# "SURGICAL MANAGEMENT OF PROXIMAL HUMERUS FRACTURES USING PHILOS PLATE"


**By**

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**In partial fulfilment of the requirements for the degree of**

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**Under the Guidance of**

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I hereby declare that this dissertation entitled **"SURGICAL MANAGEMENT OF PROXIMAL HUMERUS FRACTURES USING PHILOS PLATE"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. SIDDARAM. N. PATIL**, Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.S.DEGREE IN ORTHOPAEDICS**", the examination to be held in May 2017 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

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**Dr. VAIBHAV BHADBHADE**

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AO | Arbeitsgemeinschaft fur Osteosynthesefragen |
| AO-OTA | The AO Foundation and Orthopaedic Trauma Association |
| AP | Antero posterior |
| ASES | American Shoulder and Elbow Surgeons |
| ASIF | Association for the study of internal fixation |
| Avg | Average |
| AVN | Avascular necrosis |
| BC | Before Christ |
| cm | Centimeter |
| CT | Computed tomography |
| e.g. | For example |
| ECG | Electrocardiography |
| EMG | Electromyography |
| ESR | Erythrocyte sedimentation rate |
| gm | gram |
| HBsAg | Hepatitis B surface antigen |

| | |
|---|---|
| HIV | Human immunodeficiency virus |
| K-wire | Kirschner wire |
| Kg | Kilogram |
| lb | Pound |
| mm | Millimetre |
| MRI | Magnetic resonance imaging |
| n | Total number |
| ORIF | Open reduction internal fixation |
| p | Probability |
| PA | Per abdomen |
| PHFs | Proximal humerus fractures |
| PHILOS | Proximal humeral internal locking system |
| POP | Plaster of paris |
| S.D. | Standard deviation |
| RTA | Road traffic accident |

# ABSTRACT

**Background and objectives:** PHILOS plate offers a good functional outcome in proximal humerus fractures with context to the early joint mobilisation and rigid fixation of the fracture. This study was planned to evaluate clinical outcome and time required for fracture healing following open reduction and internal fixation with PHILOS plate for displaced proximal humerus fractures.

**Materials and methods:** The prospective study was carried out in the Department of Orthopaedics at R.L.Jalappa hospital and Reseach centre,Tamaka,Kolar from October 2014 to October 2016. A total of 30 patients with proximal humerus fracture underwent open reduction and internal fixation using PHILOS plate through deltopectoral approach**.**

**Results:** Majority of the patients (70%) were males. The male to female ratio was found to be 1:1.12 .The commonest age group was beyond 60 years. Most of the patients reported road traffic accident as the nature of trauma (70%) and involvement of right side was more common (57%). Maximum (57%) patients had 2-part fracture according to Neer's classification. The range of motion at first, second and third follow ups increased gradually during subsequent follow ups with early radiological and clinical union. Most of the patients had good outcome (47%) followed by fair (26%), excellent (20%) and poor outcome (7%). No statistically significant difference was

observed in outcome with regard to mechanism of injury ($p>0.05$), side of the fracture ($p>0.05$) and type of fracture ($p>0.05$).

**Conclusion:** Proximal humeral internal locking system (PHILOS) plate for the treatment of proximal humerus fractures leads to a satisfactory functional outcome and early union in most of the patients. However, shoulder stiffness was found to be a strong predictor of poor functional outcome.

**Key words:** Open reduction internal fixation; Proximal humeral internal locking system (PHILOS) plate; Proximal humerus fractures.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF GRAPHS

# LIST OF FIGURES

# INTRODUCTION

The field of orthopaedic surgery has been in the vanguard in creating new information, establishing new principles of treatment and solving both new and old problems of musculoskeletal system**.**

Fractures of proximal humerus is still unsolved fractures in many ways. Disagreement exists regarding reliability of classification system. The indication for surgical management continue to be modified. Fixation techniques are myriad and none is ideal for all cases[1]

Proximal humerus fractures (PHFs) accounts for approximately 4-5% of all the fractures and are next to hip fractures and distal radius fractures in the elderly population. The incidence is approximately 3/10,000 persons a year and is rapidly increasing with age[2-4] Women are affected twice as often as men[3]

About 85% of these fractures are minimally displaced or non -displaced and are effectively treated symptomatically with immobilization followed by early motion. The remaining 15% of fractures are displaced unstable and may have disruption of the blood supply. The treatment of these fractures is therapeutic challenge. Displaced and unstable extra-articular fractures are most commonly treated by operative reduction and fixation using various technique[5]

The majority of patients with this fracture are elderly, which increases the risk for their bones to be osteoporotic or brittle. The quality of the bone seems to be crucial both for the surgical intervention and the functional outcome[3]. Furthermore, an elderly patient's physical and sometimes mental fragility can create difficulties during the rehabilitation to return to normal status[3,4,6,7]

Proximal humerus fractures remain a significant and growing medical concern due to the strongly associated morbidity and epidemiological trends indicating an aging population.[7]

Most patients with undisplaced fractures will regain a functional shoulder by treating conservatively. Surgery should be considered in approximately 20% of patients,[8] either to regain better functional outcome or due to its complexity of the fracture. An ever expanding range of reconstructive options are available to treat these injuries, each with its own advantages and disadvantages.[9]

A wide variety of treatment modalities have been used in the past. These include transosseous suture fixation, tension band wiring, standard plate and screw fixation, hemireplacement arthroplasty, percutaneous wire, and screw fixation. But consensus is available on the ideal treatment modality especially of 3-part and 4-part fractures. Precontoured locking plates work on the principle of angular stability, less disruption of vascularity, and less chances of plate failure[10]

Improved fixation by locking plates are attributed to the angular stability of the screws locking in the plate and their three-dimensional distribution in the humeral head. But their use for the treatment of proximal humerus fractures demands an accurate surgical technique, long learning curve to avoid plate impingement, and screw perforation of the articular surface. Also, like with all locking plates, fracture reduction must be achieved prior to plate application which can be challenging[10]

Techniques for treating complex proximal humerus fractures vary and include fixations using tension bands, percutaneous pins, bone suture, T-plates, intramedullary nails, double tubular plates, hemiarthroplasty, Plant-Tan humerus fixator plates, Polarus nails, and blade plates. Complications of these techniques include cutout or backout of the screws and plates, avascular necrosis, nonunion, malunion, nail migration, rotator cuff impairment, and impingement syndromes. Insufficient anchorage from conventional implants may lead to early loosening and failure, especially in osteoporotic bones.[11]

The Proximal humeral internal locking system (PHILOS) plate fixation provides greater angular stability than do conventional implants. It works as a locked internal fixator and provides better anchorage of screws in osteoporotic bone,[12,13] with good functional outcomes.[14,15]

Complications associated with the PHILOS plate fixation include screw penetration into the glenohumeral joint or humeral head, screw loosening and back out, avascular necrosis of the humeral head, pseudoarthrosis with a broken plate,

subacromial impingement requiring plate removal, nonunion, malunion due to loss of purchase in the humeral head, broken distal screws with separation of the plate from the bone, and transient axillary nerve palsies.[11]

In proximal humerus fractures, PHILOS plate offers a good functional outcome with context to the early joint mobilisation and rigid fixation of the fracture. The locking plate can be used with a minimally invasive technique which permits indirect fracture reduction thus lowering the possibility of avascular necrosis (AVN) and also lowering of time of immobilization reduces the possibility of frozen shoulder. Furthermore, the proximal locking screw having the capability of being applied in multidirections makes it a fixating device with a high stability in osteoporotic bones.[16] Considering these advantages and the scarcity of data on the efficacy and the functional outcome following internal fixation with PHILOS plate for displaced proximal humerus fractures, the present study was planned.

# OBJECTIVES

To evaluate the potential outcomes of using the PHILOS plate system, a study has been planned to:

1. Evaluate the clinical outcomes

2. Understand the time required for fracture healing with use of PHILOS plate for proximal humeral fractures

# REVIEW OF LITERATURE

## ANATOMY

During 6th BC Sushruth correctly described the two shoulder bones. Western world thought of acromion as separate bone at the same period. Also at the same era Atroya fully described the bones of humans.[17]

During 5th BC Hippocrates was probably the first physician whose idea regarding shoulder anatomy perpetuated**.**

## OSTEOLOGY

The humerus bone is the largest and most proximal long bone of the upper extremity.[17] The proximal humerus has head of humerus, the greater tuberosity, the lesser tuberosity, the bicipital groove, and proximal shaft. It also has two necks and it is important to differentiate between the anatomical neck which is at the junction of the head of humerus and the tuberosities and surgical neck which is at the area below the greater and lesser tuberosities. The boundaries of the surgical neck are variable without a distinct line.

The Greater tuberosity - lies posterior and superior to humeral shaft and provides attachment for the supraspinatus, infraspinatus and teres minor muscles.

The greater tuberosity does not protrude above humeral head. The glenoid of the scapula is a shallow, concave structure with the shape of an inverted comma, is approximately 1/3rd to 1/4th the surface of humeral head, with which it articulates and provides attachment to the rim of glenoid labrum and capsule.

The Lesser tuberosity provides attachment for subscapularis muscle, it lies on the anterior aspect of the humerus and is smaller when compared to the greater tuberosity. The Bicipital groove is situated between the greater tuberosity and lesser tuberosity and lies on the anterior part of proximal humerus.The transverse humeral ligament covers the biceps tendon which lies in bicipital groove. The bicipital groove has considerable variations in height and depth.

The proximal humerus can be considered to consist of three structural and functional regions: the head of humerus, the shaft and the tuberosities. The humeral head is composed primarily of cancellous bone with two major systems of trabecular rays. A medial ray passes into the inferior medial region of the head which assists in resisting deformation by static loading; and a lateral ray runs vertically to the tuberosity and superolateral aspect of humeral head which assists to resist static loading . This pattern of arrangement of trabeculae gives rise to poor osseous support for fixation. The shaft exhibits dense cortical bone. The zone of transition is represented in the region of tuberosities and is frequently deficient in both cortical and cancellous bone often only a cavity with a thin shell of cortex represents the greater tuberosities.

Along with medial torsion of humerus in region of the upper epiphyseal plate and these osseous characteristics account for the fracture patterns of the proximal humerus.

There are some of the important relationships of the head segment with shaft and tuberosities which includes inclination angle, retroversion and translation relative to shaft and the relationship to the greater tuberosity.

There is 120-140° inclination of head segment to shaft (Avg. 145°), 30° of retroversion of head relative to forearm (0-70 degree) and translation of articular head relative to tuberosity is (3-20mm).[17,18,19]

The radius of curvature of humerus is 2.25 cm and is spheroid.

## OSSIFICATION

Ossification centres in the proximal humerus has three distinct centres including one for the humeral head and one each for the greater and lesser tuberosities. Between the fourth and sixth month of life the humeral head ossification center usually appears. The ossification centre of the greater tuberosities appears during the third year of the life and lesser tuberosities during the fifth year of life. The tuberosities fuse together by the fifth year of life and in turn, fuse with the humeral head during 7th year of life.

By 19th year the head fuses with shaft. The fusion of ossification centre, creates a weakened area in the construct, known as epiphyseal scar, making these regions susceptible to fracture in the proximal humerus.[17,18]

## THE ACROMIAN

The acromion of scapula protects the superior aspect of the glenohumeral joint and provides origin and mechanical leverage for the deltoid muscle which is prime mover of shoulder. It also forms the lateral component of the acromioclavicular joint. Along together with the coracoacromial ligament and coracoid process, the acromion forms the coracoacromial arch**.**

Acromion is rather a rigid structure under which the proximal humerus, the rotator cuff and subacromial bursa must pass. Displaced tuberosity may disrupt the contour of these structure below the coracoacromial arch, which may result in impingement and prevent normal gleno-humeral motion.[17]

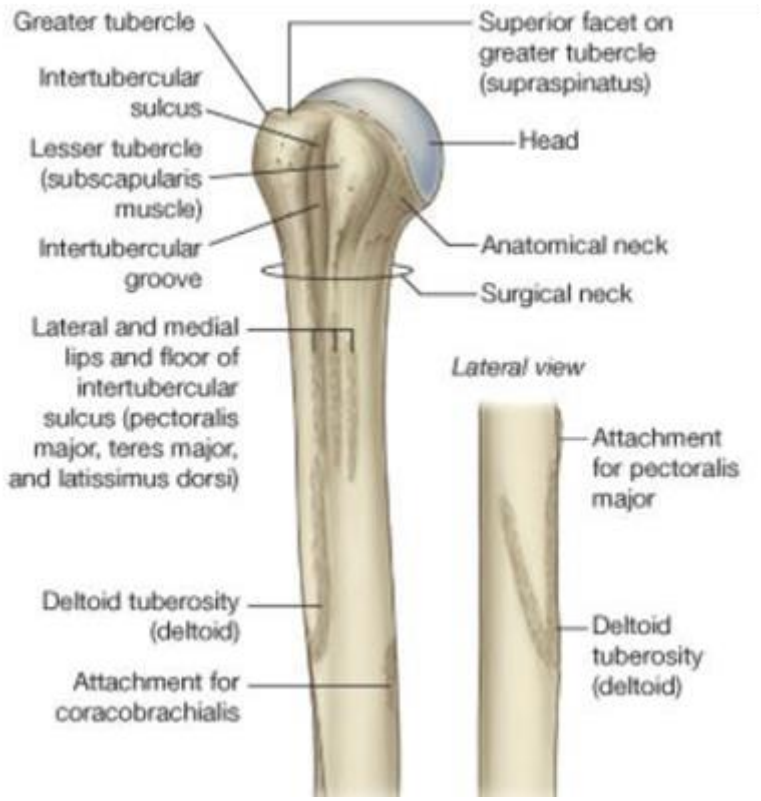



Figure 1. Anterior aspect of proximal humerus[86]


Figure 2. Posterior aspect of proximal humerus[86]

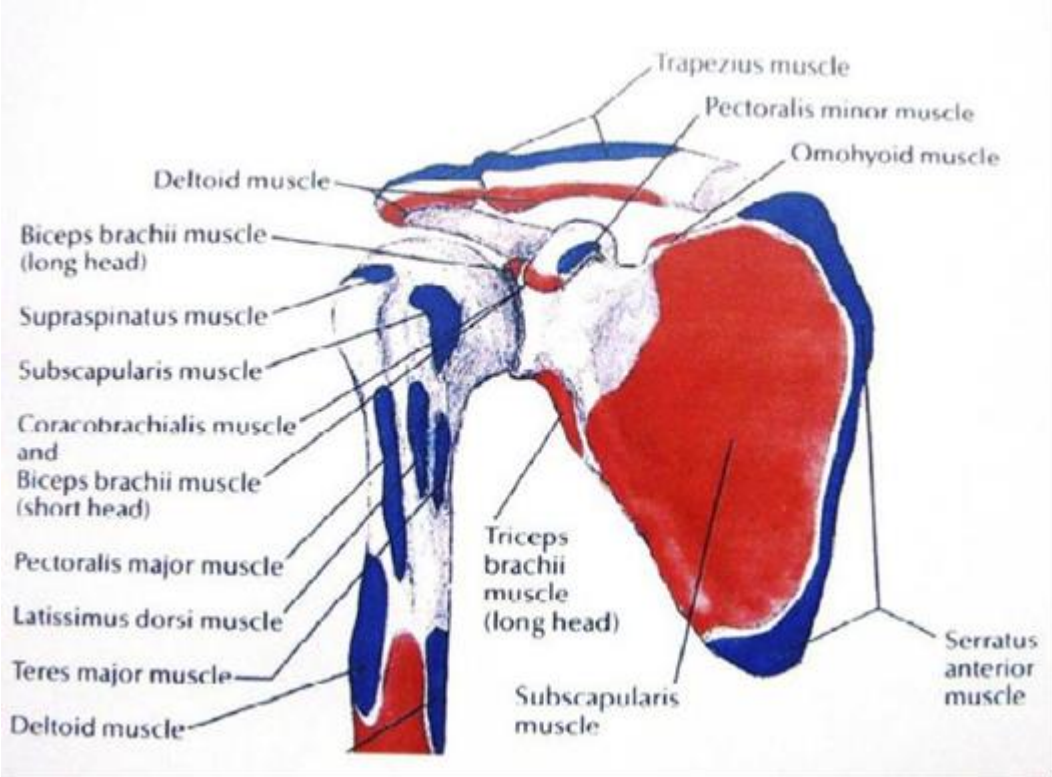



Figure 3. Anterior muscle attachments of the shoulder[87]

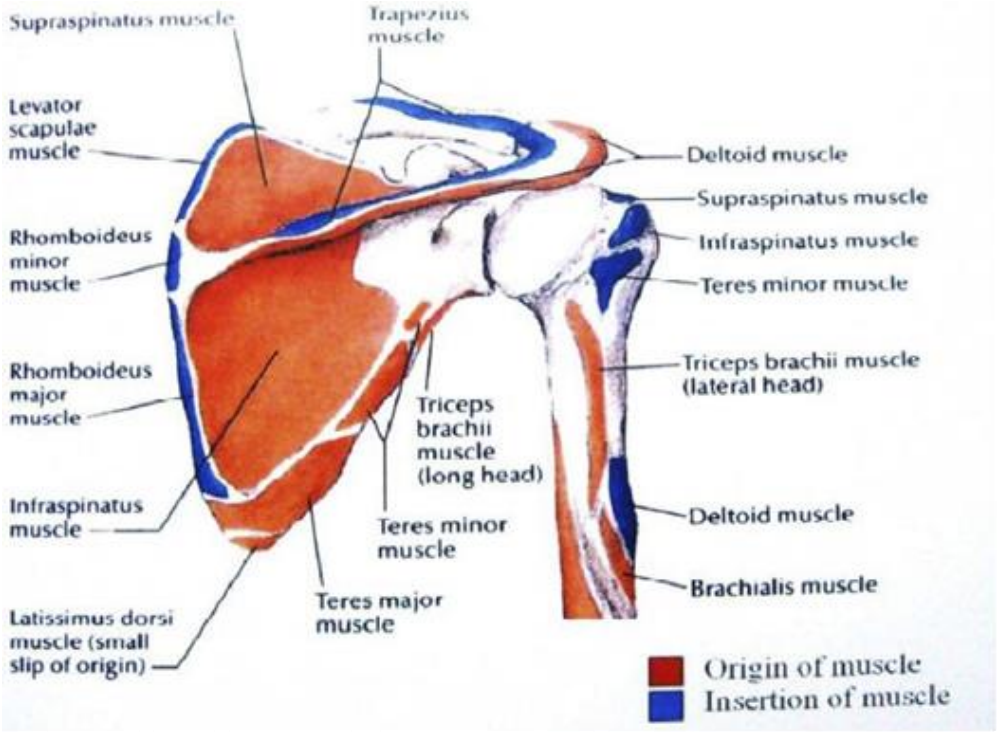



Figure 4. Posterior muscle attachments of the shoulder[87]

## THE SUBACROMIAL BURSA

The subacromial bursa is a large synovial membrane.[14] The roof of bursa is adherent to the inferior surface of the coracoacromial ligament, laterally acromion and deltoid muscle while the floor is closely adherent to rotator cuff and greater tuberosity**.**

The bursa also extends anteriorly and posteriorly around proximal humerus, creating gliding mechanism that facilitates the movement of the proximal humerus under coracoacromial arch. Fibrotic thickening and loss of glenohumeral motion occurs even in undisplaced fractures when the bursa gets injured.[14]

## ROTATOR CUFF AND MUSCLES

For gleno-humeral function the dynamic interplay of the rotator cuff and deltoid muscles are very much essential. The humeral head stability in the glenoid created by these muscles allows the deltoid muscle to function optimally. The subscapularis, supraspinatus, infraspinatus, and teres minor forms the rotator cuff. The long head of biceps tendon is also an important component of this complex. The subscapularis is an internal rotator, while the head depressor is by supraspinatus and in certain positions an internal rotator. The teres minor and infraspinatus are external rotators. Dynamic glenohumeral stability is maintained by these muscles when they work.

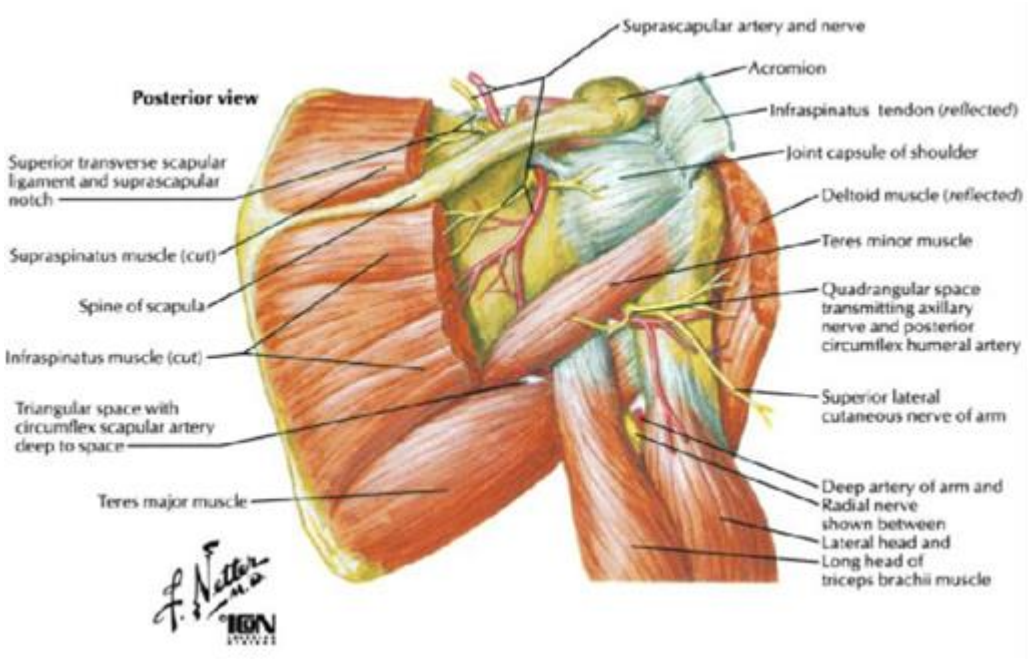



Figure 5. Rotator cuff muscles[87]

Following proximal humerus fracture, the rotator cuff must be reconstructed. The rotator cuff forces that produced the fracture can depend upon by the initial fracture pattern, displacement of the fracture fragments, reduction maneuvers and fixation techniques used to oppose the displacement forces.

The greater tuberosity gives attachment to supraspinatus at the superior facet and superior half of the middle facet. Avulsion - type forces from supraspinatus produce greater tuberosity short transverse fracture that displaces primarily superiorly. Reduction by straight abduction helps reduce the fragment and initial displacement forces gets neutralized by tension band fixation.The entire middle facet of the greater tuberosity gives attachment to the infraspinatus also if involved the fracture fragment is larger and fragment gets displaced posteriorly - superiorly. Horizontal fixation

helps neutralize the rotational forces from the infraspinatus in addition to vertical tension band to neutralize displacement forces in this fracture.

The lesser tuberosity gives insertion for subscapularis. These fractures avulse the lesser tuberosity anteriorly - medially and best neutralized by horizontal fixation. In 4-part fracture pattern the tuberosities are displaced and the supportive structures of one of the articular segments are removed. Thus fragment tilts superiorly and subsides. Disruption of the medial calcar and its blood supply can occur if the axial forces load the shaft against head segment when gets extruded laterally.[16]

The deltoid and pectoralis major are the other two important muscles in the proximal humerus region. The deltoid is a prime mover of the shoulder and originates from lateral one third of the clavicle, the acromion and spine of the scapula. It gets inserted on the deltoid tuberosity on lateral aspect of shaft of the humerus and can cause fracture displacement of the proximal humerus shaft. The other important muscle pectoralis major is a large fan shaped muscle that has a broad origin from clavicle, the upper ribs and sternocostal area. It gets inserted on the lateral lip of bicipital groove. In surgical neck humerus fractures this muscle can displace the proximal shaft of the humerus medially.

## ARTERIAL BLOOD SUPPLY

The anterior circumflex humeral artery gives major blood supply to the humeral head. The arcuate artery was first described by Laing, which is a continuation of the ascending branch of the anterior circumflex humeral artery as it penetrates the bone. The large portion of the humeral head is supplied by this arcuate tortuous artery.It enters the humerus bone in the area of intertubercular groove and there it gives branches to greater and lesser tuberosities. The branches of posterior circumflex humeral artery and from the vascular rotator cuff, through tendinous osseous anastomosis also supplies the humeral head in small contribution[14.] The blood supply to the rotator cuff as out lined by Rothman[20] routinely derived from six arteries the anterior circumflex humeral, the posterior circumflex humeral, the suprascapular, subscapular, suprahumeral and the thoracoacromial.

In 1990, Gerber[21] confirmed the significance of arcuate artery described by Laing in a cadaveric study. He demonstrated that the vessel was responsible for perfusing the entire epiphyses and when this artery gets injured only an anastomosis distal to the lesion could compensate for resulting loss of blood supply.

