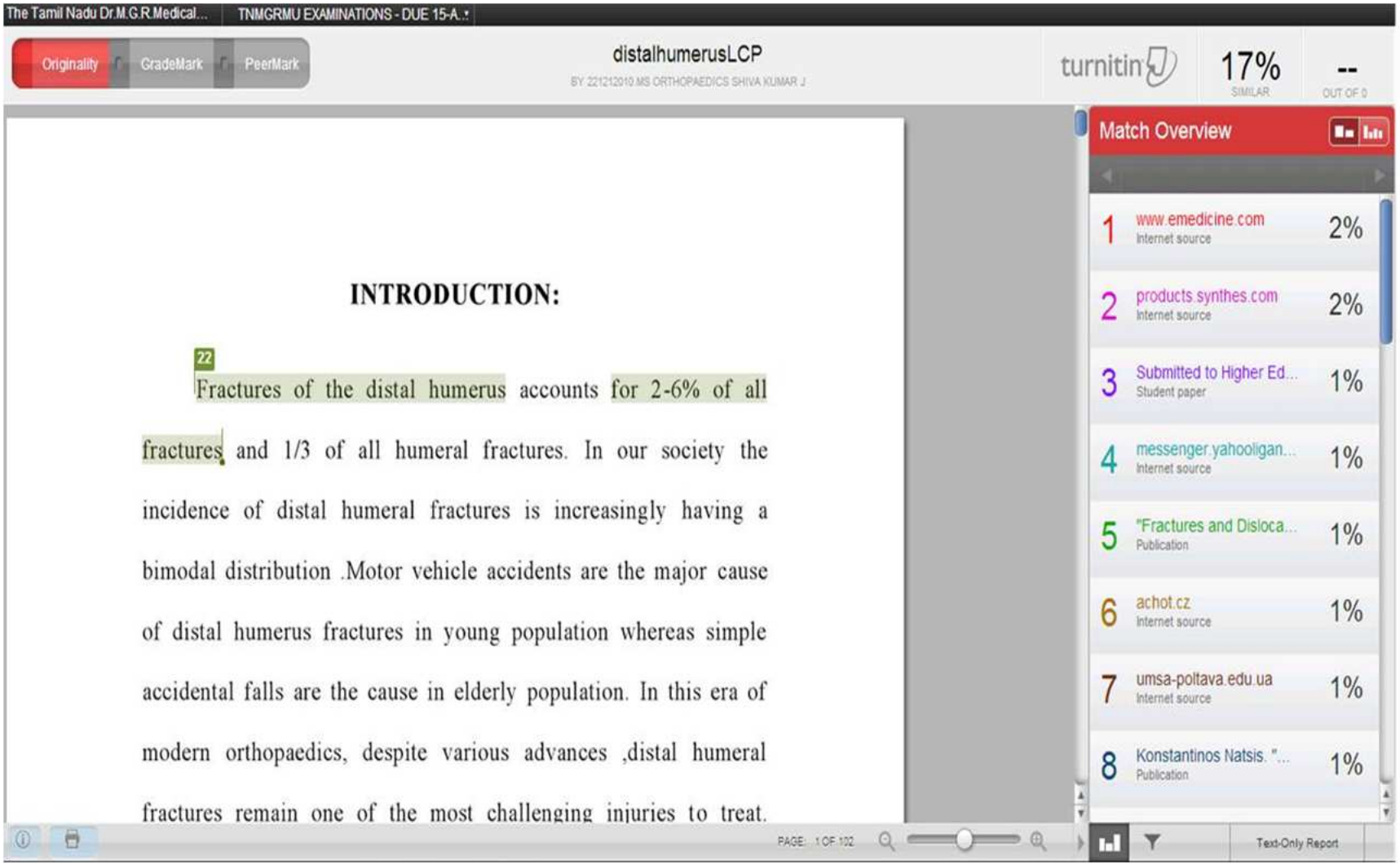
MAYO ELBOW PERFORMANCE INDEX

Criteria

Pain	45 point
Ulno humeral motion	20 points
Stability	10 points
Functional tasks(5 nos.)	25 points

Rating of MEPI scores

Excellent	90-100
Good	75-89
Fair	60-74
Poor	<60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Fractures of the distal humerus accounts for 2-6% of all fractures and 1/3 of all humeral fractures. In our society the incidence of distal humeral fractures is increasingly having a bimodal distribution .Motor vehicle accidents are the major cause of distal humerus fractures in young population whereas simple accidental falls are the cause in elderly population. In this era of modern orthopaedics, despite various advances ,distal humeral fractures remain one of the most challenging injuries to treat.
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INTRODUCTION