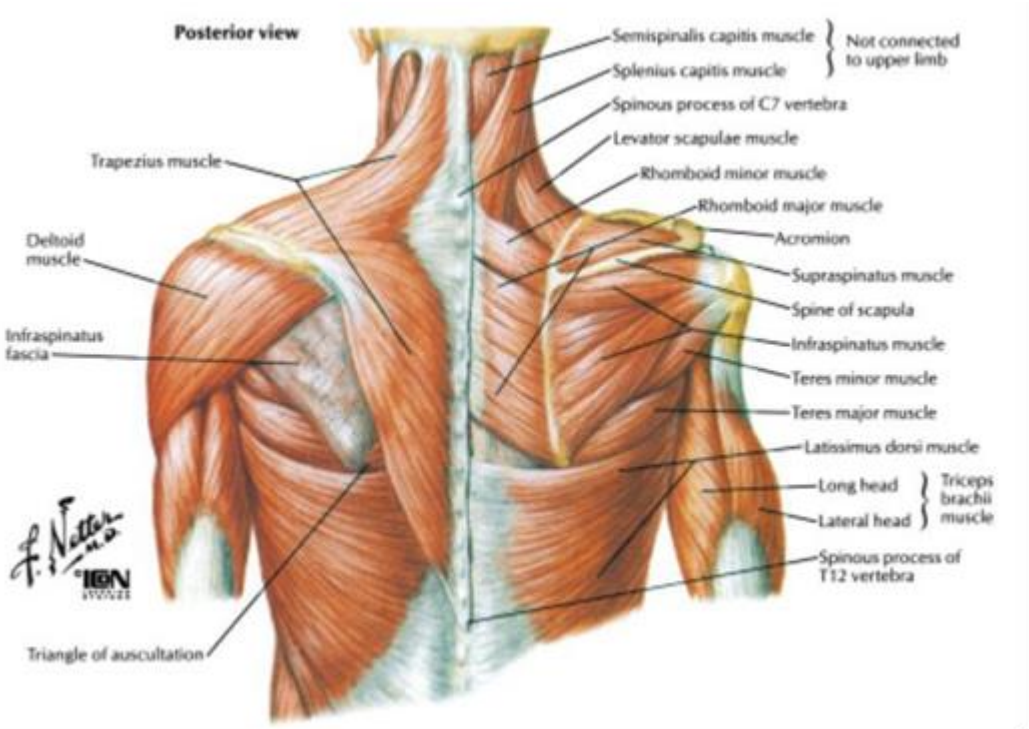



Figure 6. Muscles of the shoulder-posterior view[87]

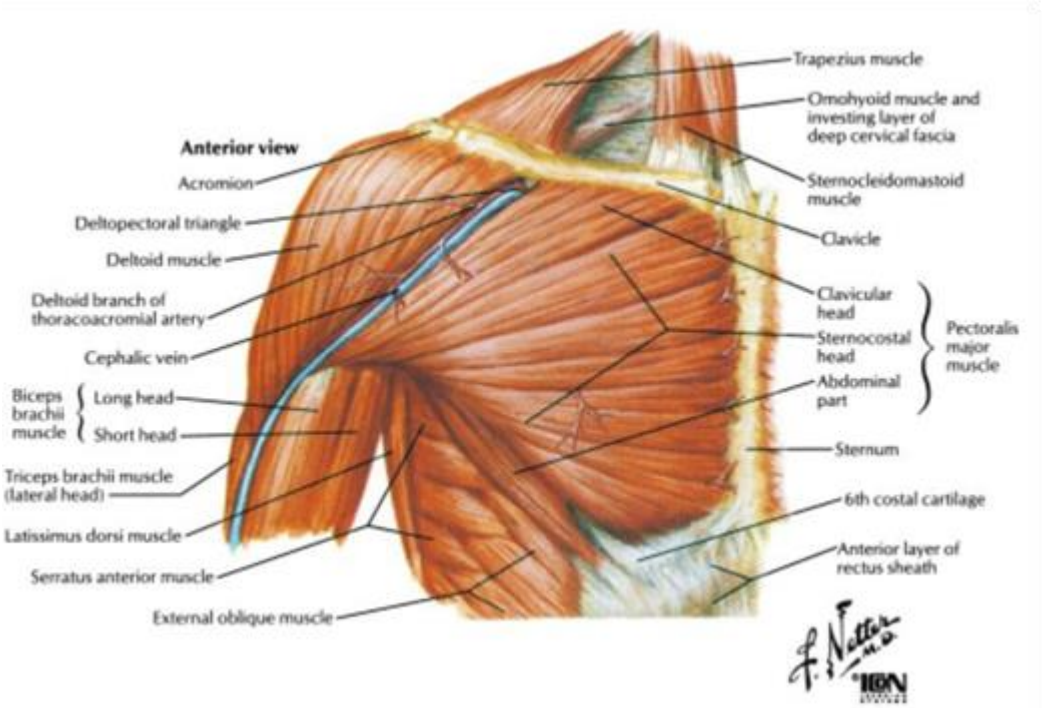



Figure 7.Muscles of the shoulder-anterior view[87]

The axillary artery is known as the “tethered trifurcation” at the level of the surgical neck. Most vascular injuries to the arterial supply of the proximal humerus occurs at the trifurcation just proximal to the anterior circumflex humeral artery.

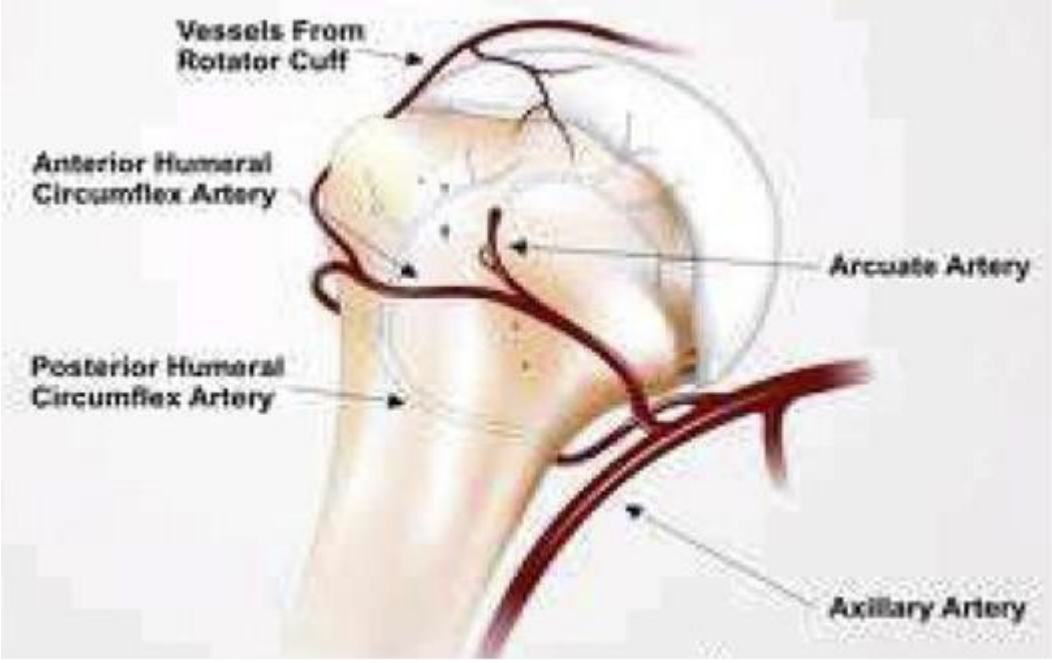



Figure 8.Arterial supply of shoulder[88]

## NERVE SUPPLY OF THE SHOULDER

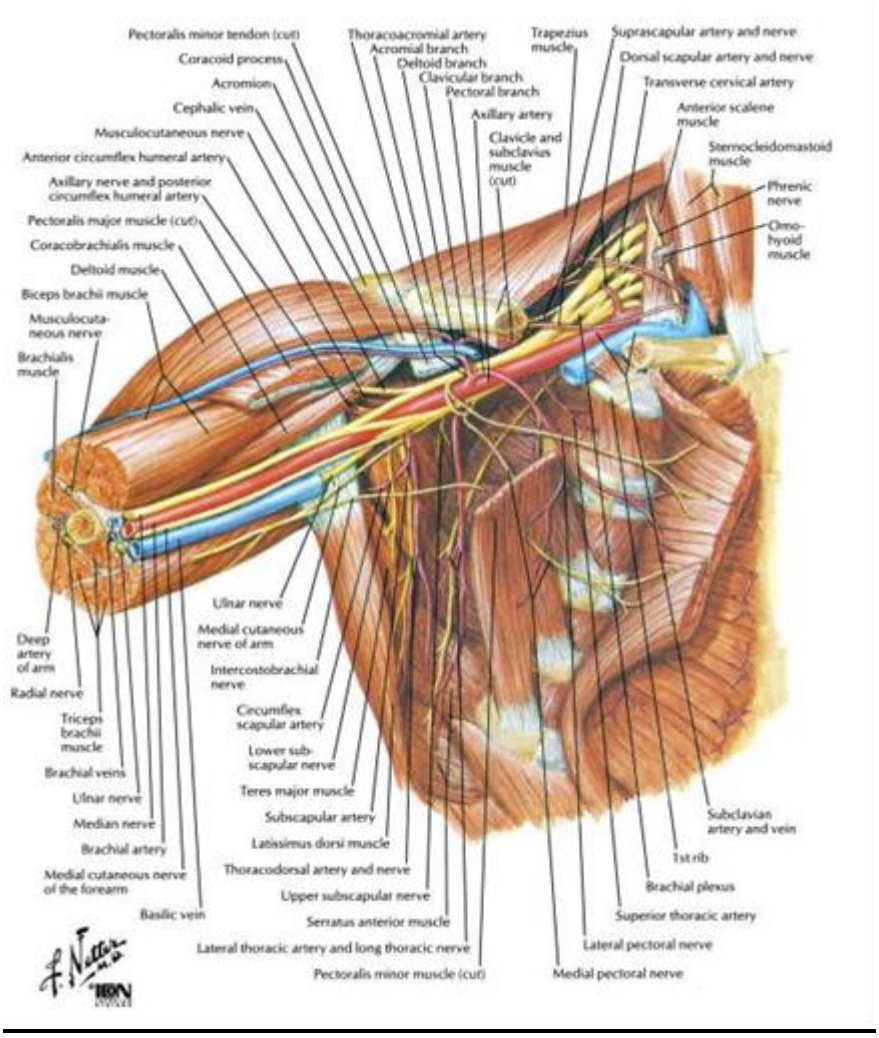



Figure 9. Nerve supply of the shoulder[89]

Proximal humerus fractures can give rise to injury to the nerves at the shoulder. The brachial plexus lies medial to the coracoid process and can be injured in violent trauma to proximal humerus and anterior fracture dislocations. Major nerves innervating the muscles around the shoulder viz- the axillary, suprascapular, and musculocutaneous, can also be involved as isolated injuries.

Axillary nerve: Takes origin from the posterior cord at the level of axilla and in most cases axillary nerve is composed of fibres from C5 and C6 roots. It crosses the anterior surface of subscapularis muscle and dips back posteriorly under its inferior border. It passes along the inferior border of capsule of the gleno-humeral joint and then through quadrangular space. It emerges from the quadrangular space and gives off a branch to the teres minor muscle and divides into anterior and posterior branches. The posterior fibres of deltoid are supplied by posterior branch and gives off the superior lateral brachial cutaneous nerve.

Anterior branch supply middle and anterior fibres of deltoid. Any abnormal downward motion of the proximal humerus can lead to traction injury to this nerve owing to its relative fixation at the posterior cord and deltoid. Its relationship to inferior capsule makes it susceptible to injury from anterior dislocation and during open repairs of anterior fracture dislocation.

Less commonly the suprascapular nerve may be injured. The two points of fixation of nerve are at its origin from upper trunk and at supra scapular notch making it susceptible to traction injuries. Musculocutaneous nerve injury is rare but does occur due to traction injuries as well as blunt trauma.

## HISTORICAL NOTE

In recent decades a great deal of information has been published as the new technique of fracture management have been developed and old techniques have been rediscovered.

In 460 BC, Hippocrates is credited with documenting the first fracture of proximal humerus and describing a method of weight traction which aided in bone healing. However little was written concerning this subject until later part of 19th century.[16]

In 1896, Kocher developed an anatomical classification in an attempt to improve diagnosis and treatment but this simplified scheme was not thorough enough and lacked consistency.[16]

In 1907, Keen performed first open reduction and internal fixation of an acute fracture of the greater tuberosity but he credited Bardenhaver with having developed concept in 1886 and Muller with having done first repair of an old fracture in 1898.[16]

In 1912, Albee and in 1923, Austin proposed immobilization by casts and splints. In 1932, Roberts SM reported that elaborate apparatus and prolonged immobilization were not beneficial as simpler forms of fixation and early motion. In

1934, Codman made a significant contribution when he divided proximal humeral fracture into four basic parts.[16]

In 1934, Howard and Eloesser developed a complex theoretical shoulder model that simulated muscle forces and demonstrated that abduction splint was not beneficial for reduction and control of muscle forces.[16]

In 1937, Meyerding suggested the use of open reduction and early mobilization to improve alignment and avoid malunions that would limit motion. Suture material, wire and screw were types of early fixation.[16]

In 1955, Rush described his method of intramedullary nailing for displaced proximal humeral fractures, which became quite popular.[16]

In 1963, Maclauglin found that fractures of greater tuberosity that healed with more than 1cm of displacement resulted in permanent disability, while those with 1/2cm of displacement or less did well. He reported that patient who had ½ to 1cm displacement of fragment often had prolonged convalescence, with some having permanent pain and disability and 20% needing reconstructive procedure.[16]

In Early 1970s the association for study of internal fixation (ASIF) group popularized osteosynthesis (AO) by plates and screws for the displaced fractures.

Dr. Charles S. Neer II has made an outstanding contribution to proximal humerus fractures. He published two articles in 1970.[8,22,23]

The first article deals with classification and evaluation and second with treatment of fracture with three part and four part displacement. The study was made of anatomy of 300 displaced proximal humerus fractures and fracture dislocations, selected at random from those treated by closed reduction under anesthesia or surgery at the New York. Orthopedic Hospital - Columbia -presbyterian medical center between 1953 and 1967. The age of patients ranged from 22 years to 89 years and average age was 55.6 years. Treatment consisted of closed reduction, under anesthesia in 162 (54%), Open reduction in 75(25%), with removal of humeral head on five occasions and prosthetic replacement in 63(21%) patients. After considering his group of patients he suggested that displacement of less than 1.0cm (or) angulation less than 45° between fragments did not alter the anatomy to such an extent that final clinical results would be jeopardized. Thus the new classification system evolved.[22]

In second article, the more complex fractures were considered. 117 patients with three-part (or) four part displacement were treated with closed reduction 77(65.8%), open reduction 43 (36.7%) (or) a proximal humeral prosthesis (43) and were followed for minimum of one year. In closed reduction only 3 had satisfactory result 19 three part fracture treated with open reduction had satisfactory result and 13 four part fracture with open reduction had satisfactory result. 7% of three part and 75% four part treated with open reduction developed osteonecrosis of head.[23]

In 1983, Pavolonian et al,[24] reported 23 of 31 patients (74%) with good to excellent results by the Neer criteria following open reduction and fixation with plate and lag screw. Half of the patients included in the study were younger patients and half of the patients were with two part and the good results in this study were attributed to these factors.

Siebler G., et al,[25] in 1985 has reported on late results of 65 proximal humerus fractures,operated upon between 1970 and 1980. Fracture classified as Neer two part (28), three part (15), and four part (21) and fracture of articular surface. In 34 cases T plate, 23 cases screws and K-wires, 3 cases primary head replacement have been 7 done. The functional result were excellent in (38%) patients, good in (22%) patients, fair in (15%) patients, poor in (25%) patients. The better results obtained in younger patients, isolated shoulder injuries and patient with 2 or 3 part fractures.

Kristiansen[26] in 1986 has reported 9(45%) satisfactory and 11(55%) unsatisfactory results for 20 patients with two-part, three-part, and four-part fracture treated with AO Buttress plate. In this study 4 cases developed infection, and in five cases impingement of plate was present and in two cases loosening of plate was present. They concluded that buttress plate offers satisfactory reduction and good stability at high risk of complications and hence the indications should be carefully considered in elderly and operation should be performed by experienced orthopedic surgeon.

In 1986, Hawkins et al[27], reported on 15 patients with three part fractures in patients ranging form 58 to 74 years who were treated with tension band wire suture or wire. 2 (13%) patients had avascular necrosis and (7%) had impingement from wire fixation. There were no non- unions, infections, or secondary displacements. The study showed that these patients achieved an average forward flexion of 120° (60-170°) and external rotation of 81° (30°-110°) after the treatment with tension band suture or wire.

In 1986, Mourdian[28] developed an intramedullary device with screw fixation for head and tuberosities. However, the incidence of Avacscular necrosis (AVN) was high and follow up was short.He used nail for 6-two part, 10-three part and 7-four part acute fractures. According to Neer functional score patient with two part fracture had 86.5 score, 3-part fracture had 80, scores 10 with three part and four part had 80 score. All patients healed without infection, 4 (19%) patients had avacscular necrosis (AVN), 5 (23%) had impingement.

Savie[29] in 1989 treated 9 patients with three-part fracture, with plate and screw used similar technique as that of pavolonien et al. All 9(100%) patients were followed for 2 years or more and had satisfactory or better rating using Neer criteria. Patients averaged 110° of abduction (range 100° to 170°).130° of flexion (range 100-170°), 35° of external rotation (10-60°). Had no case with infection, no case with impingement, had (30%) Avacscular necrosis (AVN).

Moda SK et al[29] in 1990 treated 25 patients with plate and screws. This is a very important series from India on proximal humerus fractures illustrating the reasonable degree of effectiveness of rigid internal fixation for younger patients with proximal humerus fracture. They used AO T plate in 15 patients, blade plate in 10 patients. Excellent or satisfactory result achieved in 21 of 25 patients (84%) including all 6 patients with two part, 4 of 5 with three-part, 9 of 11 with fracture dislocation and 2 of 3 with split fracture head of humerus. There were 4(11.4%) un-satisfactory result which were associated with rotator cuff damage. They concluded that AO T-plate or blade plate is best.

In 1994, Robinson CM et al.[31] reviewed 45 patients who have undergone two operative technique (AO plating and IM rush pins). Good functional results were obtained using the former technique in which 7 (87%) out of 8 patients mainly sustained fracture following high energy trauma and were above 50 years and 12 (85%) out of 14 patients who had low energy trauma and with osteoporotic bone treated with buttress plate had unsatisfactory result, but rush pin produced more reliable results in this group. Hence they recommended rush pin for low energy trauma and osteoporotic bones in elderly and plate for younger patients.

In 1995, Zyto K et al[32] their study of shoulder function after displaced fractures of proximal humerus, concluded that - it is difficult to consistently achieve success in patients with four-part fractures or fracture dislocations. However many of those with three-part fracture can be successfully treated. In their study out of thirty eight patients, 26 with 3-part, 12 with four part were followed for 3 to 3½ year,

28(74%) patients were treated conservatively, 7(18%) underwent open reduction and internal fixation, 3(8%) had hemiarthoplasty. According to Neer score 4 patients with 3 part and 7 with four part were classified failure that is total 28% of failure were present.

In 2000, Hintermann B et al.[33] studied 42 patients (34 three part, 8 four part) fractures treated using blade plate and deltopectoral approach. On final review (after average of 3.4 years). They found 13 patients with excellent result, 17 patients with good result, fair in seven, poor in 1. They concluded that rigid fixation of displaced fractures of proximal humerus with a blade plate in elderly patient provides sufficient primary stability to allow early functional treatment.

In 2002, Wijgman AJ et al.[34] assessed the intermediate and long-term results for sixty patients with a three or four-part fracture of the proximal part of the humerus who had undergone open reduction and internal fixation with cerclage wires or a T plate. The Constant score and a visual analog score for pain were calculated, and radiographs of the proximal part of the humerus were evaluated. After an average of ten years of follow-up, fifty-two patients (87%) had a good or excellent result on the basis of the Constant score whereas eight patients (13%) had a poor result. Fifty-one patients (85%) were satisfied with the result at the time of the most recent examination. Twenty-two patients (37%) had development of avascular necrosis of the humeral head, and seventeen (77%) of these twenty-two patients had a good or excellent Constant score. They concluded open reduction and internal fixation with cerclage wires or a T-plate yields good functional results in most patients. This option

should be considered even for patients with fracture-dislocation patterns that are associated with a high risk for avascular necrosis of the humeral head, as this complication did not preclude a good result.

Stable fixation of unstable proximal humerus fractures until bony consolidation. Early mobilization of the shoulder and early active rehabilitation program to ensure a good functional outcome and a good restoration of the activities of daily living.[35]

In 2004, Gerber C et al.[36] treated 34 articular fractures of the proximal humerus with good bone quality in 33 patients by open reduction and internal fixation with various modalities (Plate screw/ percutaneous pinning/osteosuture).They achieved anatomical or near anatomical reduction in 30 patients. 32 patients obtained mean constant score of 78 points. They concluded that operative treatment of complex fractures of proximal humerus gives good result if anatomical or near anatomical reduction is achieved in a patient with good bone quality.

In 2005, Charalambous CP et al.[37] treated 25 patients with proximal locking compression plate of which 20 went to union with mean neck shaft angle of 127.2°. Five cases required revision surgery for non union or implant failure. Of 25 implants, 4 had screw protrusion into gleno humeral joint, 4 had screw loosening and backing out, and 1 plate broke without further trauma. They concluded proximal locking compression plate as effective system for fracture stabilization to bony union.

In 2007, Babst R et al.[38] treated patients treated with locking compression plate. According to AO classification 16 fractures were type A, 21 type B,17 type C fractures. The mean constant score was 70 points and reached 87.3% in relation to the contralateral healthy side observed complication in 16 patients including two partial and two complete avascular necrosis, 6 primary screw perforation, 5 secondary screw perforation due to impaction of fracture,1 distal partial plate and screw pull out and 1 secondary loss of reduction. They concluded in young patients plate has best potential.

In 2007, Moonot P et al.[39] studied 32 patients with acutely displaced three or four-part proximal fractures of the humerus were treated by open reduction and internal fixation using the proximal humeral internal locking system plate. There were 23 women and 9 men with a mean age of 59.9 years . Data were collected prospectively and the outcomes were assessed using the Constant score. The mean follow-up was for 11 months (3 to 24). In 31 patients (97%) the fracture united clinically and radiologically at a mean of 10 weeks (8 to 24). The mean Constant score at final review was 66.5 (30 to 92). There was no significant difference in outcome when comparing patients aged more than 60 years (18 patients) with those aged less than 60 years (14 patients) (t-test, $p = 0.8443$). There was one case each of nonunion, malunion and a broken screw in the elderly population. Hence concluded plate provides an alternative method of fixation for fractures of the proximal humerus. It provides a stable fixation in young patients with good-quality bone sufficient to permit early mobilization. Failure of the screws to maintain fixation in the elderly remains a problem.

In 2007, Siwach R et al,[40] prospectively assessed the functional outcome and complications in 25 patients of proximal humerus fracture with osteoporosis treated with locking compression plate. Mean constant score was 80 points. According to constant score, 28% excellent outcome, 64% good functional outcome,8% had moderate outcome. Varus malalignment and subacromial impingement were observed in 8% patients. Loosening of implant and loss of reduction were observed in 4% superficial infection in 4% they concluded locking compression plate is an advantageous implant in proximal humerus fracture due to angular stability particularly in osteoporotic bone and comminuted fracture.

In 2008, Shahid R et al[41] prospectively reviewed 50 patients with proximal humerus fracture treated with proximal humerus locking compression plate from 2002 to 2006. Of which 11 patients had 2-part, eleven 3-parts, and 18 4- part fracture. Radiological union was achieved within 8 weeks in 40/41 fracture. They concluded locking compression plate as reliable implant. Increase in number of part of fracture did not affect final outcome.

In 2008, Egol KA et al[42] studied Early Complications in Proximal Humerus Fractures Treated with Locked Plates Fifty-one consecutive patients treated with a proximal humerus locking plate. A retrospective analysis was undertaken of a consecutive series of proximal humerus fractures treated with a locking plate between 2003 and 2006. Fracture union was identified in 18 male and 33 female patients with an average age of 61. All were treated with a similar protocol of open reduction internal fixation with the PHILOS plate followed by early range of shoulder motion.

Fifty one patients were available for minimum 6-month follow-up (mean, 16 months; range, 6 to 45 months). Radiographically, 92% of the cases united at 3 months after surgery, and 2 fractures had signs of osteonecrosis at latest follow-up. Eight patients (16%) had screws that penetrated the humeral head. Early implant failure occurred in 2 patients; one was revised to a longer plate, and one underwent resection arthroplasty. There was one acute postoperative infection. The major complication reported in this study was screw penetration, suggesting that exceptional vigilance must be taken in estimating the appropriate number and length of screws used to prevent articular penetration .

Hence concluded although the device provides exceptional fixation stability, its indication must be scrutinized for each individual patient, taking the extent of trauma/fracture and age into consideration and carefully weighing it against other forms of treatment.

In 2009, Brunner F et al[43] multicenter study in 8 trauma units (levels I, II, and III) with recruitment between 2002 and 2005. One hundred fifty-seven patients treated with Open reduction and internal fixation with a Philos plate. One-year follow-up rate was 84%. The incidence of experiencing any implant-related complication was 9% and 35% for non implant related complications.

Primary screw perforation was the most frequent problem (14%) followed by secondary screw perforation (8%) and avascular necrosis (8%). After 1 year, a mean Constant score of 72 points (87% of the contralateral non injured side), a mean Neer's

score of 76 points, and mean Disabilities of the Arm, Shoulder, and Hand score of 16 points were achieved. Concluded that Fixation with Philos plates preserves achieved reduction, and a good functional outcome can be expected. However, complication incidence proportions are high, particularly due to primary and secondary screw perforations into the glenohumeral joint, with an overall complication rate of 35%. More accurate length measurement and shorter screw selection should prevent primary screw perforation. Awareness of obtaining anatomic reduction of the tubercles and restoring the medial support should reduce the incidence of secondary screw perforations, even in osteopenic bone.

In 2009, Martinez AA et al,[11] retrospectively reviewed 58 patients who underwent locking compression plate fixation for proximal humerus fracture between September 2004 to march 2006. All fractures healed satisfactorily, expect in 1 patient with a valgus 4-part fracture who had malunion. Functional outcome was excellent in 13 patients, good in 36, moderate in 8, poor in 1. They concluded proximal humerus locking compression plate is appropriate treatment for proximal humerus fracture.

In 2009, Fazal MA et al,[44] retrospectively reviewed 27 patients who underwent locking compression plate fixation for proximal humerus fracture between June 2003 to June 2006. All fracture were classified as 2 part (n=13), 3 part (n=12), 4 part (n=2). All fractures united expect one 3-part fracture in 78yrs aged women in whom there was a collapse and screw penetration. Mean constant shoulder score was 70. Patients had score exceeding 75, 13 were scored between 50 and 75, and 3 were below 50. They concluded philos plate fixation provided stable fixation, minimal metal work

problem and enabled early range of motion exercises to achieve acceptable functional results.

In 2009, Papadopoulos P et al.[45] reported experience from the use of the Philos plate for the treatment of three-part and four-part proximal humeral fractures and to investigate factors influencing the final outcome. He concluded that, internal fixation with the Philos plate seems to be a reliable option in the operative treatment of upper end humeral fractures, especially in osteoporotic bone. It allows secure fracture fixation and quick shoulder mobilisation, while quick and uneventful fracture healing and very satisfactory clinical results are achieved.

In 2010, Aggarwal A et al,[46] over two and a half years, treated 56 patients with an acute proximal humerus fracture with locking plate osteosynthesis. 47 of these patients who completed a minimum follow up of 1 year were evaluated using Constant score calculation. The average follow up period was around 21.5 months. Outcomes were excellent in 17%, good in 38.5%, moderate in 34% while poor in 10.5%. The Constant score was poorer for AO-OTA type 3 fractures as compared to other types. The scores were also inferior for older patients (> 65 years old). Complications included screw perforation of head, AVN, subacromial impingement, loss of fixation, axillary nerve palsy and infection. A varus malalignment was found to be a strong predictor of loss of fixation.

They concluded locking plate osteosynthesis leads to satisfactory functional outcomes in all the patients. Results are better than non locking plates in osteoporotic fractures of the elderly.

In 2011, Osterhoff G et al[18] studied patients with proximal humerus fracture who underwent angular stable plate fixation between 2007 to 2009. Follow up was possible in 60 patients. Patients with calcar screw were assigned to group c+, patients without calcar screw to group c-. Humeral head necrosis occurred in 6 patients in (c+, 15.4%) and 3 in (c-, 14.3%). Cut out of the proximal screw were observed in 3(c+, 7.7%) and 1 (c-, 4.8%) cases. In each group 1 patient showed delayed union. There was significant loss of reduction in group c- compared to c+. He concluded the placement of calcar screw in angular stable plate fixation of proximal humerus fracture is associated with less secondary loss of reduction.

In 2012, Pawaskar AC et al[19] studied 25 patients who underwent surgery for proximal humerus fracture with locking plate between 2008 to 2010. Measurement of neck shaft angle was done at immediate post op, 3 month post op and final follow up (8 to 17 months). He found mean loss in neck shaft angle in the first 3 month was 3.8° as compared to 1.3° in the period between 3 months and final follow up. This was statistically significant (p=0.002). He concluded proximal humerus locking plate maintains reliable radiographic results even in elderly population with proximal humerus fracture.

Recently Gracitelli MEC et al[47] in 2013 evaluated functional outcomes, radiographic findings and complications of proximal humeral fractures treated with locking plates and determined prognostic factors for successful clinical outcomes. Forty patients undergoing internal fixation of fractures of the proximal humerus with the Philos plate were included in the study. The surgeries were performed between 2004 and 2011 and the patients underwent radiographic and clinical evaluation, by Constant-Murley and Dash score. Patients were on average of 61.8 ± 16.28 years, and most were female (70%). The Constant-Murley score was 72.03 ± 14.01 and Dash score was 24.96 ± 19.99. The postoperative radiographs showed a head-shaft angle of 135.43 ± 11.82.

Regression analysis showed that the patient's age and the Hertel classification influenced the Constant-Murley scale (p = 0.0049 and 0.012, respectively). Other prognostic criteria such as Neer and AO classification, head-shaft angle, the presence of metaphyseal comminution and extension of the humeral metaphyseal fragment showed no effect on prognosis. Complications occurred in four patients (10%). They concluded that, the fixation with the Philos® plate provided good clinical and radiographic results in fractures of the proximal humerus, with a low complication rate. Patient's age and Hertel classification were defined as prognostic factors that led to worse functional outcomes.

Ye T, et al[48] in his study evaluated the functional outcome of patients with complex proximal humeral fractures fixated by locking plate technology in 2013. Eighty-nine patients (27 men, 62 women) older than 50 years with 3- and 4-part

proximal humeral fractures were treated using locking plate fixation and followed up for more than 1 year. Functional outcomes were assessed by using the Disabilities of the Arm, Shoulder, and Hand (DASH) and Constant scores, and the complications were evaluated through physical and radiographic examinations. Mean DASH and Constant scores for all 89 patients were 19.6 and 66.6 points, respectively. No significant differences existed in the 2 scores between patients with 3- and 4-part fractures. Of the 71 patients without complications, 68 had an excellent functional outcome according to the DASH score, whereas 2 patients had an excellent outcome on the Constant score. For the 18 patients with complications, the functional outcomes were significantly poorer compared with patients without complications. According to the Constant score, all patients with complications were classified into a moderate or poor functional out- come, but the rate was 12% with the DASH score. In patients with 3- and 4-part proximal humeral fractures fixed with locking plate fixation, complications were the major cause of compromised functional outcomes. Study commented that, different conclusions would be reached when the functional outcome was assessed by using the DASH and Constant scores separately. Because the clinician-based Constant score may bias the results, patient-based assessments, such as the DASH score, are required for the evaluation of functional outcome after shoulder surgery.

Another study by Abdelrahman AA et al[49](2013) to evaluate the functional outcome after combined osteosynthesis and osteosuture for proximal humeral fractures enrolled 20 patients (eight men and 12 women) who underwent surgical treatment for proximal humerus fractures using proximal humeral locking plate for fixation (not original PHILOS plate). The mean age of the patients was 62.4 years.

According to Neer, seven patients had three-part fractures, 11 patients had four-part fractures (one patient had fracture dislocation), and two patients had associated fracture of proximal humeral shaft. Of the 20 patients, anatomic or near-anatomic reduction was obtained in 17 patients (85%). All fractures united in a mean of 3 months (range 2-5 months). None of the patients had avascular necrosis, implant failure, superficial or deep infection, or neurovascular injury. The mean constant score for all patients was 77. Study concluded that, the results showed that rigid fixation of the proximal humeral fractures using locking plate with preservation of the vascularity of the fracture fragments of the humeral head through minimal soft tissue dissection and preservation of soft tissue of fracture fragments were important in decreasing the complications following surgical treatment of the proximal humeral fractures.

Elgohary HS[50] in 2013 evaluated 26 osteoporotic or osteopenic patients with three-part or four-part proximal humerus fractures according to the Neer classification who underwent surgical fixation with locked plates through the standard deltopectoral approach were included in the study. The clinical outcome was evaluated with the Constant-Murley score. The average Constant score corresponds to 76.5 points, and the mean patient age in this study was 61 years. The average Constant score for pain was 13 points, strength 17 points, activities of daily living 17.9 points, and range of motion 28.6 points. All 26 fractures healed with a mean time of 11.5 weeks (8-16 weeks) and were followed for an average of 17 months. Study commented that, locked plate fixation for three-part and four-part fractures of the proximal humerus in osteopenic or osteoporotic patients is a good and reliable method of fixation with limited complications.

In 2016, Gönç U et al[51] in his retrospective study evaluated 31 patients who were treated with MIPO with average age of 58.4 years and majority of cases being neers 3 part fracture. Average Constant scores for fractured and normal shoulders were 73.2±10.9 and 84.8±5.1, respectively. Varus progression, fracture type, and age had no significant effect on functional outcome. Complications included 2 implant failures, 1 case of avascular necrosis (AVN), 1 primary screw cut-out, 1 axillary nerve injury, and 1 radial nerve injury (22.6% overall).Hence it was concluded that MIPO is a safe and effective option for the treatment of proximal humerus fractures, with good functional recovery and fewer complications, which are typically technique dependent. Reduction may be difficult, resulting in varus progression and also risk of axillary nerve injury. Careful surgical technique and correct implant selection is important in the prevention of nerve injury.

Another study conducted by Rohra. N et al [52] reviewed 30 patients who underwent open reduction and internal fixation with PHILOS plate between the years 2010 to 2015. There were 23 men and 7 women with a mean age of 36 years (range 20-64).There were 22 patients in the age group of <60 years and 8 patients in the age group of >60 years. According to Neer classification system, 12,11 and 4 patients had 2-part, 3-part, and 4-part fractures respectively and 2 patients had 4-part fracture dislocation. All surgeries were carried out at our tertiary care trauma center. Functional evaluation of the shoulder at final follow-up was done using Neer's Evaluation Criteria. The mean follow-up period was 20 months (range 14-40 months). All fractures united clinically and radiologically with mean time for radiological union was 13.2 weeks. The results were excellent in 17 patients, satisfactory in 8 patients,unsatisfactory in 4 patients and failure in 1 patient. During the follow-up, 3

cases of varus malunion, 1 case of failure of fixation were noted. No cases of AVN, hardware failure, locking screw loosening, infection or nonunion were noted. Like avascular necrosis, knowledge of anatomy and vascular supply of head of humerus and good surgical dissection, PHILOS provides stable fixation in proximal humerus fractures in order to prevent the complications to preserve vascularity of humeral head is important.

In a study conducted by C .H. Venkateswarlu et al[53] which aimed at evaluating the functional outcome of 30 consecutive patients with proximal humeral fracture treated by Philos plate fixation;who attended the hospital between December 2013 and December 2015 were included in the study; 18 women and 12 men with a mean age of 47.5years (30-60 years) are included. Data was collected prospectively and outcomes were assessed using constant shoulder score. The mean follow-up period was 12 months (6-18 months). Mean union time of all the fractures was 11.4 weeks (8-20 weeks). The mean constant shoulder score at final review was 70.5 (52-92). Philos plate provides stable fracture fixation for proximal humerus fracture in both young and elderly patients, which enables for early mobilisation and achieves acceptable functional results. Hence it was concluded that treating a proximal humerus fracture remained a challenging problem until proximal humeral internal locking system has been developed.

## INCIDENCE

Proximal humerus fractures are common, particularly in the elderly. Along with proximal femoral, distal radial, and vertebral-body fractures, they are a common type of osteoporotic fracture. Women are affected two to three times as often as men.[6,54]

An analysis of the Finnish trauma registry revealed that the incidence of proximal humerus fracture rose from 32 to 105 per 1,00,000 persons per year between 1970 and 2002, along with a rise in the average age of affected women, from 73 to 78.[55]

In Hungary, health insurance data from 1999-2003 reveal an incidence of 342 per 100 000 persons per year; in emergency rooms in the USA, there were 61 consultations for proximal humerus fracture per 1,00,000 persons in the year 2008.[56,57]

Fractures of proximal humerus comprise approximately 4 to 5% of adult fractures, of which 20% fracture are displaced requiring surgery. In Neer's original series of 300 fractures the average age of the patients was 55.6 years. Lind found that three fourth of his patients with proximal humerus fractures were over 60 years.[20]

Mayo clinic identified a predominance of proximal humerus fracture in women at ratio of 1.5:1 and Lind noted female to male ratio 3:14[58]

## HISTORY AND MECHANISM OF INJURY

In younger patients, proximal humerus fractures are usually caused by high-energy trauma, such as traffic accidents or sporting accidents. In older patients, the most common cause is a fall on the outstretched arm from a standing position, which is a type of low-energy trauma.[55,58]

## MECHANISM OF INJURY[21,58]

- Fall on outstretched hand with pronated upper extremity - Most common cause.
- Excessive rotation of the arm especially in abducted position. Described by Codman.
- Direct blow to side of shoulders - Can lead to Greater tuberosity fracture with communition.
- Strong externally rotated force when arm is at maximum external rotation and is at about 60° abduction - causes fracture of Lesser tuberosity.
- Resisted internal rotation - may cause fracture of Lesser tuberosity

## CLINICAL FEATURES[55]

Proximal humerus fractures occur as a result of fall from height usually in elderly due to osteoporotic bones, and from high energy trauma in young patients. When on examination there may be visible swelling and extensive ecchymosis but

lacerations and open fractures are rare. In cases of anterior dislocation there may be anterior bulge below the coracoid and in case of posterior dislocation there may be seen posterior bulge and anterior sulcus. On palpation tenderness around the shoulder will be present and movements may be associated with crepitus. Integrity of axillary nerve can be assessed by testing sensation at the lateral aspect of shoulder.

Typically, the patient holds the injured arm in a protective posture close to the chest. Pain, swelling, tenderness and hematoma of the proximal portion of the humerus may indicate the presence of a fracture. The perfusion and sensorimotor function of the limb should be tested in the periphery. The axillary nerve functioning should be tested as well.

## DIAGNOSTIC EVALUATION

X-ray assessment includes a trauma series with a true anteroposterior view, an axial view, and a scapular Y view. In the acute condition, because of pain, the axial view is often unobtainable. Computed tomography (CT) may yield important additional information particularly for complex fracture types, about the size and position of the individual fragments and about potentially accompanying bony injuries, e.g., of the coracoid process or glenoid.[59]

A careful history is an important component of the assessment, to establish the mechanism of injury and to define the "personality" of the fracture. Further, it is

imperative that concomitant injuries, such as head injuries, are identified and treated. Information about the patient's pre-trauma shoulder function and other co-morbidities are important considerations in the fracture management.[59]

Physical examination is used to identify damage to skin or neurovascular bundle. Open fractures of the proximal humerus are rare although, fractures that displaced may cause swelling, extensive ecchymosis, skin tenting, or pressure necrosis. Neurologic or vascular injuries are most common in cases of fracture-dislocations. They must be identified expeditiously, documented, and appropriately treated, often in conjunction with other specialists such as vascular surgeons and/or interventional radiologists.[59]

Standard radiographs of the shoulder, including an anterior-posterior view, an axillary view, and a trans-scapular view, should be obtained on all patients with a suspected shoulder fracture. In the majority of cases, these plain radiographs are sufficient to define the fracture pattern. Computed tomography(CT) can be used to evaluate for a head-splitting component, better define the bone quality or the degree of comminution, and to further delineate configuration of the fracture. Full-length views of the affected and contralateral humerus may be useful for templating if arthroplasty is being considered.[59]

# FRACTURE CLASSIFICATION

## Radiological classification

Following proximal humeral fractures the fracture pattern is an important consideration when deciding upon treatment for and predicting the risk of osteonecrosis. The Neer[8] and the AO/ASIF[60] classifications are the most commonly employed classification systems. According to Neer classification, the fracture patterns are differentiated by the number of fragments, the direction of dislocation, and the involvement of the articular surface. To be considered a fragment, the fracture part must be displaced > 1 cm or must be angulated > 45°.The AO/ASIF classifies fractures based on the likelihood of avascular necrosis of the humeral head and severity of the injury. However, some studies have demonstrated low inter-observer reliability for the Neer and AO/ASIF systems.[61,62]

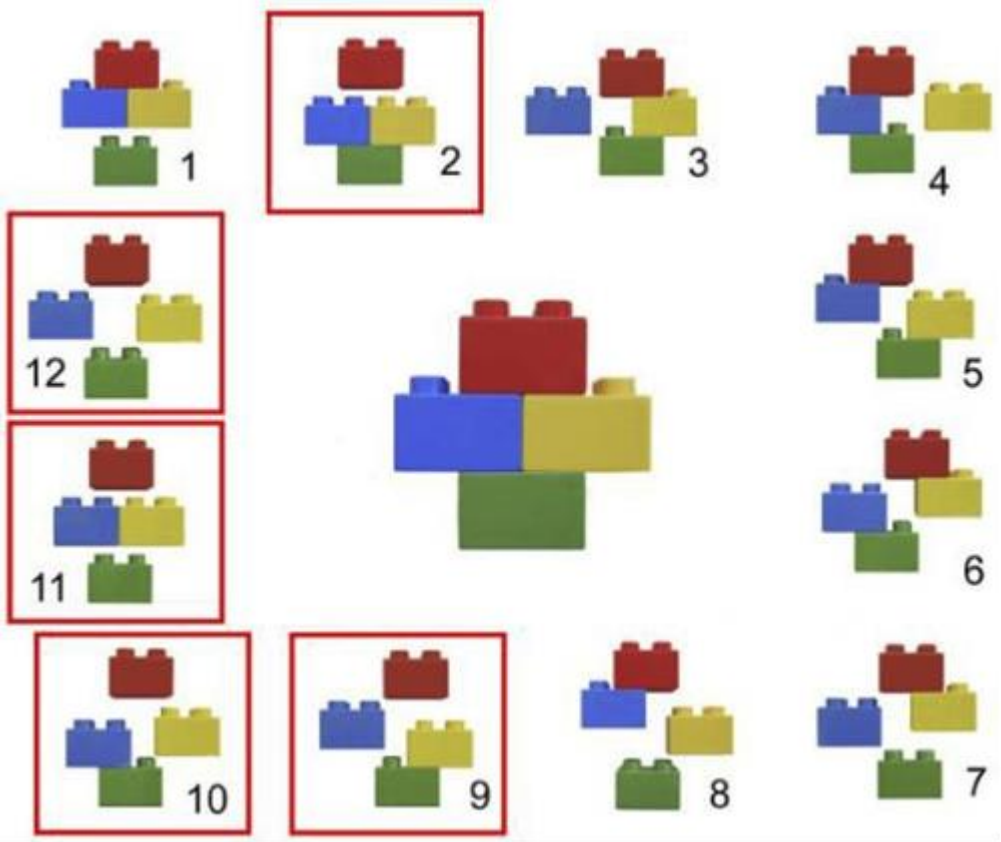



Figure 10. Binary or lego description system

Combinations of five basic fracture planes results in 12 basic fracture patterns. Basic fracture planes lie between the greater tuberosity and the head, the greater tuberosity and the shaft, the lesser tuberosity and the head, the lesser tuberosity and the shaft and between the lesser and the greater tuberosity

Hertel et al. more recently devised a binary (LEGO) system for proximal humeral fractures.[63] They utilized this system, which corresponds to the four-part system but provides more description, and correlated it to humeral head perfusion, which was assessed intra-operatively. They found that the most relevant predictors of ischemia were the length of the dorsomedial metaphyseal extension, the

integrity of the medial hinge, and the basic fracture type determined with the binary description system.

The Neer classification is the one most frequently used in routine clinical situations. Neer modified the Codman four-fragment theory by taking account of the degree of displacement and by adding luxation and head-split fractures. He classified non-displaced fractures as "one-part fractures," because they can be considered a stable unit and can thus be treated conservatively. Neer defined the threshold values distinguishing mildly displaced from displaced fractures as 1 cm of displacement and/or 45 degree of angulation. Displaced fractures are classified as two-fragment, three-fragment, or four-fragment fractures. Anterior and posterior luxation fractures and head-split fractures are classified as separate entities.[60] The Neer classification has two main disadvantages: It does not account for all possible fracture morphologies, nor does it enable prognosis of necrosis of the humeral head.

## CLASSIFICATIONS[21,64,65]

Various other methods prior to the Neer classification had been proposed including anatomical level (or) location of injury, mechanism of injury, amount of contact by the fracture fragments and degree of displacement.

In 1896 Kocher was the first to devise a classification system of proximal humeral fractures based on anatomical levels.

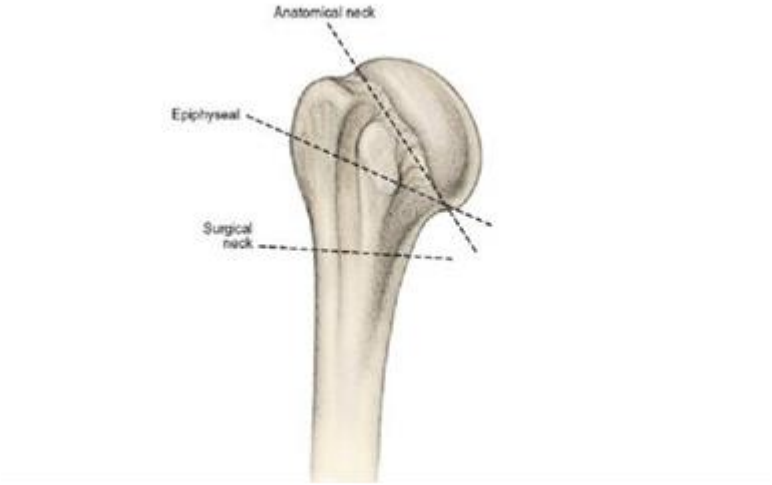



Figure 11. Kochers classification

## KOCHERS CLASSIFICATION

- Anatomical neck
- Epiphyseal region
- Surgical neck.

In 1934 Codman first described the main fracture fragments (segments) and their attachments, which cause displacement.

- Greater tuberosity
- Lesser tuberosity
- Head
- Shaft

Codman hypothesized fracture lines fall into remnant of old epiphyseal scar.

In 1955 Watson-Jones classified fracture according to mechanism of injury.

- Contusion crack fracture
- Impacted adduction type fracture
- Impacted abduction type fracture.

The major disadvantage of this classification system is that changes in humeral rotation alteration alter radiographic appearance of fracture.

## NEER CLASSIFICATION[8]

First described in 1970 and then simplified in 1975, was developed from the retrospective review of 300 fractures[10]. Following are the requirements to classify fractures.

- Segment angulation of 45°
- Segment displacement of 1 cm
- Adequate radiographs (Trauma series ± CT scans)
- Knowledge of the pathology and deforming forces

## NEER'S CLASSIFICATION RELIABILITY

Poor inter and intra observer reliability were shown by three studies. Neer defined distinct categories. The four segment classification is based on the presence or absence of displacement of one or more of the four major segments. Six groups were defined.

Group I includes all fracture, regardless of location or number of fracture lines, that have displacement of less than 1cm and angulation of less than 45°.

Group II fractures consist of articular-segment displacement or anatomical neck fractures. These are rare lesions that can lead to malunion or avascular necrosis.

Group III is composed of surgical neck angulation of greater than 45°. Three subtype include angulation of greater than 45°. Three subtypes include; angulated, separated or unimpacted, and comminuted surgical neck fractures.

Group IV fractures constitute greater tuberosity fractures with displacement of more than 1 cm from the lesser tuberosity. This fracture pattern is pathognomonic of a rotator cuff tear.

Group V is composed of displaced lesser tuberosity fractures that occur as isolated avulsion fractures, such as after a seizure or in association with a nondisplaced surgical neck fracture.

Group VI consists of fracture dislocations, either anterior or posterior, including impression fractures.

## AO CLASSIFICATION

AO Classification forms the basis of severity of injury and risk of osteonecrosis

***Type A fracture***

These are extra articular and involve one of the tuberosities. (osteonecrosis unlikely in this group).

- A1: Extra articular unifocal tuberosity.
- A2: Extra articular unifocal fracture with impacted metaphyseal fracture.
- A3: Extra articular unifocal fracture with non impacted metaphyseal fracture.

***Type B fracture***

Extra articular fracture but involve both tuberosities with concomitant metaphyseal fracture (or) glenohumeral dislocation (osteonecrosis less likely in this group).

- B1: Extra articular bifocal fractures with impacted metaphyseal fracture.
- B2: Extra articular bifocal fracture with non impacted metaphyseal fracture.
- B3: Extra articular bifocal fracture with glenohumeral dislocation.

***Type C fracture***

These are articular fracture with vascular isolation of articular segment. They have high risk of osteonecrosis.

- C1: Fracture with slight displacement.

- C2: Impacted fracture with marked displacement.

- C3: Fracture associated with glenohumeral dislocation.

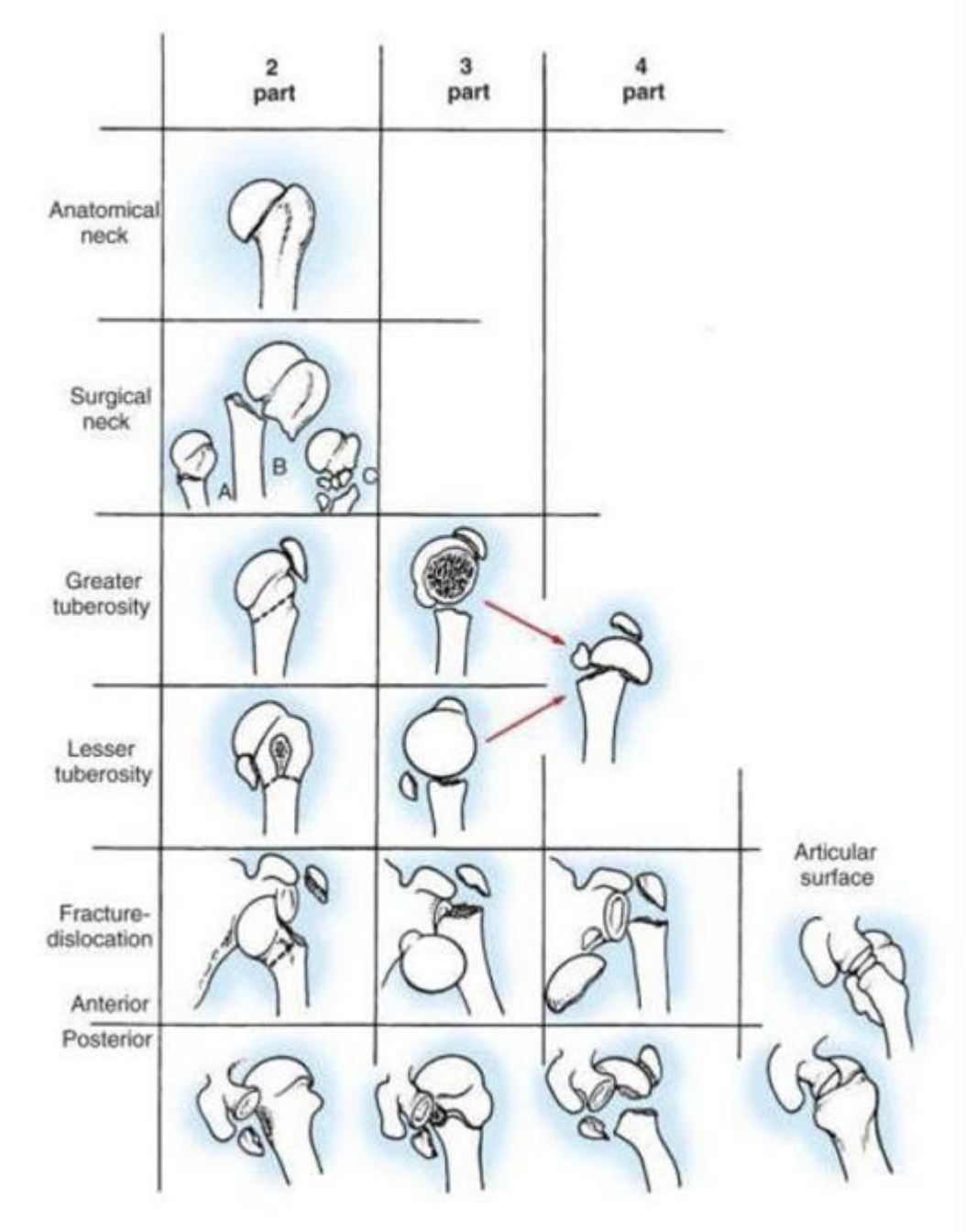



Figure 12. Neers four segment classification-Neer's terminology of four-segment classification of displaced fractures and fracture-dislocations relates pattern of displacement (two-part, three-part, or four-part) and key segment displaced.

In each two-part pattern, segment named is one displaced. Two-part surgical neck fractures are impacted (A), unimpacted (B), and comminuted (C).

All three-part patterns have displacement of shaft segment, and displaced tuberosity identifies type of three-part fracture. In four-part pattern, all segments are displaced. Fracture-dislocations are identified by anterior or posterior position of articular segment. Large articular surface defects require separate recognition

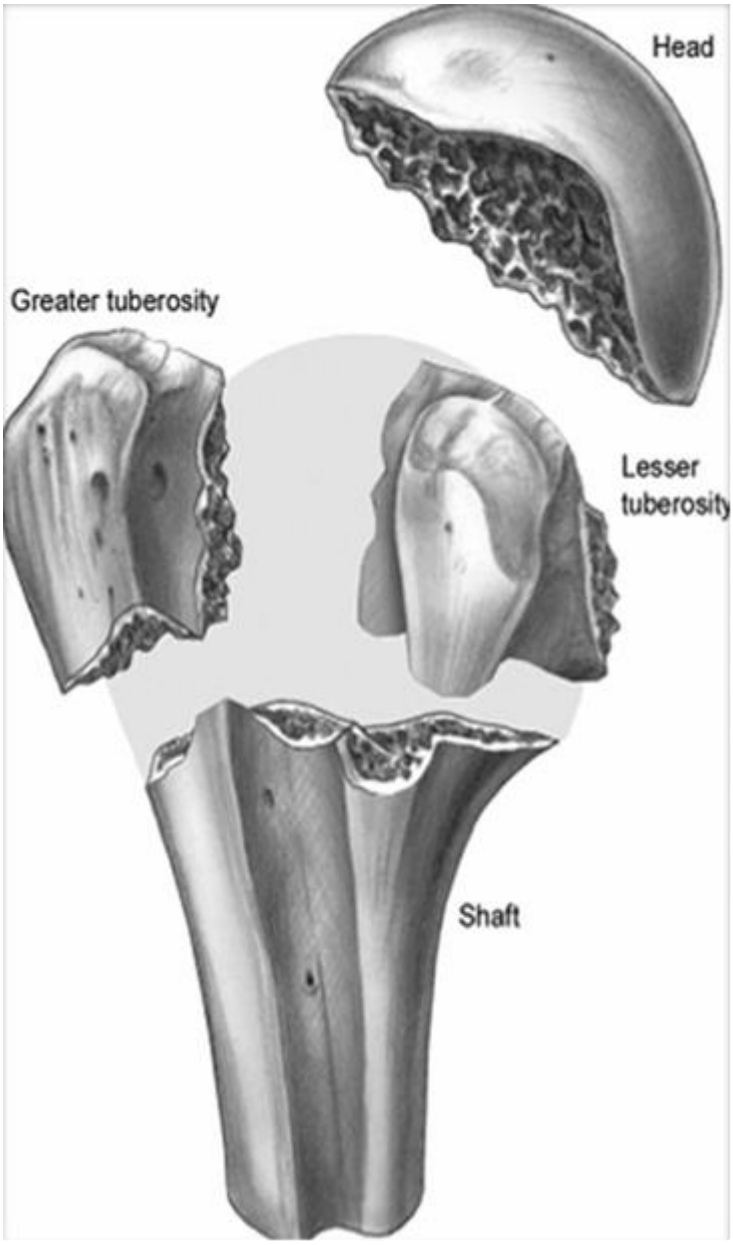



Figure 13. Codmans classification

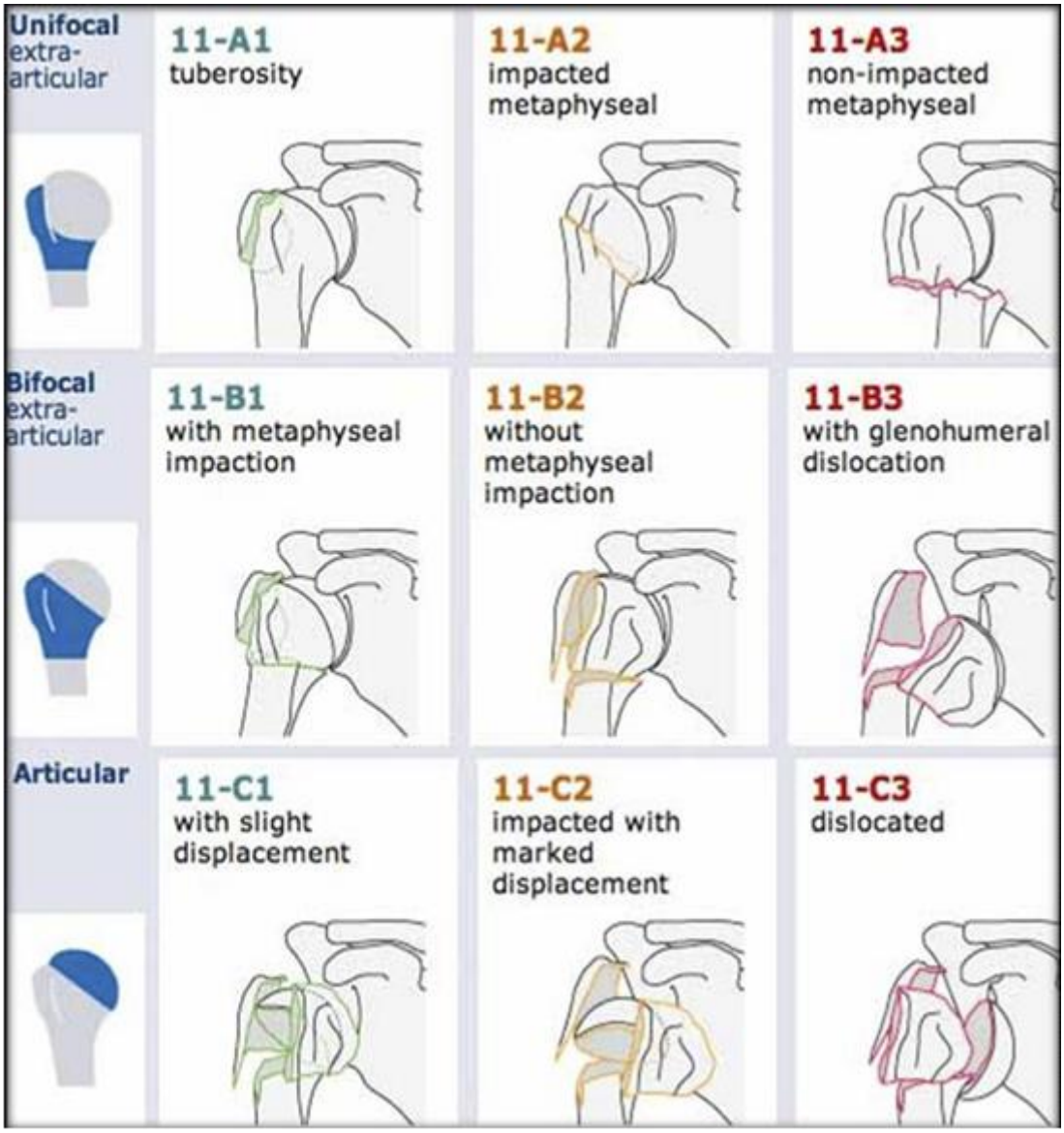



Figure 14. AO classification

## FRACTURE PERSONALITY

The fracture personality is defined by the location of the fracture, fracture configuration, and stability of the fracture.The mechanism of injury, the forces exerted and the osseous strength are determined by these characteristics.

Neer's classification has become the working classification both in the literature and at the bedside for displaced proximal humerus fractures. The four segment classification offers the clinician its significance and a comprehensive understanding of the fracture personality. The four segments considered here are the head, the shaft and the greater and lesser tuberosities. According to Neer's classification the fracture must be displaced greater than 1 cm and/or angulated greater that 45 degrees to fulfill the criteria to be called a displaced proximal humeral fracture. Neer also describes the "key segment" involved. The four-segment concept considers existing vascularity of the head, relationship of the articulating surface and muscle forces on the fragments. The forces of the muscles exerted on each fragment determine the ultimate resting position of the fracture and its potential response to treatment. The deforming forces arise primarily from pectoralis major and latissimus dorsi pulling the lesser tuberosity medially, while the greater tuberosity was pulled upward, backward and laterally by the supraspinatus, infraspinatus, and teres minor. These muscle actions must be appreciated in planning the management of fractures.[64]

Fracture location and configuration are prominent in the discussion of displaced humerus fractures, fracture stability must always be recognized in the definition of a fracture. Stability of the fracture is defined as the ability to withstand physiologic forces without further displacement in an immobilized posture. This definition actually provides us with one of treatment objectives.

Neer's monumental study on displaced fractures involving the proximal humerus provides a sound basis for analysis because of his recognition of fracture personality and identification of the key segment displaced.[8,9]

## TREATMENT

Although the fracture pattern is an important consideration when deciding upon treatment for and predicting the risk of osteonecrosis after proximal humeral fractures, other patient-related factors contribute to the personality of the fracture. These factors, as well as surgeon expertise, must also be considered when determining treatment. In a recent review, Murray et al. outlined the patient-related factors which they consider to be most significant in contributing to the personality of the fracture.[9]

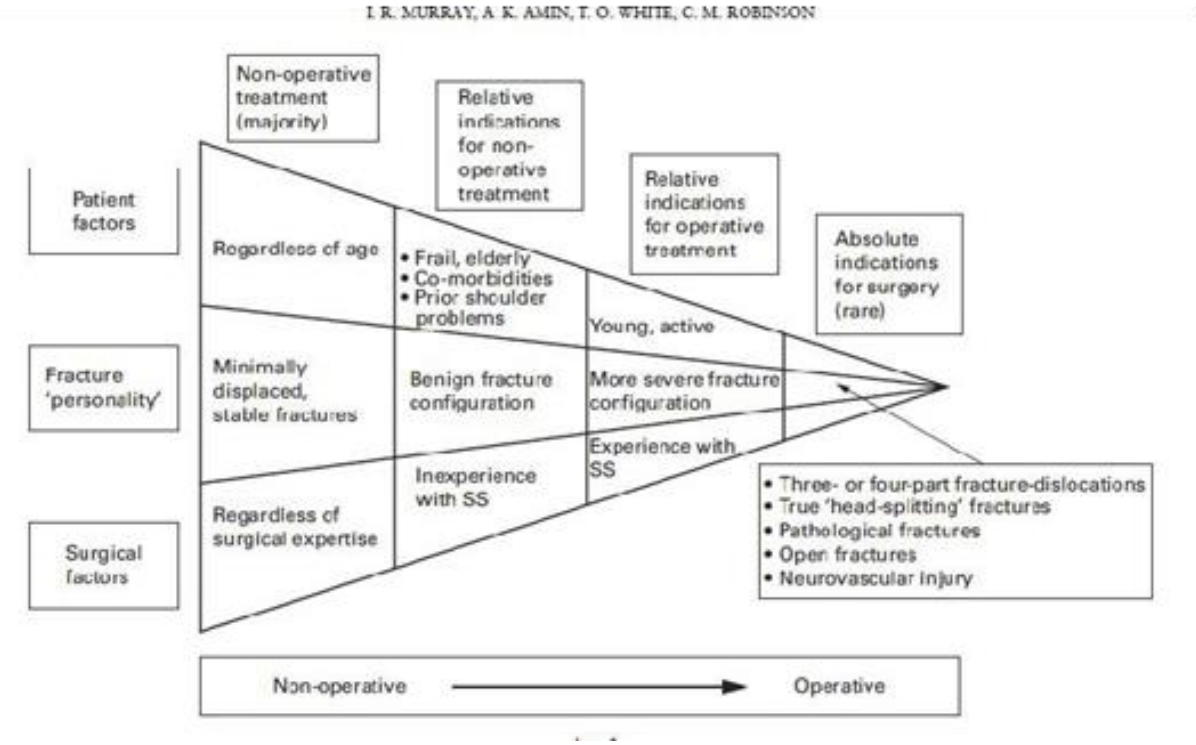



Figure 15. Flowchart depicting the way in which patient fracture and surgery related factors interact to influence treatment[9]

The factors that they consider to be relative indications for non-operative treatment include benign fracture configurations, frail, elderly patients, and those patients with co-morbidities such as severe osteoporosis, smoking, drug and alcohol abuse, diabetes mellitus, rheumatoid arthritis, and immunocompromised states. Other fractures fall into one of three groups: fractures in which surgery is essential, fractures which may benefit from reduction and fixation, and fractures which may benefit from arthroplasty.[59]

The rare cases for which surgery for proximal humerus fractures is essential include cases of open fractures, an associated vascular injury, and pathologic fractures. Three- and four-part fracture-dislocations and head splitting fractures are

very strong indications for surgery as well, but all patient characteristics must be considered before operating in all patients.[59]

Fractures which may benefit from reduction and fixation are those in which operative treatment can be expected to improve the outcome compared to non-operative treatment. Murray et al.[9] outlined their recommendations for fractures in which reduction and fixation should be considered:

• Two-part greater or lesser tuberosity fractures, or three- and/or four-part fractures in which the greater tuberosity is displaced by more than 1 cm.

• Fractures with a displaced fragment of the articular surface of the humeral head attached to a displaced tuberosity fragment.

• Unstable two-part surgical neck fractures in which there is disengagement of the shaft from the humeral head, due to displacement or extensive metaphyseal comminution.

• Two-, three- or four-part fractures in which there is varus or valgus deformity of the humeral head to the shaft by > 30° from the normal head shaft inclination angle of 130°.

• Three- or four-part anterior fracture-dislocations caused by propagation of a posterior humeral head fracture (‘Hill-Sachs lesion’) and with retained soft-tissue attachments to the humeral head at surgery (‘Type 1’ anterior fracture-dislocation).

• Three- or four-part posterior fracture-dislocations caused by propagation of a fracture of the anterior humeral head (‘reverse Hill-Sachs’) and with retained soft-tissue attachments to the humeral head at surgery.

Arthroplasty in the form of humeral head hemiarthroplasty or reverse total shoulder arthroplasty may be considered in patients with appropriate fracture patterns in whom reduction and fixation is ill-advised, who are medically stable, can tolerate extensive surgery, and who are able to participate in the prescribed postoperative rehabilitation program.[59]

Voos et al.[66] described their general indications for hemiarthroplasty for proximal humeral fractures to include: displaced three- and four-part fractures, age > 70 years, severe osteoporosis, humeral head osteonecrosis, failure to maintain open reduction and internal fixation, head-splitting fracture, and fracture-dislocation. They also defined their indications for reverse total shoulder age > 70 years combined with low demands, a fracture with severe tuberosity and metaphyseal comminution, severe osteoporosis, cuff tear arthropathy, fatty infiltration of a massive rotator cuff tear, a failed hemiarthroplasty, and comorbidities that would affect tuberosity healing.

## TREATMENT OPTIONS

### Non-operative

The advantages of non-operative treatment of appropriately selected proximal humerus fractures are the minimal risk of infection and operative complications with similar functional outcomes to operatively treated fractures. Outcomes are improved if supervised physical therapy is started earlier and immobilization is minimized. However, functional outcome is worse in cases of nonunion, symptomatic malunion,

or avascular necrosis. This finding, in addition to the observation of worse outcomes with secondary surgery than with primary operative treatment, has helped to define the previously described indications for primary operative treatment.[59]

## Reduction and percutaneous fixation

Minimally invasive reduction and percutaneous fixation techniques include Kirschner (K-) wire, screw fixation, Humerus Block (Synthes, Bettlach, Switzerland), or combination techniques. The advantage of these minimally invasive techniques is that they require less dissection and, potentially, less disruption of the vascular supply to the humeral head than do traditional open techniques. Resch et al. have popularized a technique for percutaneous reduction and fixation of proximal humeral fractures, including three and four part fractures.[67-69] This Humerus Block technique utilizes a metal block that is fixed to the humeral shaft by a cannulated cortical screw. The shaft is brought into alignment with the humeral head with axial traction under image intensifier guidance. Through a small incision, an elevator is used to reduce the head fragment. Two crossed K-wires are passed through the block at an angle of 45° and into the head fragment. K-wires and cannulated screws are then used to percutaneously reduce and fix the greater and/or lesser tuberosity fragments. This implant construct seeks to take advantage of the features of semi-rigidity and controlled impaction.[67] In this controlled impaction philosophy, the implant is a guiding tool rather than a rigid fixation device and allows for impaction of the humeral head.

Bogner et al.[70] published the results of a series of 51 patients with three-and four-part proximal humeral fractures treated with percutaneous fixation and reduction using the Humerus Block implant. Of the 51 fractures, three hemiarthroplasties (5.9%) were performed subsequent to the Humerus Block; two were performed because of fragment dislocation and one because of avascular necrosis of the humeral head. Of the remaining 48 fractures, the mean Constant score at follow-up was 61 in the 32 with a three-part fracture and 50 in four-part fractures. Ninety percent healed primarily, while secondary displacement of fragments or migration of the K-wires was seen in 10%.

Brunner et al.[71] also reported on the outcomes of 58 patients treated with the Humerus Block technique, noting a Constant score of 74, but requiring an unplanned re-operation rate of 40%.

Keener et al.[72] followed 27 patients who were treated with closed or percutaneous reduction and percutaneous fixation of displaced two-, three-, and four-part proximal humeral fractures. They found that all fractures healed after the index procedure and the mean ASES score was 83 and the mean Constant score was 74.

Fenichel et al.[73] reviewed the outcomes of 50 patients with proximal humeral fractures treated with closed reduction and percutaneous pinning using threaded pins. They found that the average Constant score was 81, while fractures confined to the surgical or anatomical neck generally did better than those associated with a greater tuberosity fragment.

Open reduction and internal fixation (ORIF) provides the features of anatomical fracture reduction, rigid fixation, and the possibility of bone grafting. However, as compared to minimally invasive techniques, there may be a higher risk of infection and avascular necrosis with ORIF. Further, adequate screw purchase with standard internal fixation requires a cortical thickness of > 4 mm. A standard deltopectoral approach has commonly been used for this fixation technique. Recently, straight lateral and shoulder strap approaches have been described for use in this setting. These approaches require identification and protection of the axillary nerve, but improve access to the lateral aspect of the proximal humerus for fracture reduction and plate positioning.[59]

The technique for ORIF in the presence of multiple fragments generally involves first identifying the fragments and the rotator cuff tendons. K-wires, elevators, and/or osteotomes are then used to gently manipulate the head fragment. A lateral plate can then be used to correct the translation of the medial shaft and reduce and fix the fragments into the anatomic position. In cases where there is a significant metaphyseal bone defect, the defect may be filled with local bone graft or bone-graft substitute. Alternatively, an allograft strut may be used to support the medial column, especially in cases of varus instability.[59]

There have been several recent studies which have demonstrated satisfactory outcomes following ORIF of proximal humeral fractures. Brunner et al.42 treated 158 fractures and at 1 year follow up noted a Constant score of 72. They found

screw perforation to be the most common complication (22%) and reported an 8% rate of avascular necrosis.

Sudkamp et al.[74] followed 187 patients treated with ORIF using a locking proximal humeral plate. At one year, they found a mean Constant score of 71 and a 14% rate of screw perforation.

Solberg et al.[75] found better clinical outcomes in older patients with three-and four-part proximal humeral fractures with initial valgus angulation (compared to those with initial varus angulation) and a metaphyseal segment attached to the articular fragment of greater than 2 mm.

Robinson et al.[76] treated 47 patients with a proximal humeral fracture in which there was a severe varus deformity. They used a standard operative protocol of anatomical reduction, fixation with a locking plate, and supplementation by structural allografts in unstable fractures and found a median Constant score of 86 at 2 years post-operatively.

## Intramedullary nail

Intramedullary nails may provide stable fixation for proximal humerus fractures and require minimal soft tissue dissection for insertion. They are especially suited for two-part surgical neck fractures, as three- and four-part fractures are not

generally amenable to reduction and fixation with an intramedullary device. The technique involves closed or percutaneous reduction of the fracture, a deltoid splitting approach to the humeral head, and antegrade insertion of the intramedullary nail. As a result of this starting point, the rotator cuff insertion may be damaged with this technique, leading to pain, stiffness, and shoulder dysfunction. Reports of intramedullary nailing of proximal humeral fractures have generally demonstrated satisfactory outcomes in patients with two-part fractures, but less reliable outcomes in patients with three- and four-part fractures.[59] One recent report found no differences in the functional outcome of proximal humeral fractures treated with either a plate or an antegrade nail.[77]

## Arthroplasty

Arthroplasty is an important treatment option for proximal humerus fractures in which there is a severe, head-splitting component, particularly in the case of an older patient with poor bone quality. Hemiarthroplasty has generally been the arthroplasty procedure of choice for acute fractures, with the goals being to restore the tuberosities to the anatomic position and to achieve the appropriate head component height, off-set, and version. The outcomes of hemiarthroplasty in lower-demand, elderly patients, especially in the setting of tuberosity comminution, cuff tear arthropathy, or a massive rotator cuff tear with fatty infiltration, have led to the popularity of the reverse shoulder arthroplasty in this situation. Specifically, it is an attractive option because of the ability of the prosthesis to compensate for tuberosity dysfunction. Further, the reverse total shoulder arthroplasty may also be used in the

setting of a proximal humeral malunion or a failed hemiarthroplasty for proximal humeral fracture.[59]

The technique for humeral head hemiarthroplasty for treatment of a proximal humerus fracture has been well described and generally follows the principles outline by Neer.[8] A standard deltopectoral approach is utilized, the tuberosities are identified and protected for later reconstruction, and the remaining head fragments are removed. The humeral canal is prepared and the humeral component is trialed and implanted, ensuring appropriate height, head size, offset, and version. Restoration and healing of the tuberosities has been shown to be the most critical portion of the reconstruction and, as such, much has been written about improving techniques to promote stability and tuberosity healing. The techniques involve suturing the tuberosities to each other and to the prosthesis, with some incorporating cerclage with cable or suture and/or bone grafting. A reverse shoulder arthroplasty for treatment of a proximal humeral fracture may be performed through a superolateral or deltopectoral approach. The principles of fracture exposure, proper implant positioning, and tuberosity reattachment outlined for hemiarthroplasty hold true for reverse arthroplasty as well.[59]

Robinson et al.[78] reviewed the outcomes of 138 patients treated with hemiarthroplasty for a proximal humerus fracture. They found the best functional outcome in younger patients with no preoperative neurological deficit, no postoperative complications, and a satisfactory radiographic appearance of the shoulder at six weeks. Poorer results were noted in elderly patients, particularly in

those with a neurological deficit, a postoperative complication requiring a reoperation, or an eccentrically located prosthesis with retracted tuberosities.

In a multicenter study of 167 patients who had a hemiarthroplasty for three- and four-part fractures, Kralinger et al.[79] noted anatomical healing of the tuberosity significantly influenced the outcome as measured by the Constant score and subjective patient satisfaction. This finding was corroborated by another multicenter analysis on the functional outcome of shoulder hemiarthroplasty for fractures.[80]

A recent systematic review of the literature examining the role of hemiarthroplasty in the early management of proximal humerus fractures found a mean Constant score of 57.[81] No pain or only mild pain was experienced by most patients, but marked limitation of function persisted. Complications related to the fixation and healing of the tuberosities were observed in 11% of cases.

The outcome reports of reverse shoulder arthroplasty for treatment of proximal humerus fractures have been more limited in number. Bufquin et al.[82] reported on the short term (mean 22 months) outcomes of 43 patients, noting mean active anterior elevation of 97° and mean active external rotation in abduction of 30°. They concluded that these outcomes demonstrated satisfactory mobility despite frequent (53%) migration of the tuberosities. Cazeneuve et al.[83] reported the clinical and radiological outcome at a mean of 6.6 years for 36 fractures treated with reverse total shoulder arthroplasty. They found a Constant score of 53 and noted that 63% of

patients had radiological evidence of loosening of the glenoid component. However, only one patient had aseptic loosening of the baseplate at 12 years' follow-up.

## COMPLICATIONS

The complications of proximal humerus fractures may occur as a result of the injury, or secondary to operative treatment. Several have been previously discussed and they most commonly are related to avascular necrosis and/or tuberosity malunion. Complications most commonly associated with non-operative treatment are avascular necrosis and symptomatic malunion. While operative treatment methods seek to reduce the incidence of malunion, they introduce the complications of infection, iatrogenic neurologic or vascular injury, and hardware migration and failure. Arthroplasty is indicated in severe cases where rates of avascular necrosis are high and fracture fixation is ill-advised, but it brings its own set of challenges and complications. Tuberosity malunion or nonunion, leading to rotator cuff dysfunction, is a primary complication leading to poor outcomes. However, component malposition, instability, heterotopic ossification, periprosthetic fracture, glenoid erosion, infection, and nerve injury are not uncommon after hemiarthroplasty for proximal humeral fracture. With reverse total shoulder arthroplasty, the complication list also includes scapular notching and glenoid loosening.[59]

### Neurologic injuries and brachial plexus injuries[17,21]

Neurologic injuries and brachial plexus injuries occur in up to 50% proximal humerus fractures. Axillary nerve may be injured in anterior fracture dislocations.

Carefully document any deficits and monitor them via electromyography (EMG). Explore injuries showing no improvement at 3 months. In elderly patients,fractures at the surgical neck, dislocation, blunt trauma with associated hematoma and in failed open reduction and internal fixation (ORIF) the risk of nerve injury is increased.

## Vascular injuries[17,21]

Axillary artery injury may occur in displaced proximal humerus fractures, usually following severe penetrating trauma or blunt trauma. Injury to axillary artery also may be seen with minimally displaced fractures in the elderly patient with arteriosclerosis due to lack of elasticity of the vessel walls. Although it is always important to evaluate the radial pulse, its presence can be misleading in a case of vascular injury due to collateral circulation. Injury to axillary artery is rare but has been reported. Maintain a high index of suspicion and proceed to an angiogram when signs of vascular compromise are present. These include pallor, paresthesias, pulselessness, expanding hematoma, unexplained hypotension, bruits and pulsatile external bleeding. Perform arterial repair emergently when indicated.

Failure to recognize and treat these injures can have catastrophic consequence, including amputation, gangrene and neurologic compromise (due to compression from the hematoma). Stable forth has noted 4.9% of vascular injury and 6.1% of brachial plexus injury.

## Frozen shoulder or stiffness[17,21]

With non operative and operative management of proximal humerus fractures frozen shoulder may occur. This emphasizes the need for a directed physiotherapy program to maintain mobility during the post fracture and postoperative period. Patients who do not respond to stretching exercises may require operative management, including arthroscopic and/or open release of adhesions. Manipulation under anesthesia should not be performed alone, as risk of re-fracture exists.

## Avascular necrosis[17,21]

AVN is seen in up to 14% of 3-part fractures treated with closed reduction and in up to 34% of 4-part fractures. AVN leads to pain and stiffness in the shoulder and may ultimately require total shoulder arthroplasty.

## Malunions[17,21]

Malunion of greater tuberosity occur as a result of the pull of the rotator cuff. If only the supraspinatus is involved the displacement is superior. Impingement syndrome may occur if there is union at this site. Displacement is posterior if the pull is predominately by infraspinatus. Union at this site may result in posterior impingement against the glenoid, resulting in decreased external rotation.

Surgical indications include pain and loss of function. Superior tuberosity malunion may be treated with acromioplasty if it is not severe or tuberosity osteotomy and cuff mobilization. Acromioplasty offers no benefit in posterior malunions, which are treated by tuberosity osteotomy and capsular release. Malunion of isolated lesser tuberosity are very rare.

2-part fractures (surgical neck) malunions and malunions of 3-part fractures may be multiplanar in nature with combinations of rotation, flexion/extension, and varus/valgus deformities.

Significant angulation may be accepted at the surgical neck. However, there is concomitant loss of elevation. Additionally, varus malunion places the greater tuberosity in the subacromial space with loss of lateral humeral offset. Prosthetic replacement is required in the malunion and avascular necrosis of the humeral head in 3 and -4 part fractures. Frequently, posttraumatic arthritis is present on the glenoid surface and a glenoid component also should be used.

Fracture-dislocation malunion may be difficult to treat. The head component may be dislocated anteriorly or posteriorly. Great care must be taken in its mobilization and removal as there may be adhesion of the neurovascular bundle in the associated scar tissue. Prosthetic replacement usually is necessary of different treatment types. Improved use of limited internal fixation with percutaneous fixation, with or without growth factors to help accelerate healing, also will produce more reliable outcomes with less morbidity. The use of humeral head replacement will

continue to be refined and will produce functional outcomes with consistent pain relief. Finally, ideal rehabilitaton for fractures treated operatively or nonoperatively will minimize time for functional recovery following these injuries.

## Description of the implant

### Proximal humeral internal locking system plate

Proximal humeral internal locking system plate is anatomically shaped to accommodate the junction of the humeral head and the humerus shaft. In addition to the holes for the locking head screws in the area of the humeral head the plate has small holes in order to fix the rotator cuff with traction sutures or cerclage wires.[84]

*Figure 16.* Proximal humeral internal locking system plate

Proximal humerus internal locking plates are a part of latest generation of anatomically precontoured locking compression plates. PHILOS plates are

developed by AO/ASIF group. It provides angular stability, adequate buttressing and load sharing support to prevent collapse of fragments to overcome most of the main hardware problems. Conventional implants have higher risk of screw loosening in the humeral head. In these plates the screws in the humeral head are locked into the plate and cannot back out or toggle. The plate thus act as an external fixator put internally. The screws alternately diverge and converge improving the purchase in the head. The crossed screws increase the pullout strength dramatically.

Figure 17. Philos aiming device

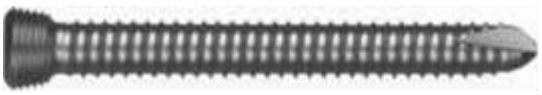


Figure 18. LCP locking devices


Figure 19. PHILOS direct measuring device

In the shaft area different plate fixation techniques are possible due to the combination holes provided by the internal locking plate, permitting insertion of different types of screw. Conventional small fragment screws can also be introduced, on the one hand as compression screws.

Loss of reduction over time could be prevented by the placement of one or two calcar screws running tangentially to the medial curvature of the humeral surgical neck. Loss of fracture reduction was linked to the presence or absence of medial support.[85]

## Features of plates

- Anatomic design
- Angular stability
- Versatile adaptability

1. Anatomic design

The plates are anatomically precontoured for lateral aspect of proximal humerus. No bending is required. The plates are low profile for low risk of

subacromial impingement. PHILOS plate has 9 proximal locking head screws in different orientation to ensure good distribution of forces across the screws and is available up to 12 holes.

2. Angular stability

The proximal locking screws produce an angular stable construct to enhance the grip in osteoporotic bone and multifragment fractures. The proximal two screws are parallel and make an angle of 95 degree with the plate. The lower two screws are divergent and the lowermost screws are oblique screws to support inferomedial cortex to prevent varus collapse. It provide adequate stability in weak cancellous bone in humeral head without screw plate compression. It also reduce vascular periosteal damage beneath the plate.

3. Versatile adaptability

The plate is very versatile as it has 3 different types of holes. 2mm suture holes where the sutures passed through rotator cuff and knotted to the plate. These help to maintain reduction and neutralize muscle tension.

Locked head screw in proximal part in different orientations for angular stability, increasing buttressing and provide high pull out strength.

LCP-Combi holes the choice of two fixation techniques in one implant dynamic compression with standard screw and/or stability with locking head screw to satisfy various intra operative requirements. A compression screw can be applied for indirect reduction.

The function of screws in internal fixator is more like to that of external fixator pins. Angular stability is the basic principle of the internal fixator is, where as stability of conventional plate osteosynthesis relies on friction caused by compression between the bone & the plate. The principle of fixation of angular stable devices is screw locking. Compression between bone and plate is a voided, thereby biological integrity of periosteum is maintained.

- The friction transfers load tangentially between the implant surface and bone in dynamic compression plate, while in interlocking plates the screws with threaded head acts as a peg connecting the splint to bone.
- Precise contouring of the fixator is not necessary.
- Locking of the screws in the internal locking plate and the very close proximity of the plate to the bone allows for the use of monocortical screws .Damage to the intramedullary blood vessels by the application of conventional bicortical screws is eliminated by the use of monocortical screws.

# PRINCIPLES OF FIXATION

## Locked Plating Using Locking Screws

• Screws get locked to the plate, forming a fixed-angle construct.

• Healing of the bone is achieved indirectly by callus formation when using locking screws exclusively.

• Maintenance of primary reduction

• No further tightening is possible once the locking screws engage the plate.

Therefore, regardless of degree of reduction the implant locks the bone segments in their relative positions. Stability under load by locking the screws to the plate, the axial force is transmitted over the length of the plate. The risk of a secondary loss of the intraoperative reduction is reduced.

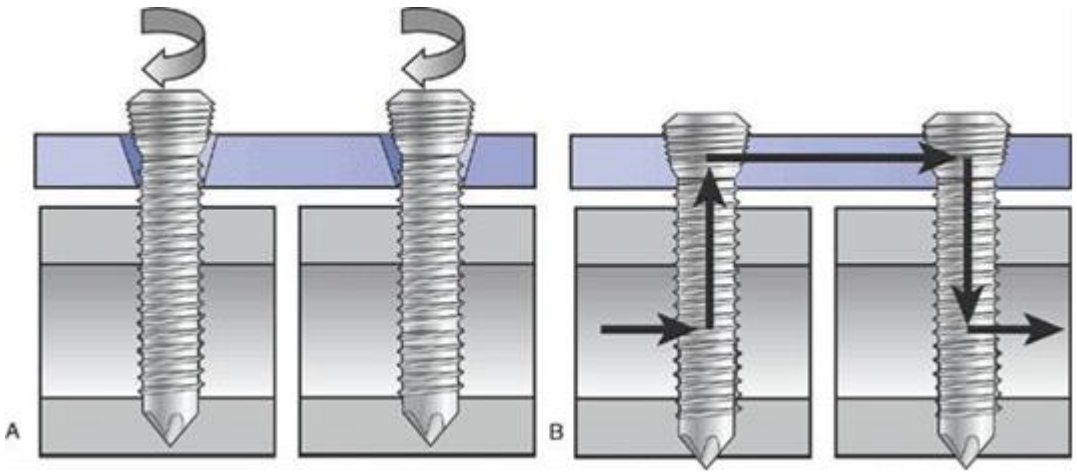



*Figure 20. Friction transfer in LCP*

## INSTRUMENTS AND IMPLANTS

1. PHILOS plates instrument set including drill bits 2.8 mm
2. Aiming device
3. 3.5mm cortical screws & 3.5mm locking head screws of appropriate sizes
4. Drill bit
5. Drill sleeve
6. Philos direct measuring device
7. Kirschner Wires
8. Mobile X - ray unit
9. Image intensifier

# MATERIALS AND METHODS

This study was conducted at R.L.Jalappa Hospital,Tamaka, Kolar during the period from October 2014 to October 2016 inlcuding the follow-up period of six months

## Study design

The study design was two year prospective study.

## Study period

Present study was conducted from October 2014 to October 2016.

## Place

The present study was carried out in the Department of Orthopaedics, R.L.Jalappa hospital,Tamaka,Kolar.

## Source of Data

Patients sustained with proximal humerus fractures presenting at Department of Orthopedics, R.L.Jalappa hospital,Tamaka,Kolar were included in the study.

## Sample Size

A total of 30 cases were enrolled in the study.

## SELECTION CRITERIA

### Inclusion

1.Patients with 2-, 3- or 4-part proximal humeral fracture

2.Patients aged greater than 18 years. Women of reproductive age group will be included only if they have no plan of pregnancy during the study duration.

3.Patients willing to undergo surgery for treatment of proximal humeral fractures

### Exclusion

1.Type III-C compound fractures

2.Patients not fit for surgery due to any pre-existing morbidity

## Ethical clearance

Approval for the study was obtained from the Institutional Ethics Committee, Sri Devraj Urs Medical college, Kolar.

## Informed Consent

Patients fulfilling the selection criteria were informed about the nature of the study. The consent for surgery and anaesthesia was also taken from the patient and attendants

after explaining the procedure and possible complications in their own vernacular language (Annexure I).

## Data collection

At the arrival of the patient with these fractures a careful history was elicited from the patients and/or attendants about age, sex, details of injury, duration were obtained through an interview. Patients were evaluated for associated medical problems and associated injuries and were addressed. Patients were subjected to clinical and local examination. These findings were recorded on predesigned and pretested proforma (Annexure II).

## Investigations

Patients were subjected to following investigations.

- Routine blood examination for hemoglobin %, total and differential count, ESR, blood grouping and Rh typing.
- Routine urine examination for proteins, sugar and microscopic examination
- Blood urea, serum creatinine, random blood sugar & coagulation profile
- HIV- I & II, HBsAg, ECG according to the risk factors.
- Echocardiography as and when needed.
- X-ray - Shoulder AP,LATERAL and TRANS-AXILLARY(OPTIONAL) view and Chest - PA view.

• CT scan with 3D reconstruction was done in selected cases to improve the understanding of fracture pattern. CT scan is useful in multifragmentary fractures, to quantify displacement of the tuberosity, when plain X-rays fail to clearly show the fracture and when there is a concern for concomitant glenoid or scapular injury.

• MRI studies were not carried out in any of our patients


Figure 21. CT Scan with 3D reconstruction of shoulder

## Procedure

The local examination of injured shoulder was done to look for the attitude, swelling, deformity and loss of function. Any nerve injury was also carefully looked for and noted. Local neurological deficit of axillary nerve over lateral aspect of shoulder was assessed by looking for anaesthetic patch. Fracture was stabilized temporarily by POP U- slab and arm sling. A thorough preoperative assessment of the patients was done, which included general condition of the patient and

clinical (Inspection, Palpation, Measurements, Movements, Associated injuries) and radiological assessment of the type of the fracture.

Patients were evaluated for associated medical problems and reference was taken from respective departments and necessary treatment started. Associated injuries were evaluated and treated simultaneously. All patients were will be operated within five days of the injury.

Limb was shaved from shoulder to elbow including axilla a day before the surgery. Injection tetanus toxoid and antibiotics were given 1 hour prior to the surgery.

## Anaesthesia

Brachial block or General anaesthesia was used in all the patients according to their medical condition.

## Patient position and draping

Patients placed in beach chair position on operating table. Drape the arm free, because it will have to be moved during the approach.

## Surgical approach

Surgical approach preferred was Deltopectoral approach. The incision should begin just above the coracoid process, which is palpated in deepest point in the concavity of the clavicle distally towards acromioclavicular joint. An 10 to15 cm incision started from just above coracoid process advanced following the line of deltopectoral groove. The internervous plane is between the deltoid muscle which is supplied by axillary nerve and the pectoralis major muscle, which is supplied by the medial and lateral pectoral nerves. Retract pectoralis major medially and deltoid laterally, splitting the two muscle apart. The cephalic vein is retracted either medially or laterally.

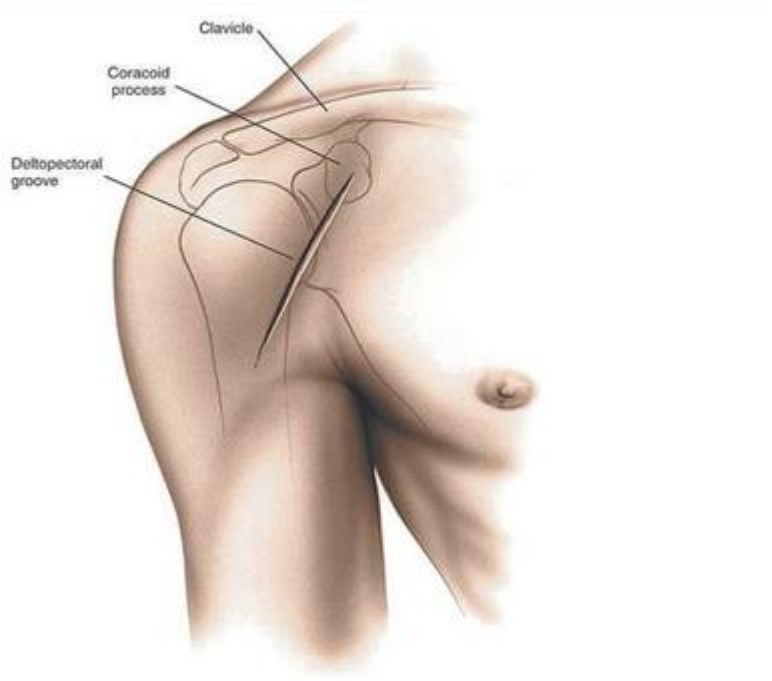



Figure 22. Deltopectoral incision-Make a straight incision in the deltopectoral groove, starting at the level of the coracoid process

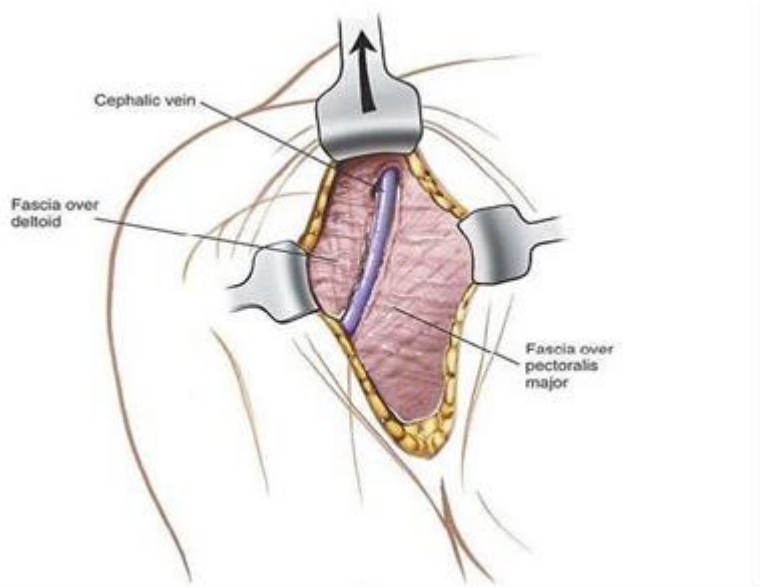



Figure 23. Exposure of cephalic vein and deltopectoral groove - Retract the axillary incision cephalad to expose the cephalic vein and the deltopectoral groove

The short head of biceps (supplied by the musculocutaneous nerve) and the coracobracialis muscle (supplied by the musculocutaneous nerve) must be displaced medially before access can be gained to the anterior aspect of shoulder joint. Beneath the tendons lie the transversely running fibers of subscapularis muscle. Perform external rotation to the arm to stretch the subscapularis muscle, bringing the muscle belly into wound and making its superior and inferior borders easier to define. Pass a blunt instrument between the capsule and the subscapularis muscle, then divide the subscapularis from insertion onto to the lesser tuberosity of humerus .Incise the capsule longitudinally to enter the joint wherever the selected repair must be performed

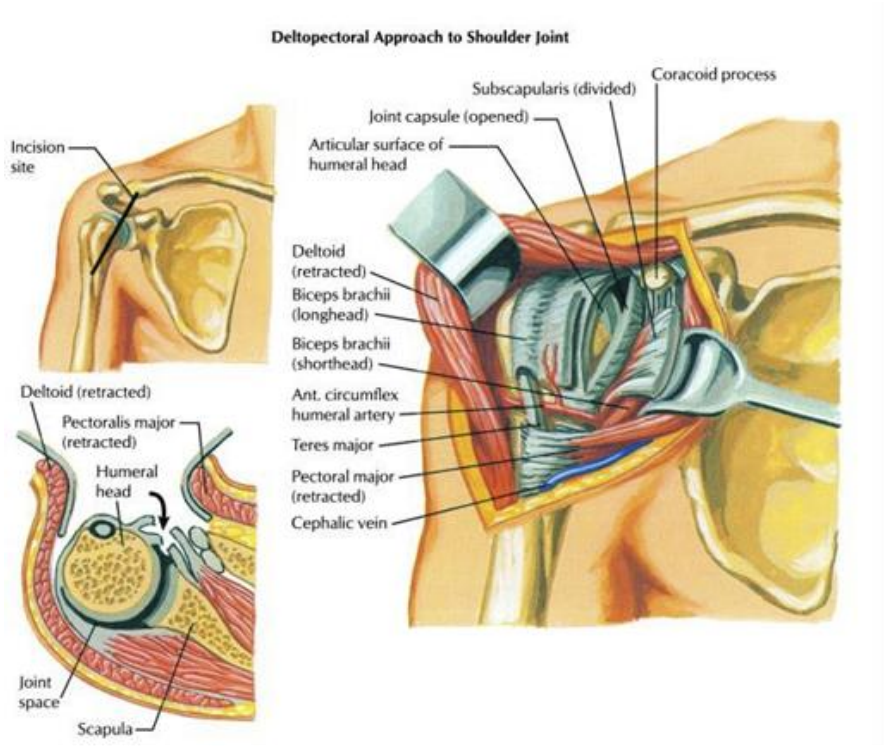



Figure 24. Shoulder joint exposed

## Procedure

All patients received a prophylactic dose of 1gm of injection taxim intravenously preoperatively. The surgery was done in beach chair position, under brachial block or general anesthesia. Through delto-pectoral approach, the fracture site was exposed and reduced with minimal soft tissue dissection. Briefly, the anatomical relationship between humeral head and greater tuberosity was reduced and fixed temporarily with K wires. In case of obvious rotation or displacement of the humeral head, a joystick technique was used .Then the shaft fragment was reduced by abduction, traction and rotation of the arm. The fragments will be indirectly reduced with the help of traction sutures, which are placed in the insertions of rotator cuff tendons, and by extremity rotation. When acceptable reduction is obtained, the

PHILOS plate will be placed at least 1 cm distal to the upper end of the greater tuberosity and fixed to the humeral shaft. An aiming device is then attached to the upper part of the plate, and the head fragments are secured with Kirschner wires, after image intensifier control. The required lengths of the locking head screws is determined with a direct measuring device, and four to six locking screws are then inserted using a specially designed hexagonal screw driver. Proximal locking screws were inserted to hold the humeral head.

All proximal locking screws were placed in a unicortical fashion through an external guide and confirmed to be within the humeral head with intraoperative fluoroscopy. AP (internal and external rotation) views and axillary views 90 degrees to each other were used to visualize screw placement. The distal shaft screws were placed bicortically. A minimum of three bicortical screws were used. Fluoroscopic images were taken to confirm satisfactory fracture reduction, plate positioning and proper length of screws in the humeral head. Range of motion of shoulder was checked on the table for impingement. Wound was closed in layers over drain under negative suction, which was removed after 48 hours.

## Postoperative management

After surgery the shoulder was immobilised in an universal shoulder immobiliser. Appropriate antibiotics as well as analgesics were used. Immediate post operative check radiographs were taken to determine the alignment of the bone and maintenance of reduction. Sutures removed by 10=12th day.

## Rehabilitation

Depending upon the pain pendulum exercises are begun as soon as possible. At first week passive range of motion started. Active range of motion was started at 2-4 weeks postoperatively, depending on stability of osteosynthesis. At fourth to sixth week immobilization is discontinued. Active assisted movements started up to 900 abduction with no forced external rotation.

At sixth to eighth week-full range of movements with active exercises started. At the end the patients were examined clinically and radiologically, assessed for range of motion and bony union and complications. The patients with shoulder stiffness were given physiotherapy for 1 to 2 weeks on outpatient basis.

## Follow up

Follow-up of patients was done at six weeks, three months and six months following the surgery.

## Assessment

For all subjects, radiographs were performed at the end of six weeks, three months and six months follow-up. Patients were evaluated based on the following parameters at the time of discharge and all the three follow ups;

- Range of motion of the Shoulder
- Complications

- Clinical union
- Radiological union

## Final outcome[90]

The Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure is a 30-item, self-report questionnaire designed to measure physical function and symptoms in patients with musculoskeletal disorders or operated cases of the upper limb.The questionnaire was designed to help describe the disability experienced by people with upper-limb disorders and also to monitor changes in symptoms and function over time. Testing has shown that the DASH performs well in both these roles. It gives clinicians and researchers the advantage of having a single, reliable instrument that can be used to assess any or all joints in the upper extremity.

In the DASH scoring system outcome, a higher scores indicate a greater level of disability and severity, whereas, lower scores indicate a lower level of disability.The score on both test ranges from 0 (no disability) to 100 (most severe disability).

# DISABILITIES OF THE ARM,SHOULDER AND HAND

| ***SI.NO.*** | ***QUESTIONAIRRE*** | ***NO DIFFICULTY*** | ***MILD DIFFICULTY*** | ***MODERATE DIFFICULTY*** | ***SEVERE DIFFICULTY*** | ***UNABLE*** |
|---|---|---|---|---|---|---|
| 1 | Open a tight or new jar | 1 | 2 | 3 | 4 | 5 |
| 2 | Write | 1 | 2 | 3 | 4 | 5 |
| 3 | Turn a key | 1 | 2 | 3 | 4 | 5 |
| 4 | Prepare a meal | 1 | 2 | 3 | 4 | 5 |
| 5 | Push open a heavy door | 1 | 2 | 3 | 4 | 5 |
| 6 | Place an object on a shelf above your head | 1 | 2 | 3 | 4 | 5 |
| 7 | Do heavy household chores (e.g., wash walls, wash floors | 1 | 2 | 3 | 4 | 5 |
| 8 | Garden or do yard work | 1 | 2 | 3 | 4 | 5 |
| 9 | Make a bed | 1 | 2 | 3 | 4 | 5 |
| 10 | Carry a shopping bag or briefcase | 1 | 2 | 3 | 4 | 5 |
| 11 | Carry a heavy object (over 10 lbs) | 1 | 2 | 3 | 4 | 5 |
| 12 | Change a lightbulb overhead | 1 | 2 | 3 | 4 | 5 |
| 13 | Wash or blow dry your hair | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | Wash your back | 1 | 2 | 3 | 4 | 5 |
| 15 | Put on a pullover sweater | 1 | 2 | 3 | 4 | 5 |
| 16 | Use a knife to cut food | 1 | 2 | 3 | 4 | 5 |
| 17 | Recreational activities which require little effort (e.g., cardplaying, knitting, etc) | 1 | 2 | 3 | 4 | 5 |
| 18 | Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.) | 1 | 2 | 3 | 4 | 5 |
| 19 | Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.) | 1 | 2 | 3 | 4 | 5 |
| 20 | Manage transportation needs (getting from one place to another). | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 21 | Sexual activities. | 1 | 2 | 3 | 4 | 5 |
| 22 | During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? (circle number | ***NOT AT ALL***<br><br>1 | ***SLIGHTLY***<br><br>2 | ***MODERATELY***<br><br>3 | ***QUIET A BIT***<br><br>4 | ***EXTREMELY***<br><br>5 |
| 23 | During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? (circle number | ***NOT LIMITED AT ALL***<br><br>1 | ***SLIGHTLY LIMITED***<br><br>2 | ***MODERATELY LIMITED***<br><br>3 | ***VERY LIMITED***<br><br>4 | ***UNABLE***<br><br>5 |
| | | ***NONE*** | ***MILD*** | ***MODERATE*** | ***SEVERE*** | ***EXTREME*** |
| 24 | Arm, shoulder or hand pain | 1 | 2 | 3 | 4 | 5 |
| 25 | Arm, shoulder or hand pain when you performed any | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | specific activity | | | | | |
| 26 | Tingling (pins and needles) in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 27 | Weakness in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 28 | Stiffness in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 29 | During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? | ***NO DIFFICULTY***<br>1 | ***MILD DIFFICULTY***<br>2 | ***MODERATE DIFFICULTY***<br>3 | ***SEVERE DIFFICULTY***<br>4 | ***SO MUCH DIFFICULTY THAT I CANNOT SLEEP***<br>5 |
| 30 | I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. | ***STRONGLY DISAGREE***<br>1 | ***DISAGREE***<br>2 | ***NEITHER AGREE NOR DISAGREE***<br>3 | ***AGREE***<br>4 | ***STRONGLY AGREE***<br>5 |

**DASH DISABILITY/SYMPTOM SCORE** = [(sum of n responses)/n - 1] x 25, where n is equal to the number of completed responses.

**DASH DISABILITY/SYMPTOM SCORE**

At least 27 of the 30 items must be completed for a score to be calculated. The assigned values for all completed responses are simply summed and averaged, producing a score out of five. This value is then transformed to a score out of 100 by subtracting one and multiplying by 25. This transformation is done to make the score easier to compare to other measures scaled on a 0-100 scale. A higher score indicates greater disability.

**DASH disability/symptom score = [(sum of n responses)/n - 1] x 25,**

*where n is equal to the number of completed responses*.

The final assessment using DASH score for outcome was interpreted as below.

**Excellent - 0 to 55 points**

**Good - 56 to 70 points**

**Fair - 71 to 85 points**

**Poor - 86 to 100 points**

## STATISTICAL ANALYSIS

Data obtained was coded and entered into Microsoft Excel spreadsheet. The categorical data was expressed as rate, ratio and percentage. The continuous data was expressed as mean ± S.D. Fisher's exact test was used to find the association between categorical data. A 'p' value of less than or equal to 0.05 was considered as statistically significant.

Figure 25. Philos instruments

Figure 26. Position and drapping

Figure 27. Incision marking

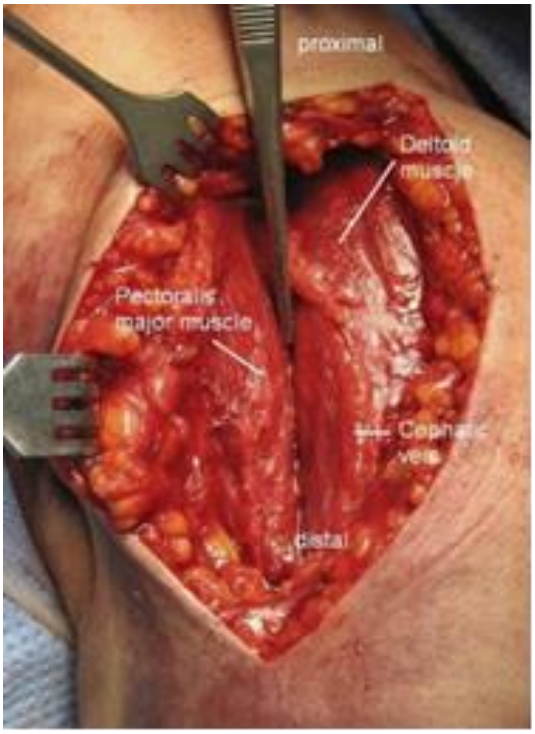



Figure 28. Deltopectoral groove

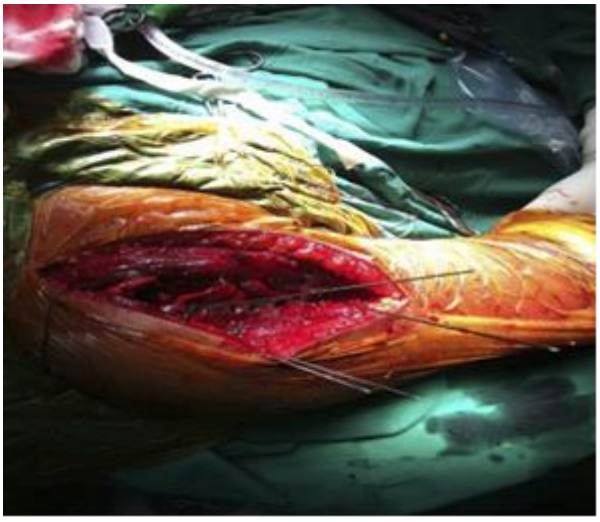


Figure 29. Fracture reduced and fixed with k wires to the plate

Figure 30. Fracture fixed with philos plate and screws and traction sutures for rotator cuff

Figure 31. Wound closure

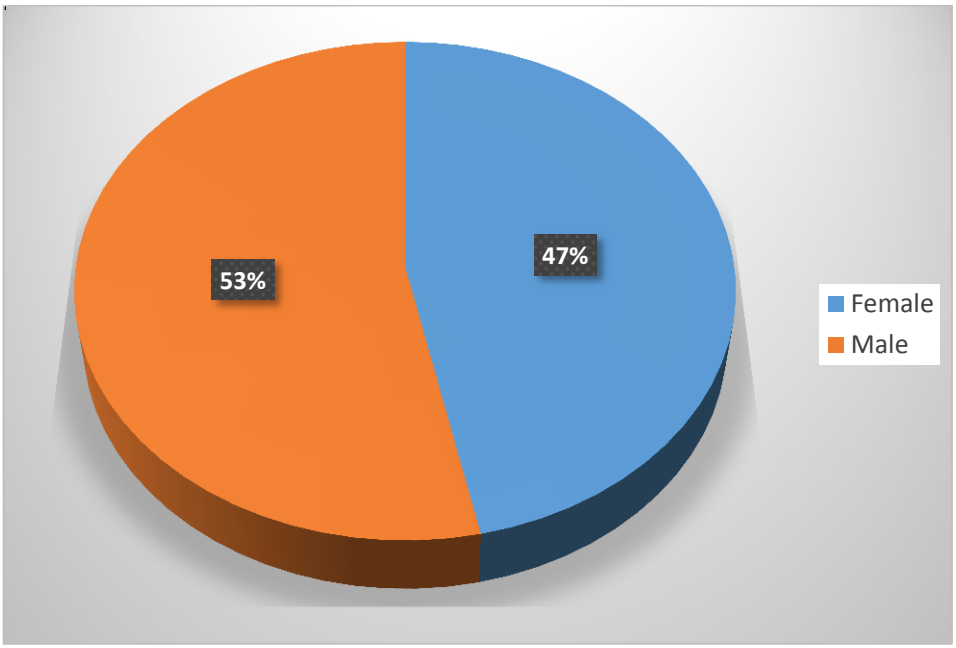
# RESULTS

This prospective study was conducted at R. L. Jalappa hospital, Kolar for a period of two years from October 2014 to October 2016 including the follow up period. A total of 30 patients sustained with proximal humerus fractures were studied.

Data obtained was analysed and the final results and observations were interpreted as below.

Table 1: Sex distribution

| SEX | Number | Percentage |
|---|---|---|
| Female | 14 | 46.7 |
| Male | 16 | 53.3 |
| Total | 30 | 100 |

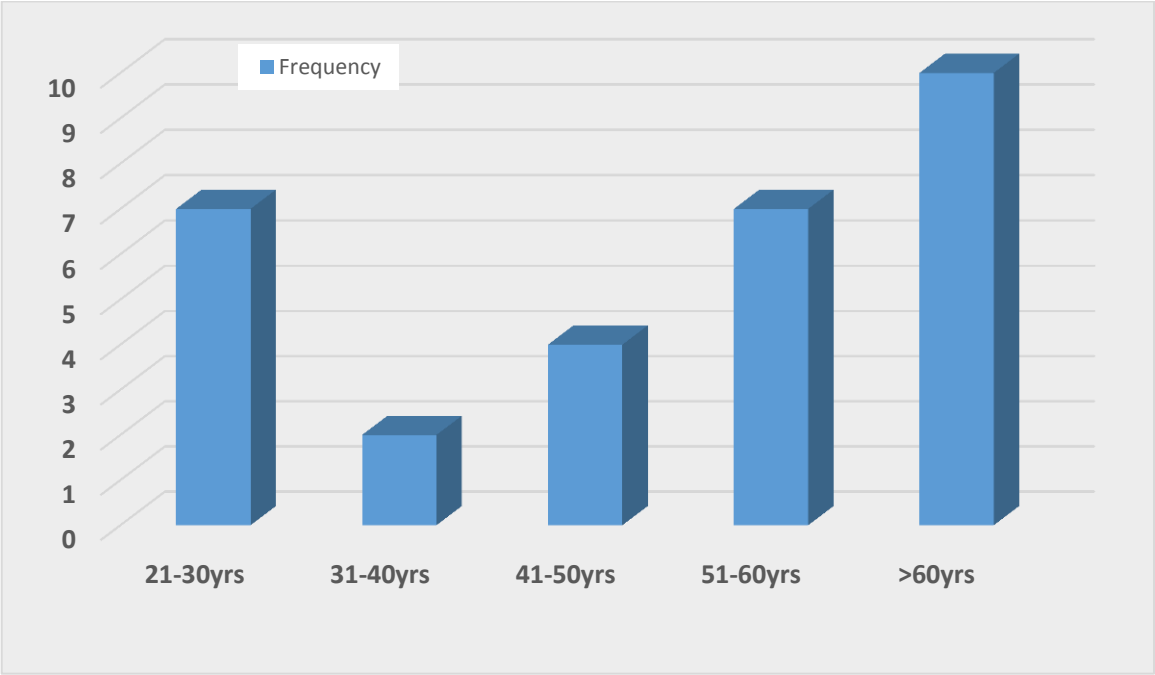



Graph 1: Sex distribution

In the present study 47% of the patients were females and 53% were males. The male to female ratio was **1.12 : 1**

Table 2: Age distribution

| AGE | Number | Percentage |
|---|---|---|
| 21-30yrs | 7 | 23.33 |
| 31-40yrs | 2 | 6.67 |
| 41-50yrs | 4 | 13.33 |
| 51-60yrs | 7 | 23.33 |
| >60yrs | 10 | 33.33 |
| Total | 30 | 100 |

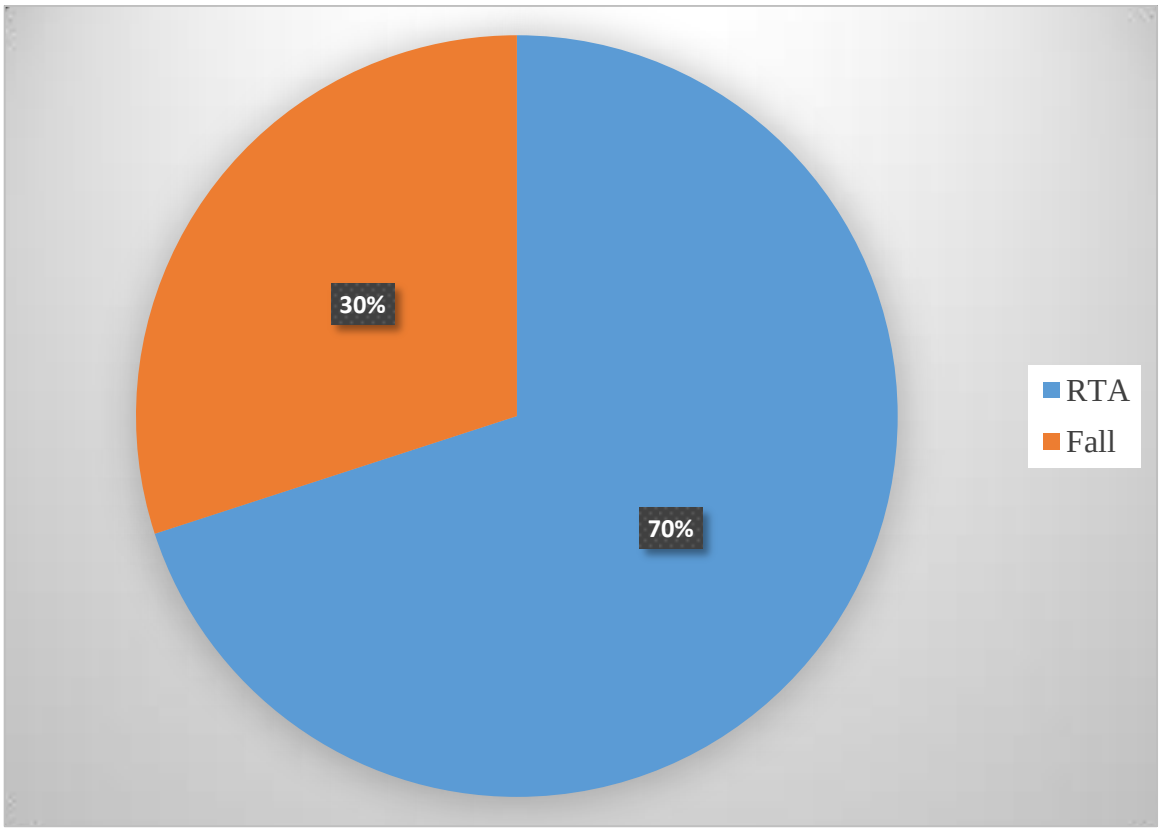



Graph 2:Age distribution

In this study most of the patients presented with age beyond 60 years.

Table 3: Nature of trauma

| Nature of trauma | Number | Percentage |
|---|---|---|
| RTA | 21 | 70 |
| Fall | 9 | 30 |
| Total | 30 | 100 |

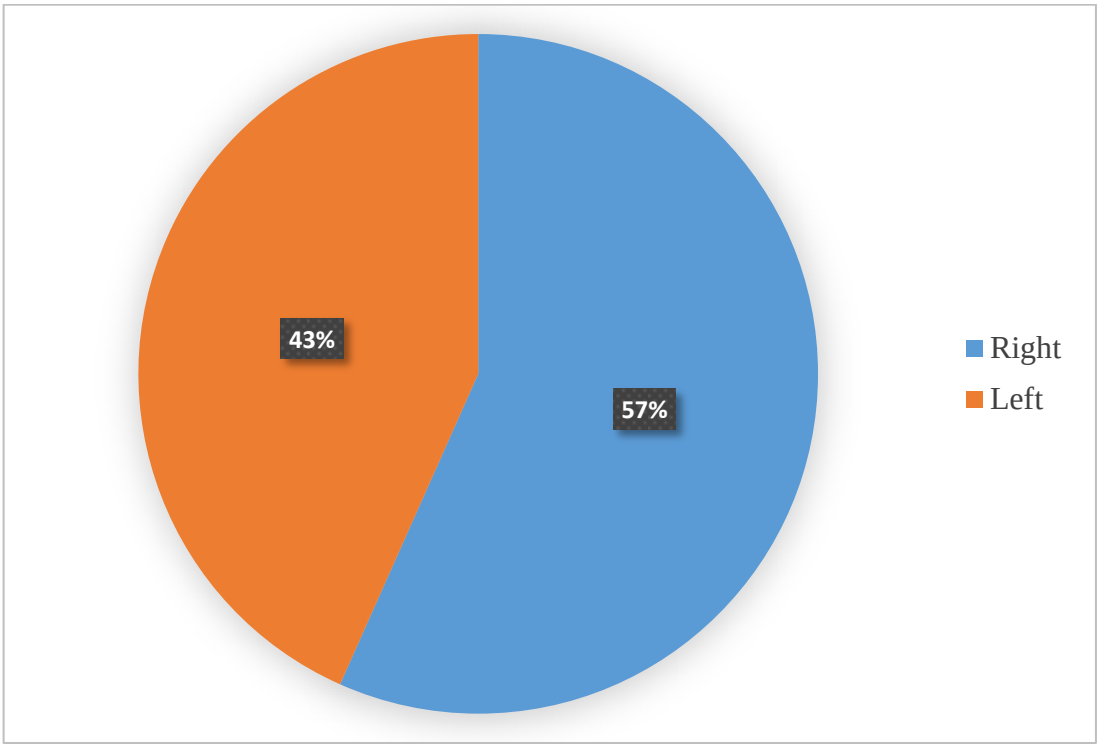



Graph 3:Nature of trauma

In the present study 70% of the patients presented with road traffic accident and 30% with history of fall as nature of trauma.

Table 4: Side involved

| Side | Number | Percentage |
|---|---|---|
| Right | 17 | 56.7 |
| Left | 13 | 43.3 |
| Total | 30 | 100 |

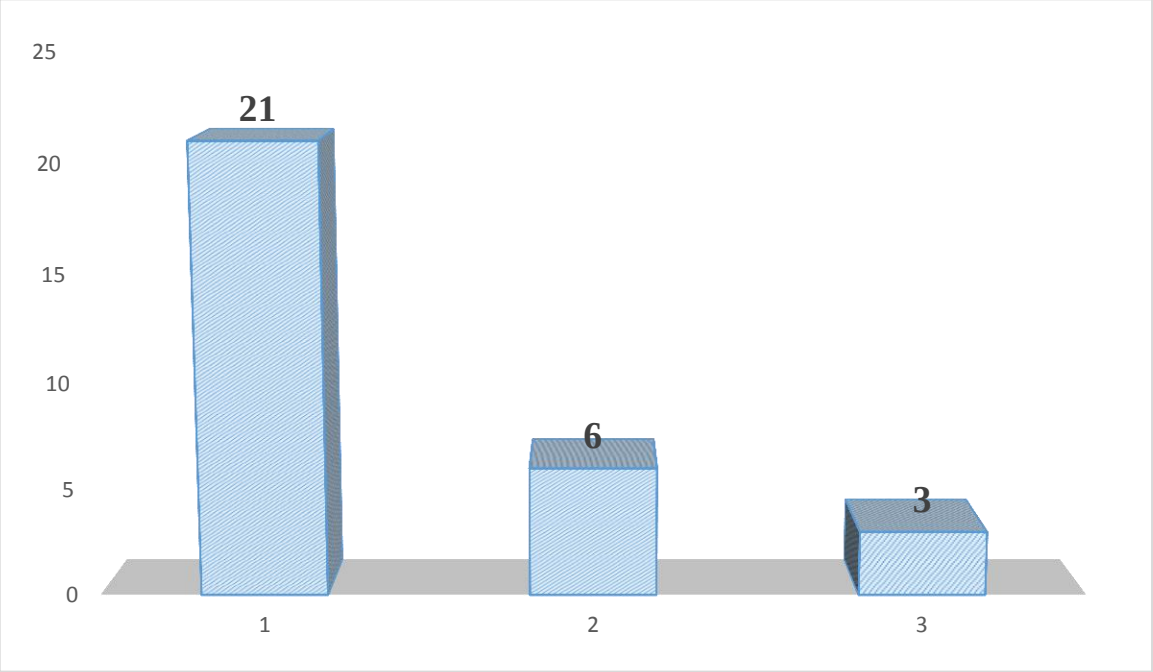



Graph 4: Side involved

In this present study 57% of the patients presented with right sided proximal humerus fracture

Table 5: Duration of injury

| Duration | Number | Percentage |
|---|---|---|
| 1 | 21 | 70 |
| 2 | 6 | 20 |
| 3 | 3 | 10 |
| Total | 30 | 100 |



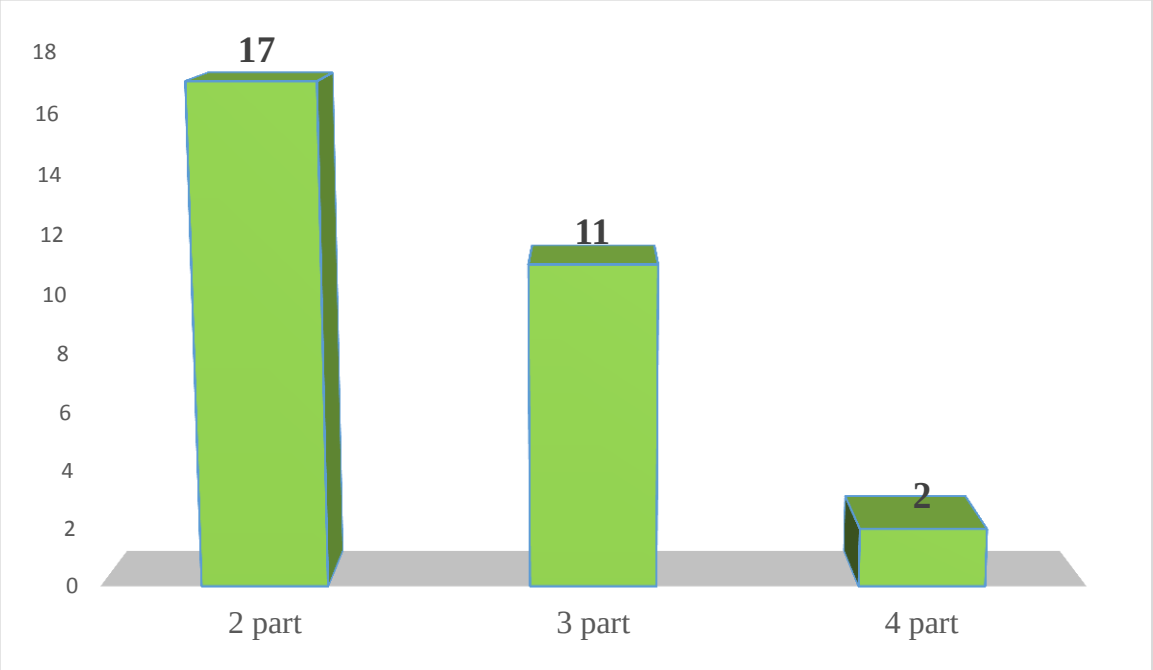

Graph 5: Duration of injury

In the present study, most of the patients (70%) presented with duration of

one day following injury

Table 6: Fracture classification

| Neer classification | Number | Percentage |
|---|---|---|
| 2 part | 17 | 56.7 |
| 3 part | 11 | 36.7 |
| 4 part | 2 | 6.7 |
| Total | 30 | 100 |

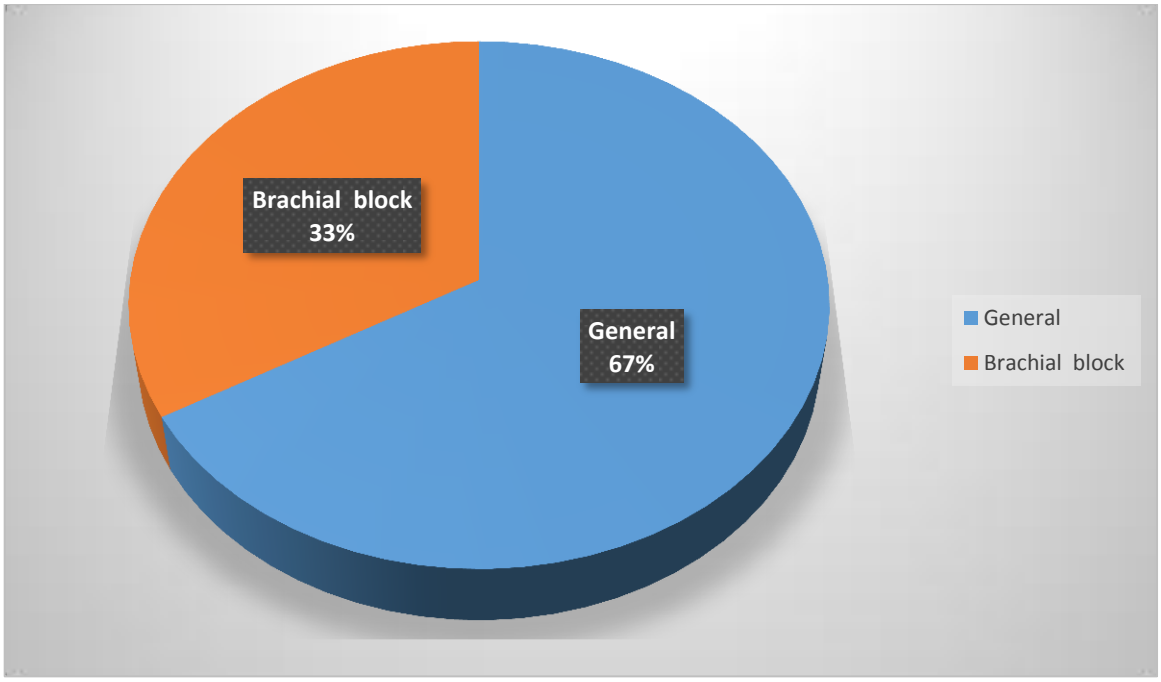



Graph 6: Fracture classification

In this study, 56% of the patients presented with 2-part fracture, 37% with 3-part fracture and 7% with 4-part fracture of the proximal humerus according to Neer's classification

Table 7: Type of anaesthesia

| Anesthesia | Number | Percentage |
|---|---|---|
| General | 20 | 66.7 |
| Brachial block | 10 | 33.3 |
| Total | 30 | 100 |




Graph 7: Type of anaesthesia

In this study most of the patients underwent the surgery under general anaesthesia (67%).

Table 8: Follow up at 6 weeks (first follow up)

| Variables | | Number | Percentage |
|---|---|---|---|
| Clinical union | Yes | 0 | 0 |
| | No | 30 | 100 |
| Pain at fracture site | Yes | 30 | 100 |
| | No | 0 | 0 |
| Complications | Yes | 0 | 0 |
| | No | 30 | 100 |
| Radiological union | Yes | 2 | 6.6 |
| | No | 28 | 93.4 |

In the present study at first follow up at six weeks pain at fracture site was noted in all the patients (100%) with no clinical union as well and radiological union in 6.6%.

Table 9: Follow up at 3 months (second follow up)

| Variables | | Number | Percentage |
|---|---|---|---|
| Clinical union | Yes | 27 | 90 |
| | No | 3 | 10 |
| Pain at fracture site | Yes | 5 | 16.7 |
| | No | 25 | 83.3 |
| Complications | No | 24 | 80 |
| | Malunion | 1 | 3.3 |
| | Stiffness | 4 | 13.3 |
| | Varus malunion | 1 | 3.3 |
| Radiological union | Yes | 27 | 90 |
| | No | 3 | 10 |

In this study during second follow up at three months, clinical union was noted in 90% of the patients and radiological union in 90%. Pain at fracture site was reported by 17% of the patients and complications observed were malunion (3%),varus malunion(3%) and stiffness (13%).

Table 10: Follow up at 6 months (third follow up)

| Variables | | Number | Percentage |
|---|---|---|---|
| Clinical union | Yes | 30 | 100 |
| | No | 0 | 0 |
| Pain at fracture site | Yes | 3 | 10 |
| | No | 27 | 90 |
| Complications | No | 24 | 80 |
| | Malunion | 1 | 3.3 |
| | Stiffness | 4 | 13.3 |
| | Varus malunion | 1 | 3.3 |
| Radiological union | Yes | 30 | 100 |
| | No | 0 | 0 |

In the present study all the patients (100%) had clinical and radiological union. Pain was reported by 10% of the patients while complications noted were varus malunion (3%), malunion (3%) and stiffness (13%).

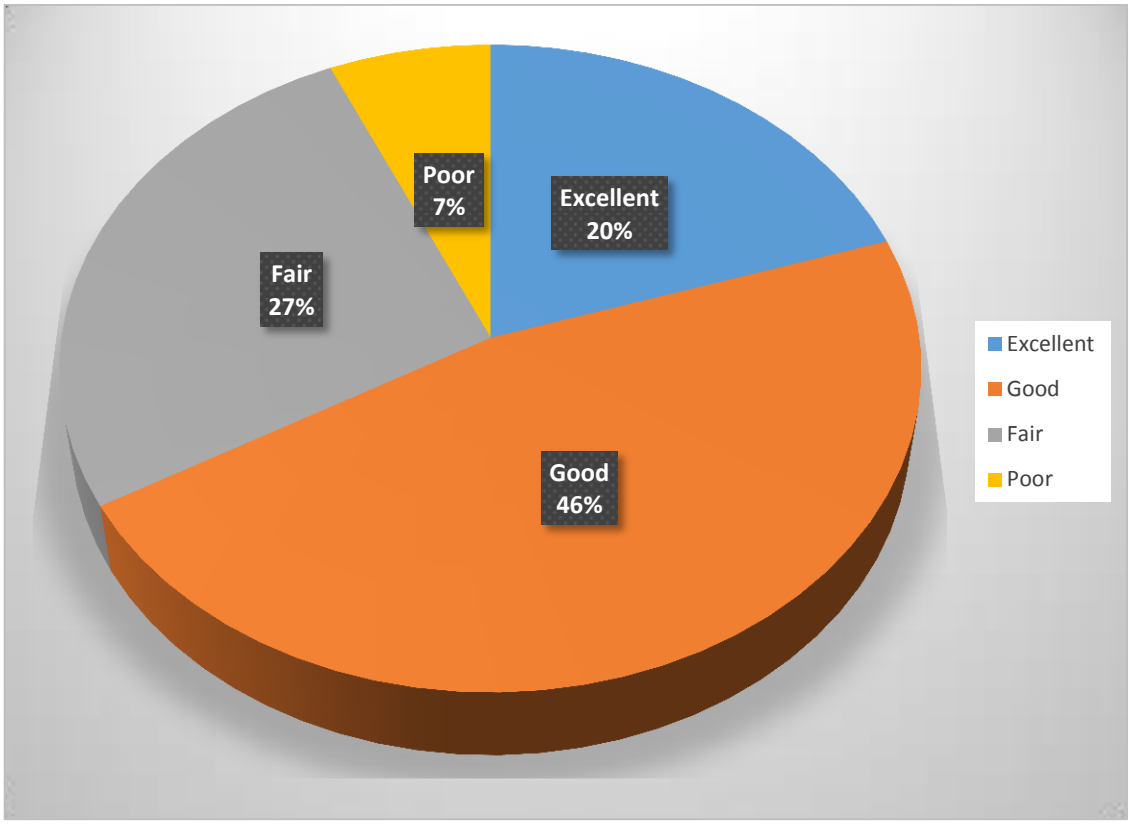
Table 11: RANGE OF MOTION

| | | Mean | SD |
|---|---|---|---|
| Follow up at 6 weeks (First follow up) | Flexion | 89.33 | 15.29 |
| | Abduction | 98.3 | 15.3 |
| | External rotation | 38 | 8.86 |
| | Internal rotation | 42 | 12.14 |
| Follow up at 3 months (Second follow up) | Flexion | 98 | 15.4 |
| | Abduction | 105.33 | 15.69 |
| | External rotation | 48.33 | 9.12 |
| | Internal rotation | 51.3 | 9.3 |
| Follow up at 6 months (Third follow up) | Flexion | 110 | 12.86 |
| | Abduction | 115.6 | 16.7 |
| | External rotation | 57.3 | 8.2 |
| | Internal rotation | 60.6 | 12.8 |

The range of motion at first, second and third follow ups is as depicted in table. It was observed that, there was gradual increase in mean flexion, abduction, external rotation and internal rotation during subsequent follow up.

Table 12: Final outcome based on dash score

| Outcome | Number | Percentage |
|---|---|---|
| Excellent | 6 | 20 |
| Good | 14 | 46.67 |
| Fair | 8 | 26.66 |
| Poor | 2 | 6.67 |

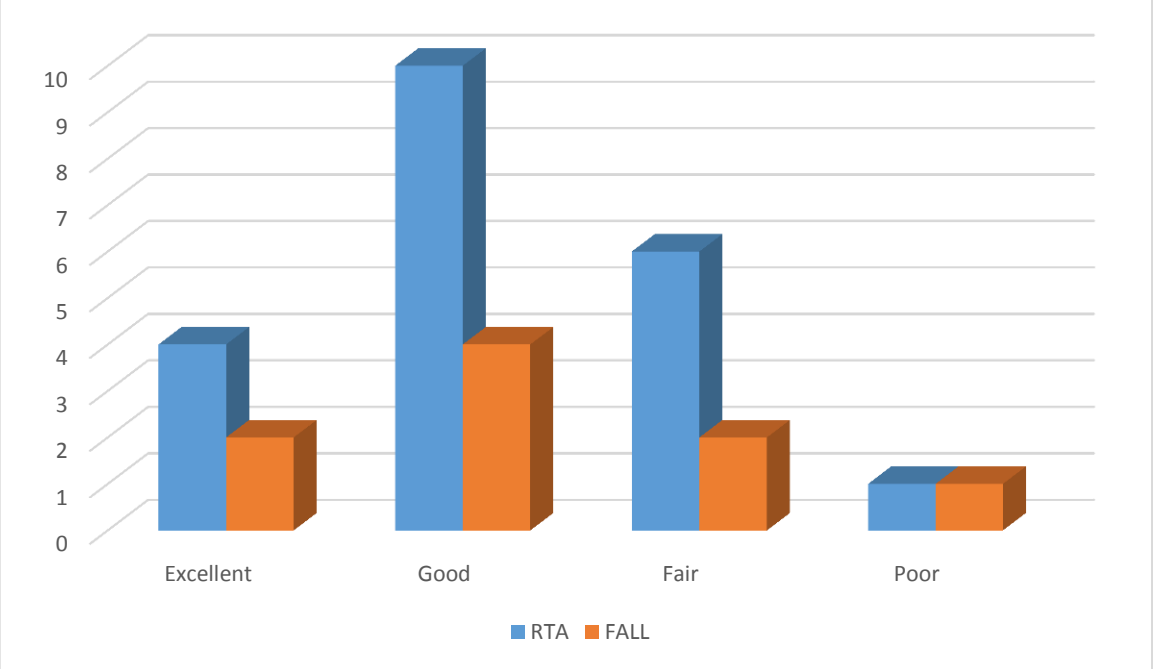



Graph 8:Final outcome based on DASH score

In the present study most of the patients had good outcome (47%) followed by fair (26%), excellent (20%) and poor outcome (7%).

Table 13: Association of outcome with mechanism of injury

| Outcome | RTA | FALL | P Value |
|---|---|---|---|
| Excellent | 4 | 2 | **0.914** |
| Good | **10(71%)** | **4(29%)** | |
| Fair | 6 | 2 | |
| Poor | 1 | 1 | |

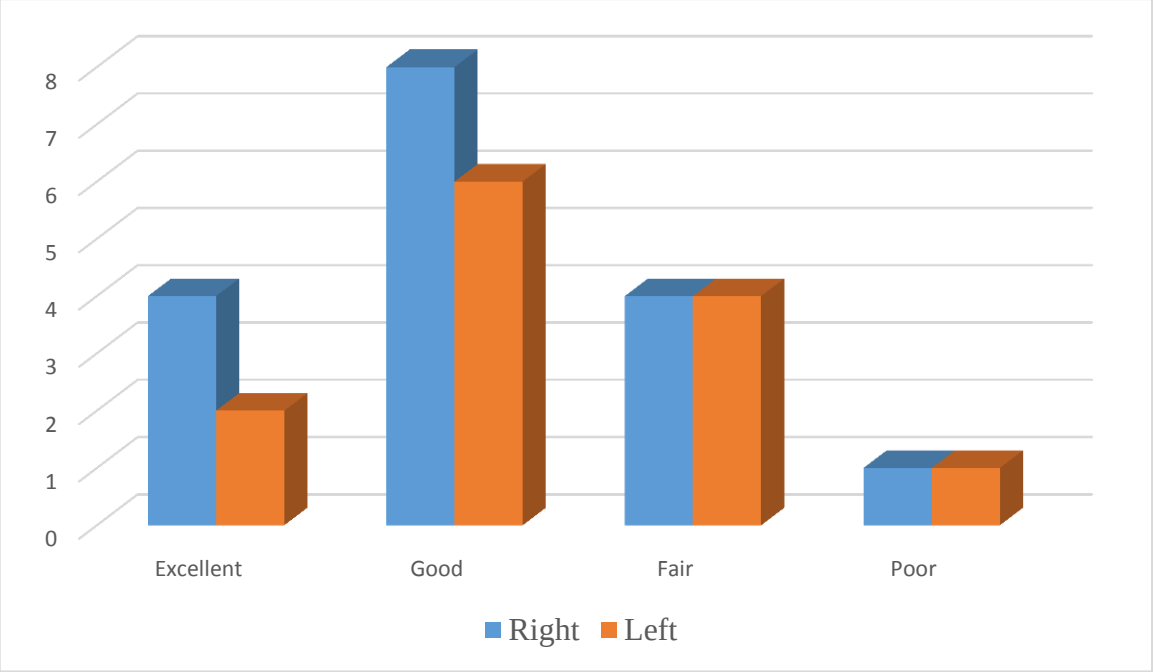



Graph 9: Association of outcome with mechanism of injury

In this study of the 14 patients with good outcome, RTA was the mechanism of injury in 71% compared to fall in 29% and the difference was statistically not significant (p=0.914)

Table 14: Association of outcome with side involvement

| Outcome | Right | Left | P Value |
|---|---|---|---|
| Excellent | 4 | 2 | **0.935** |
| Good | **8(53%)** | **6(47%)** | |
| Fair | 4 | 4 | |
| Poor | 1 | 1 | |

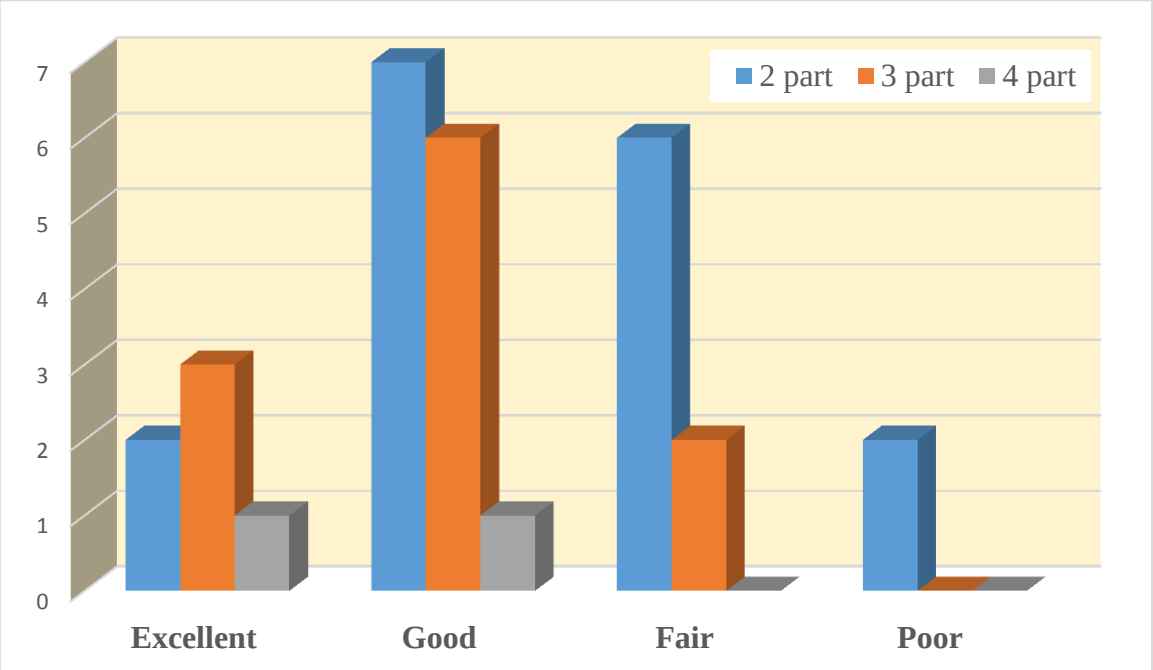



Graph 10: Association of outcome with side involvement

In the present study among the patients with good outcome, 57% of the patients had right and 43% had left sided fracture and no statistically significant association was noted (p=0.935)

Table 15: Association of outcome with type of fracture

| Outcome | **2 part** | **3 part** | **4 part** | P Value |
|---|---|---|---|---|
| Excellent | 2 | 3 | 1 | **0.562** |
| Good | 7 | 6 | 1 | |
| Fair | 6 | 2 | 0 | |
| Poor | 2 | 0 | 0 | |




Graph 11: Association of outcome with type of fracture

In this study no statistically significant association was observed between outcome and type of fracture (p=0.562).

# DISCUSSION

Proximal humerus fractures may present with many different configurations in patients with varying comorbidities and expectations. As a result, the treating physician must understand the fracture pattern, the quality of the bone, other patient-related factors, and the expanding range of reconstructive options to achieve the best functional outcome and to minimize complications.

Current treatment options range from non-operative treatment with physical therapy to fracture fixation using percutaneous or open techniques to arthroplasty reconstructions. However, the best management in these injuries is still uncertain. Most of the proximal humerus fracture which are un-displaced can be treated conservatively. Even if the injury is thoroughly analysed and the literature is understood, treatment of displaced fracture or fracture dislocation is difficult. Many studies have shown that the displaced fracture of the proximal humerus have a poor functional prognosis when left untreated because of severe displacement of fragments.[91]

Open reduction and internal fixation (ORIF) provides the features of anatomical fracture reduction, rigid fixation, and the possibility of bone grafting. With the aim of getting anatomically accurate reductions, rapid healing and early restoration of function, open reduction and internal fixation, is the preferred modality of treatment.

In proximal humerus fractures, PHILOS plate offers good functional outcome with context to the early joint mobilisation and rigid fixation of the fracture. The present study was undertaken to assess the efficacy and the functional outcome following internal fixation with PHILOS (proximal humeral internal locking system) plate for displaced proximal humerus fractures.

The present two year prospective study was conducted at R. L. Jalappa hospital and Research Centre, Kolar from October 2014 to October 2016. A total of 30 patients sustained with proximal humerus fracture were enrolled. Patients underwent open reduction and internal fixation using PHILOS plate through deltopectoral approach.

The incidence of proximal humerus fractures is high in women. Women are affected two to three times as often as men.[4] In the present study majority that is 53% of the patients were males with male to female ratio of 1.12:1 suggesting male preponderance. However, Agarwal S, et al.[44] and Gerber C, et al.[21] reported male preponderance with male to female ratio of 1.7:1 and 1.35:1 respectively. The higher male to female ratio can be explained by the involvement of day to day activities compared to females.

Proximal humerus fractures are common, particularly in the elderly.[4] In this study beyond 60 years was the commonest age group comprised of 33% of the patients. The youngest patient was aged 24 years and the eldest was aged 80 years. These findings were consistent with a study by Gerber C, et al.[21] who reported mean age of 44.9 years.

In the present study 70% of patients presented with road traffic accident and 30% history of fall as mode of injury. These findings were near consistent with a study done by Aggarwal S, et al,[46] who reported fall in 65% of the patients and road traffic accident in 35%. In this present study most of the patients presented with left fracture (57%). Similar fracture pattern was reported in a study by Gerber C, et al.[21]

In this study, patients with only 2-part, 3-part & 4-part fracture of proximal humerus were included based on Neer's classification. Accordingly, the 2-part fractures were noted in most of the cases (57%) followed by 3-part (38%) and 4-part (7%).

It is evident that, majority of proximal humerus fractures are treated conservatively. There are different surgical options for the fixation of proximal humerus fractures, e.g., interfragmentary fixation with sutures, percutaneous pinning, intramedullary fixation and hemiarthroplasties. The recent trend is to use less invasive procedures for reduction and fixation of the fracture. The lesser invasive the procedure the more are the operative prerequisites, viz., 1) good bone stock, 2) minimal comminution of the tuberosity, 3) patient willing to participate in postoperative physiotherapy regimes and 4) advanced operative skills.[92]

Fixation of proximal humerus fractures with plates and screws has been associated with complications such as pullout of screws in osteoporotic bone, subacromial impingement and avascular necrosis of the humeral head due to excessive periosteal stripping[92] .Kristiansen and Christensen[26] have reported a high incidence of

fixation failure following use of T-buttress plates in fixation of proximal humerus fractures. Wijgman et al.[34] have reported good intermediate and long-term results in 87% of patients who had three-and four-part fractures fixed with T-buttress plate. The average age of the patients in their study was 48 years.

Recently newer implants such as the Plant Tan humerus fixator plate, Polaris nail and the PHILOS plate have been used for fixation of proximal humerus fractures. The plate is pre-shaped and contoured for the proximal humerus. The benefits of this implant are that it gives enhanced purchase in osteopenic bone, there is no loss of reduction or varus/valgus angulations, the locking screws into the plate provide angular and axial stability of the construct. With regard to functional outcome following use of locking plates (PHILOS) early benefits can be gained. The only technically demanding part of the surgery is to obtain the correct version of the humerus for accurate plate positioning. With this plate, there is less insult to the vascular supply of the fracture as the soft tissue envelope is not disturbed and hence there is less chance of osteonecrosis. The other demanding aspect is to avoid placing the plate too proximally on the humerus with resulting impingement of the top of the plate on the acromion. This can be avoided by using a K wire inserted through a hole at the top of the plate, which should line up with the tip of the greater tuberosity. This is done during initial positioning of the plate. Positioning the plate too high can also lead to incorrect placement of the divergent screws in the humeral head. Care should be taken to avoid penetration of the head and subsequent chondrolysis with proximal interlocking screws.[92]

In the present study open reduction and internal fixation through deltopectoral approach with PHILOS plate carried and nearly half of the study population had good outcome (47%). Among the others, fair and poor outcomes were noted in 26% and 7% while excellent outcome was noted in 20% of the patients. The outcome was independent to side of fracture, mode of injury and type of fracture as no statistically significant association was noted between side of fracture(p=0.935), mode of injury(p=0.914), type of fracture(0.562) and outcome. Majority of the patients had clinical (90%) and radiological union (90%) during second follow up at three months. The range of motion at first, second and third follow ups showed gradual increase in mean flexion, abduction, external rotation and internal rotation during subsequent follow ups. These findings suggest that internal fixation with PHILOS (proximal humeral internal locking system) plate for displaced proximal humerus fractures results in overall good results that is nearly 67% of the patients had excellent and good results.

The recent evolution of locking plate technology for proximal humerus fractures seems to have revolutionized the management of these fractures. However there have been very limited prospective studies investigating the results of locking plates for open reduction and internal fixation of proximal humeral fractures.[46] Most of these studies have reported good functional outcomes and recommended the use of locking plates for proximal humerus fractures especially in elderly patients with poor bone quality.

Esser[93] reported excellent results in 22 out of his 26 patients of three part and four part fractures of proximal humerus treated with a modified clover leaf plate. Wijgman et al[34] reported good to excellent results in 87% of their 60 patients with three or four part proximal humerus fractures operated with a T-buttress plate and cerclage wires. Paavolainen et al[24] reported satisfactory results in 74.2% of their 41 patients with severe proximal humerus fractures treated with plate and screw devices. However all these authors found poor results in 4 part fractures and recommended a prosthetic replacement in such patients.

In a study Koukakis A et al[12] prospectively evaluated 20 patients with fractures of the proximal humerus who were treated with a PHILOS plate from September 2001 to January 2004 at Harlow, UK. Functional assessment was done using the Constant shoulder score. Authors commented that, the preliminary results seem to be satisfactory. According to our experience, the plate design provides stable fixation with a good functional outcome and eliminates most hardware problems such as failure and impingement syndrome. The PHILOS plate is suitable for the majority of fractures provided that the correct surgical technique is used.

In 2009, MA Fazal et al,[44] retrospectively reviewed 27 patients who underwent locking compression plate fixation for proximal humerus fracture between June 2003 to June 2006. All fracture were classified as 2 part (n=13), 3 part (n=12), 4 part (n=2). All fractures united expect one 3-part fracture in 78 yrs aged women in whom there was a collapse and screw penetration. The constant shoulder score was > 75 in 11 patients, 13 were scored between 50 to 75, and 3 below 50. They concluded

philos plate fixation provided stable fixation, minimal metal work problem and enabled early range of motion exercises to achieve acceptable functional results.

Egol KA et al[42] in his retrospective analysis studied early complications in proximal humerus fractures treated with locked plates in 51 consecutive patients who were treated with a proximal humerus locking plate from 2003 to 2006.Radiographically, 92% of the cases united at 3 months after surgery, and 2 fractures had signs of osteonecrosis at latest follow-up. The major complication reported in this study was screw penetration, suggesting that exceptional vigilance must be taken in estimating the appropriate number and length of screws used to prevent articular penetration. Authors concluded that, although the device provides exceptional fixation stability, its indication must be scrutinized for each individual patient, taking the extent of trauma/fracture and age into consideration and carefully weighing it against other forms of treatment.

In 2009, Brunner F et al.[44] 30 in his multicenter study from 8 trauma units from 2002 to 2005 enrolled 157 patients and treated with open reduction and internal fixation with a Philos plate. One-year follow-up rate was 84%. The incidence of experiencing any implant-related complication was 9% and 35% for non implant related complications. Primary screw perforation was the most frequent problem (14%) followed by secondary screw perforation (8%) and avascular necrosis (8%). After 1 year, a mean Constant score of 72 points (87% of the contralateral noninjured side), a mean Neer's score of 76 points, and mean Disabilities of the Arm, Shoulder, and Hand score of 16 points were achieved. They concluded that fixation with Philos

plates preserves achieved reduction, and a good functional outcome can be expected. However, complication incidence proportions are high, particularly due to primary and secondary screw perforations into the glenohumeral joint, with an overall complication rate of 35%. More accurate length measurement and shorter screw selection should prevent primary screw perforation. Awareness of obtaining anatomic reduction of the tuberosities and restoring the medial support should reduce the incidence of secondary screw perforations, even in osteopenic bone.

Proximal humerus fractures, remain a challenging problem for the surgeon because the complication rate for these fractures still remains high. The internal locked system (PHILOS) plate is a new device used for proximal humerus fracture fixation is designed to decrease the high complication rate. In the present study at second follow up complications observed were malunion(5%) and stiffness (10%) and during third follow varus malunion (5%), malunion(5%) and stiffness (10%).

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In 2009, Brunner F et al[44] in his multicenter study reported incidence of implant-related complication as 9% and 35% for non implant related complications. Primary screw perforation was the most frequent problem (14%) followed by secondary screw perforation (8%) and avascular necrosis (8%).

# CONCLUSION

It may be concluded that, Proximal humeral internal locking system (PHILOS) plate for the treatment of proximal humerus fractures leads to a satisfactory functional outcome in most of the patients with early union of fracture. The results are comparable to other studies with respect to mechanism of injuries, side involved and Neer's classification (2-part, 3-part & 4-part) of proximal humerus fractures. The shoulder stiffness was found to be a strong predictor of poor functional outcome and should be avoided wherever possible by anatomical reduction and accurate plate fixation.

The PHILOS plate is an ideal construct and a stable implant to use for fractures of the proximal humerus in Neer's 2-part, 3-part, and 4-part and osteoporotic fractures of the proximal humerus in elderly patients hence allowing early mobilisation of the shoulder.

# SUMMARY

PHILOS plate offers a good functional outcome in proximal humerus fractures with context to the early joint mobilisation and rigid fixation of the fracture. The present study was aimed to evaluate the efficacy,functional outcome and time required for fracture healing following open reduction and internal fixation with PHILOS plate for displaced proximal humerus fractures.

This two year prospective study was carried out in the Department of Orthopaedics at R.L.Jalappa hospital and Research Centre, Kolar. A total of 30 patients sustained with proximal humerus fracture presented during the study period from October 2014 to October 2016 were enrolled. Patients underwent open reduction and internal fixation using PHILOS plate through deltopectoral approach.

Majority of the patients (53%) were males and male to female ratio was 1.12:1. Most of the patients presented were beyond 60 years. Road traffic accident was the nature of trauma in 70% of the patients and 57% of the patients presented with right sided proximal humerus fracture. Maximum (56%) patients presented with 2-part fracture according to Neer's classification. Most of the patients had surgery under general anaesthesia (67%). At first follow up at six weeks, pain at fracture site was noted in all the patients (100%) and radiological union in (6.6%). During second follow up at three months, clinical union was noted in 90% of the patients and radiological union in 90%. Pain at fracture site was reported by 17% of the patients

and complications observed were malunion (3%),varus malunion(3%) and stiffness (13%). During third follow up at six months all the patients (100%) had clinical and radiological union. Pain was reported by 10% of the patients while complications noted were varus malunion (3%), malunion (3%) and stiffness (13%). The range of motion at first, second and third follow ups increased gradually during subsequent follow ups. Most of the patients had good outcome (47%) followed by fair (26%), excellent (20%) and poor (7%) outcome. No statistically significant difference was observed in outcome with regard to mechanism of injury (p=0.914), side of the fracture (p=0.935) and type of fracture (p=0.562).

Proximal humeral internal locking system (PHILOS) plate for the treatment of proximal humerus fractures leads to a satisfactory functional outcome in most of the patients. However, shoulder stiffness secondary to plate impingement was found to be a strong predictor of poor functional outcome.

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92. Thyagarajan DS, Haridas SJ, Jones D, Dent C, Evans R, Williams R. Functional outcome following proximal humeral interlocking system plating for displaced proximal humeral fractures. Int J Shoulder Surg. 2009 Jul-Sep; 3(3):57-62.
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# ANNEXURE I

# CONSENT FORM

Title of the study: "SURGICAL MANAGEMENT OF PROXIMAL HUMERUS FRACTUES USING PHILOS PLATE "

**Investigator:**

Dr. _____

**Guide:**

Dr._____

Respected Mr/ Mrs :

We request you to participate in our study as you are eligible to be included. During the study you will be asked questions regarding your present and past medical history and you are supposed to answer to the best of your knowledge.

Your participation in this study is voluntary. Your decision whether or, not to participate will not affect your treatment protocol at R.L.Jalappa hospital,Kolar.If you decide not to participate,you are free to withdraw at any point of time.

## Introduction and purpose

Proximal Humerus Fractures are one of the most common fractures of the shoulder especially in the elderly with osteoporotic bones, usually due to low- energy trauma like simple falls. Problems of these fractures are (1) association with substantial morbidity (2) malunion, (3) great financial burden to the family and (4) associated medical problem like diabetes, hypertension.

The main purpose of the current study is to assess the clinical outcome and time required for fracture healing of these patients with proximal humerus fractures treated with PHILOS plate fixation, with regard to functional mobility, stability and the range of movements using DASH scoring system.

## Procedure

If you consent to participate in this study, the relevant data is collected as per the proforma, and the final diagnosis is confirmed after correlating both clinical and radiological evidences .The subject is then posted for the proposed surgery after obtaining the fitness for surgery .Patient will be discharged accordingly and would be followed up with post-operative x-rays and regular physiotherapy. The patients will be

followed up at 6 weeks, 3 months and 6 months till radiological union was seen. Radiographs will be taken in AP and Axillary views to look for signs of radiological union. At every follow up clinical examination would be done. Clinical union would be there if fracture site becomes stable and pain free. The time taken for radiological and clinical union would be noted down. You will also be observed for any kind of complication and if present will be treated.

The Advantages are :.

1. Improved early shoulder mobility at 1 and 3 months postoperatively.
2. More Angular stability
3. Rigid fixation

Disadvantages are:

1. Shoulder stiffness
2. Malunion

## Alternatives

Even if you decline the participation in study, you will get the other routine line of management

## Voluntary participation/withdrawal

Taking part in this study is voluntary. You may choose not to take part in this study, or if you decide to take part you can later change your mind and withdraw from the study. Your decision will not change the present or future health care or other services that you will receive at R.L.Jalappa hospital,Kolar.

## Costs

The cost to the patient of the implant, would come to around Rs-15,000/-

and would be explained to the patient.

## Compensation

As the subject voluntarily consents to be a part of the study, no compensation will be given.

## Confidentiality

All information collected about the subject during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify the subject in this research record. Information from this study may be published, but the subjects identity will be confidential in any publication.

## Consent to participate in research study

"I voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form".

Signature of the Participant or legally authorized representative.

Participant's Name : …….

Signature : …….

Name of the legally authorized representative: …….

Signature

Witness's Name Signature

Investigators name and Signature Date and Place

From,

Dr. _____

Post Graduate Student,

Department of Orthopaedics, SRI DEVARAJ URS MEDICAL COLLEGE

TAMAKA, KOLAR-563101.

: …….

: …….

: …….

: …….

:……

# ANNEXURE 2- PROFORMA

1) NAME: _____

2) AGE: _____ Years

3) SEX: M/F _____

4) ADDRESS: _____

5) OCCUPATION: _____

6) DATE OF INJURY: _____

7) DATE OF ADMISSION: _____

8) DATE OF SURGERY: _____

9) DATE OF DISCHARGE: _____

10) NATURE OF TRAUMA:

a) RTA Yes/No b) Sports injuries Yes/No

c) Fall from height Yes/No d) Assault Yes/No

e) Trivial injuries Yes/No f) Other injuries Yes/No

11) Mechanism of injury

a) Direct Yes/No b) Indirect Yes/No

12) DURATION SINCE INJURY:

A) < 1 week  b) > 1 week

13) SIGNIFICANT PAST HISTORY:

a) History of Diabetes Yes/No

Hypertension Yes/No

Asthma Yes/No

Epilepsy Yes/No

Other conditions Yes/No

b) Previous history of fractures Yes/No

14) SIGNIFICANT FAMILY HISTORY: _____

15) GENERAL PHYSICAL EXAMINATION:

a) Pulse rate: ____/min  b) Blood Pressure: _____mmHg

c) Spo2: _____ %  d) Respiratory Rate: _____/min.

e) Pallor Yes/No

f) Cyanosis Yes/No

g) Icterus Yes/No

h) Lymphadenopathy Yes/No

I) RS examination:

j) CVS examination:

k) PA examination:

l) CNS examination:

m)Presence of associated injury: Yes/No

If yes, specify _____

16) LOCAL EXAMINATION

a) Inspection:

i. Attitude

ii. Swelling

iii. Skin discoloration.

b) Palpation:

i. Greater tuberosity

ii. Head of Humerus

iii. Tenderness

c) Measurements:

d) Movements:

i. Flexion Normal/Restricted

ii. Extension Normal/Restricted

iii. Abduction Normal/Restricted

iv. Adduction Normal/Restricted

v. External rotation Normal/Restricted

vi. Internal rotation Normal/Restricted

17) RELEVANT INVESTIGATIONS:

-Roentgenogram of the Shoulder joint AP and AXILLARY views: Yes/No

-Additional x-rays of associated injuries Yes/No

-Routine blood investigations like Hb%, TC, DC, and ESR Yes/No

-Renal profile Yes/No

-HIV I &II HBsAg Yes/No

-Chest X-ray, ECG Yes/No

18) DIAGNOSIS: _____

19) TREATMENT:

First Aid:

a) Immobilisation of the limb Yes/No

b) Shoulder brace/POP ‘U’ slab Yes/No

c) Analgesics Yes/No

Definitive Treatment:

a) Relevant investigations and medical fitness for surgery: Yes/No

b) Anaesthesia : Brachial block/General Anaesthesia

c) Philos plate:Yes/No

d) Antibiotic therapy- Pre-op and Post-op Yes/No

e) Analgesics Yes/No

20) COMPLICATIONS:

Intraoperative:

a) Difficulty in reduction of fragments Yes/No

b) Excessive bleeding Yes/No

c) Wrong placement of implant Yes/No

d) Other complications Yes/No

Postoperative:

A) Immediate:

a) Bleeding Yes/No

b) Infection Yes/No

B) Delayed:

a) Chronic Infection Yes/No

b) Shoulder Stiffness Yes/No

c) Malalignment Yes/No

d) Failure of implant Yes/No

e) Malunion Yes/No

21) FOLLOW UP: (at 6 weeks, 3 months, and 6 months)

Date:

Serial No. of Follow Up:

Time since Surgery: _____ Clinical Union:

- Pain at fracture site Yes/No

- Radiological Union: X-Ray Yes/No

22) DASH SCORING SYSTEM

| ***SI.NO.*** | ***QUESTIONAIRRE*** | ***NO DIFFICULTY*** | ***MILD DIFFICULTY*** | ***MODERATE DIFFICULTY*** | ***SEVERE DIFFICULTY*** | ***UNABLE*** |
|---|---|---|---|---|---|---|
| 1 | Open a tight or new jar | 1 | 2 | 3 | 4 | 5 |
| 2 | Write | 1 | 2 | 3 | 4 | 5 |
| 3 | Turn a key | 1 | 2 | 3 | 4 | 5 |
| 4 | Prepare a meal | 1 | 2 | 3 | 4 | 5 |
| 5 | Push open a heavy door | 1 | 2 | 3 | 4 | 5 |
| 6 | Place an object on a shelf above your head | 1 | 2 | 3 | 4 | 5 |
| 7 | Do heavy household chores (e.g., wash walls, wash floors | 1 | 2 | 3 | 4 | 5 |
| 8 | Garden or do yard work | 1 | 2 | 3 | 4 | 5 |
| 9 | Make a bed | 1 | 2 | 3 | 4 | 5 |
| 10 | Carry a shopping bag or briefcase | 1 | 2 | 3 | 4 | 5 |
| 11 | Carry a heavy object (over 10 lbs) | 1 | 2 | 3 | 4 | 5 |
| 12 | Change a lightbulb overhead | 1 | 2 | 3 | 4 | 5 |
| 13 | Wash or blow dry your hair | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | Wash your back | 1 | 2 | 3 | 4 | 5 |
| 15 | Put on a pullover sweater | 1 | 2 | 3 | 4 | 5 |
| 16 | Use a knife to cut food | 1 | 2 | 3 | 4 | 5 |
| 17 | Recreational activities which require little effort (e.g., cardplaying, knitting, etc) | 1 | 2 | 3 | 4 | 5 |
| 18 | Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.) | 1 | 2 | 3 | 4 | 5 |
| 19 | Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.) | 1 | 2 | 3 | 4 | 5 |
| 20 | Manage transportation needs (getting from one place to another). | 1 | 2 | 3 | 4 | 5 |

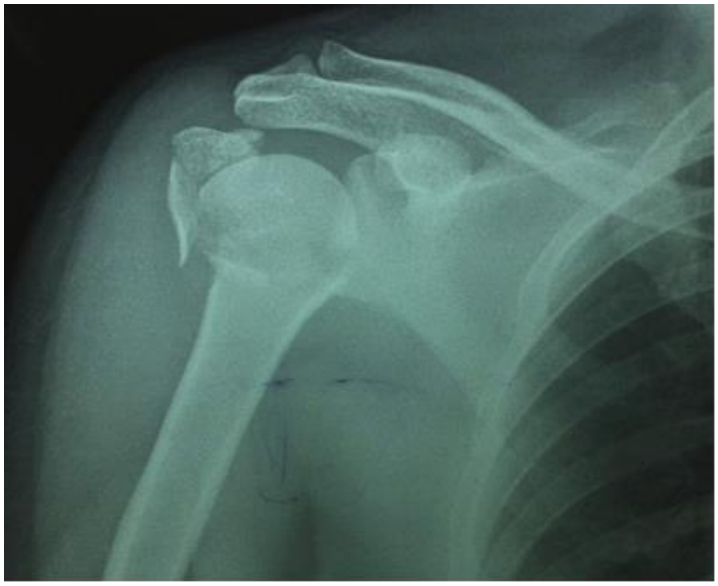
| | | | | | | |
|---|---|---|---|---|---|---|
| 21 | Sexual activities. | 1 | 2 | 3 | 4 | 5 |
| 22 | During the past week, to what extent has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? (circle number | ***NOT AT ALL***<br><br>1 | ***SLIGHTLY***<br><br>2 | ***MODERATELY***<br><br>3 | ***QUIET A BIT***<br><br>4 | ***EXTREMELY***<br><br>5 |
| 23 | During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? (circle number | ***NOT LIMITED AT ALL***<br><br>1 | ***SLIGHTLY LIMITED***<br><br>2 | ***MODERATELY LIMITED***<br><br>3 | ***VERY LIMITED***<br><br>4 | ***UNABLE***<br><br>5 |
| | | ***NONE*** | ***MILD*** | ***MODERATE*** | ***SEVERE*** | ***EXTREME*** |
| 24 | Arm, shoulder or hand pain | 1 | 2 | 3 | 4 | 5 |
| 25 | Arm, shoulder or hand pain when you performed any | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | specific activity | | | | | |
| 26 | Tingling (pins and needles) in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 27 | Weakness in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 28 | Stiffness in your arm, shoulder or hand | 1 | 2 | 3 | 4 | 5 |
| 29 | During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? | ***NO DIFFICULTY***<br>1 | ***MILD DIFFICULTY***<br>2 | ***MODERATE DIFFICULTY***<br>3 | ***SEVERE DIFFICULTY***<br>4 | ***SO MUCH DIFFICULTY THAT I CANNOT SLEEP***<br>5 |
| 30 | I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. | ***STRONGLY DISAGREE***<br>1 | ***DISAGREE***<br>2 | ***NEITHER AGREE NOR DISAGREE***<br>3 | ***AGREE***<br>4 | ***STRONGLY AGREE***<br>5 |

# ANNEXURE 3

# PHOTOGRAPHS

## EXCELLENT OUTCOME - CASE No: 1



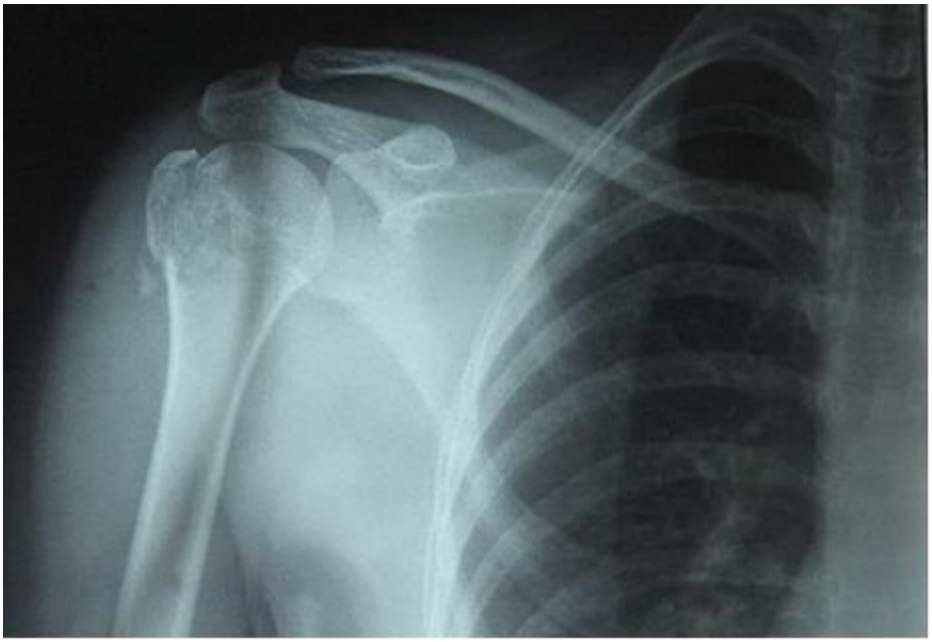
**PRE-OP XRAY**


**IMMEDIATE POST-OP XRAY**

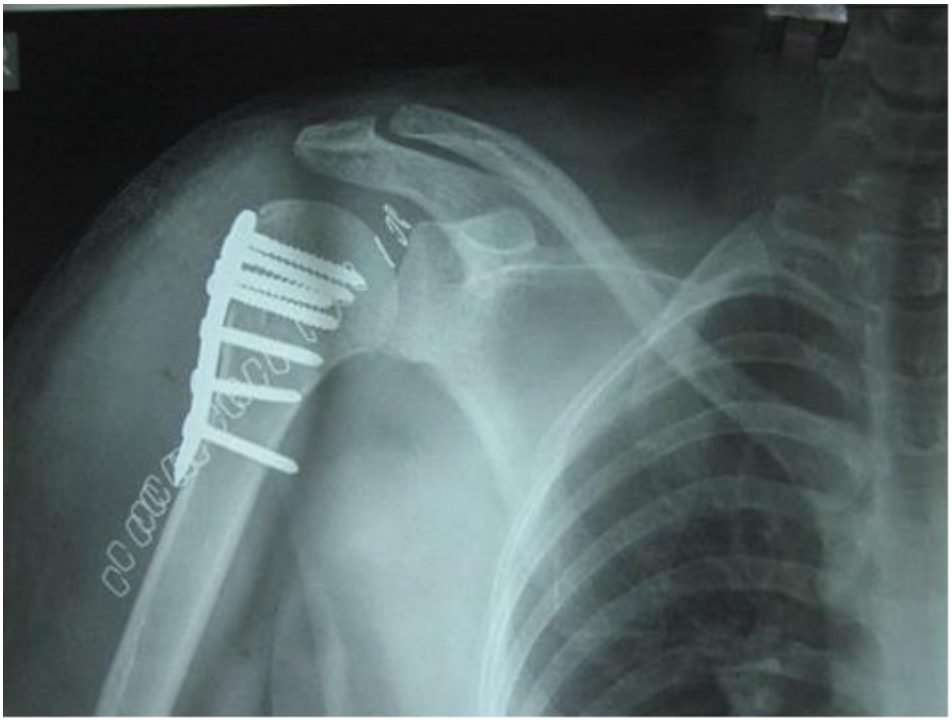

**X-RAY AT 6 MONTHS FOLLOW UP - AP VIEW**

**CLINICAL OUTCOME - RANGE OF MOVEMENTS**

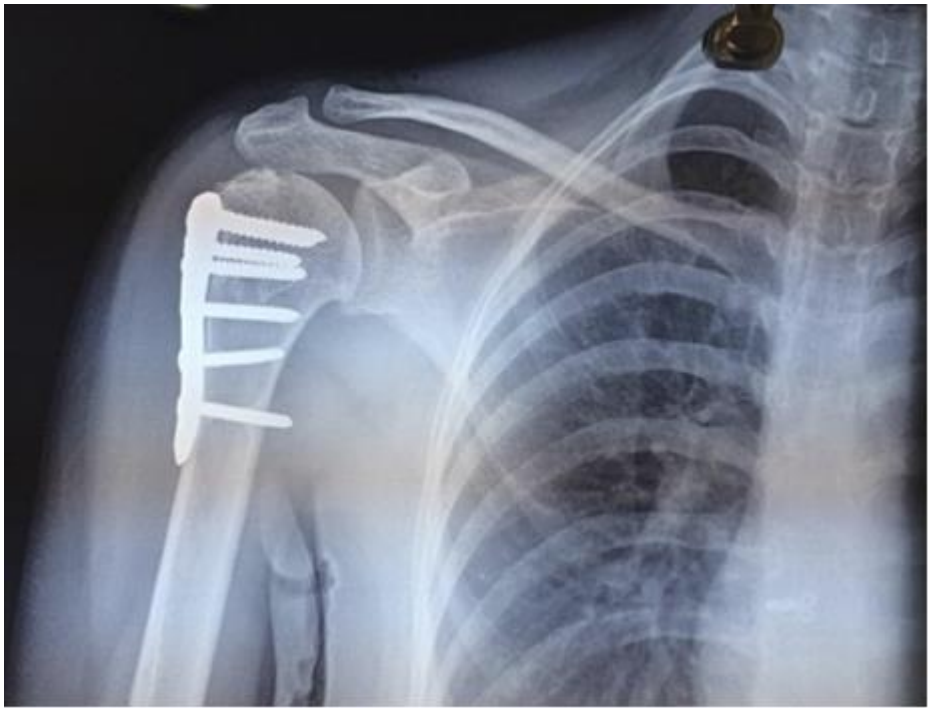
## GOOD OUTCOME - CASE No: 2



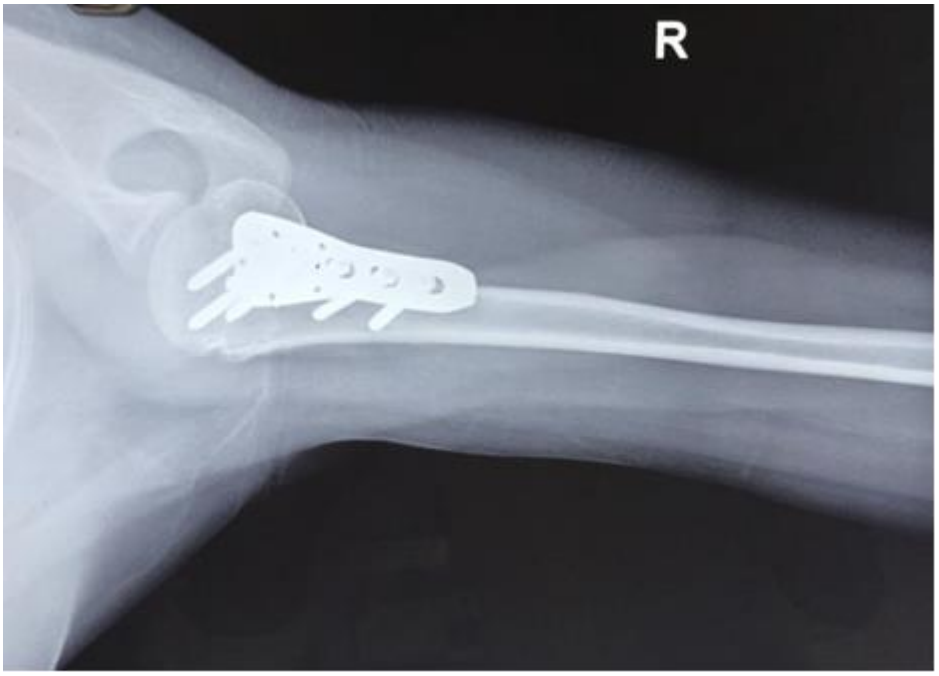
**PRE-OP XRAY**



**IMMEDIATE POST-OP XRAY**



**X-RAY AT 6 MONTHS FOLLOW UP - AP VIEW**




**X-RAY AT 6 MONTHS FOLLOW UP - AXILLARY VEIW**

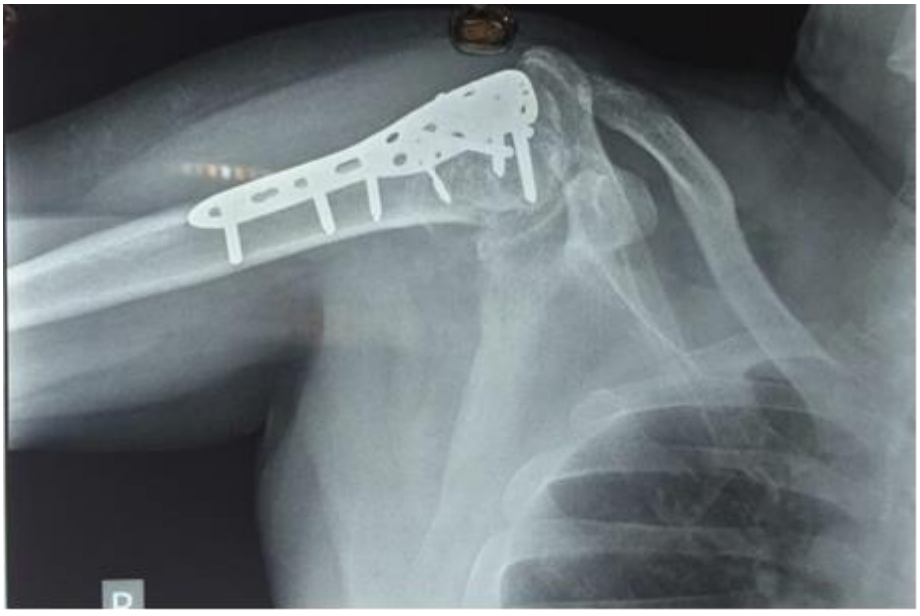
**CLINICAL OUTCOME - RANGE OF MOVEMENTS**

## FAIR OUTCOME - CASE No: 3

**PRE-OP X-RAY**

**IMMEDIATE POST-OP X-RAY**

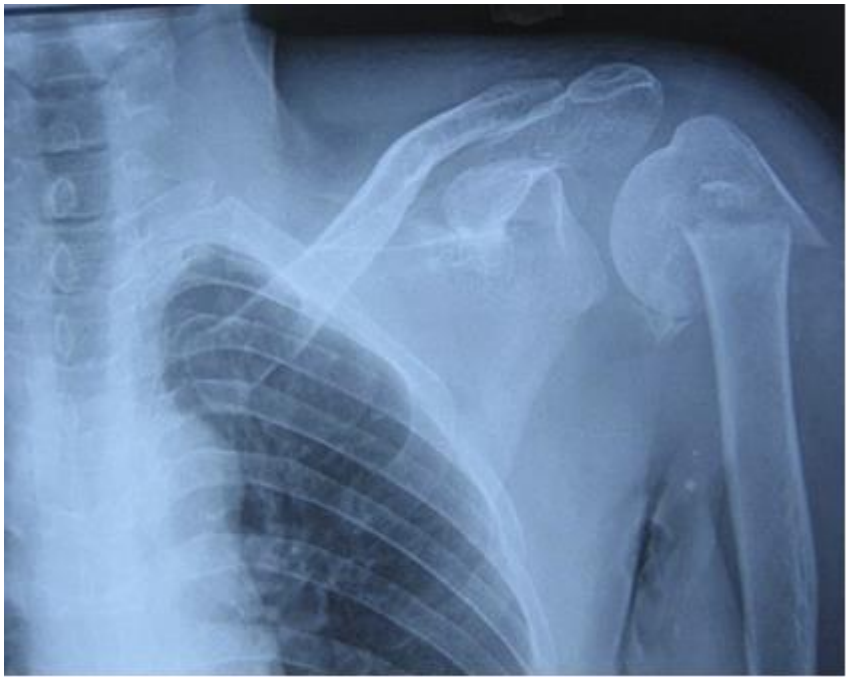

**X-RAY AT 6 MONTHS FOLLOW UP - AP VIEW**



**X-RAY AT 6 MONTHS FOLLOW UP - AXILLARY VIEW**

**CLINICAL OUTCOME-RANGE OF MOVEMENTS**

## POOR OUTCOME - CASE No: 4



**PRE-OP X-RAY**


**IMMEDIATE POST-OP X-RAY**

**X-RAY AT 6 MONTHS FOLLOW UP - AP VIEW**

**X-RAY AT 6 MONTHS FOLLOW UP - AXILLARY VIEW**

**CLINICAL OUTCOME - RANGE OF MOVEMENTS**

# ANNEXURE 4

# MASTER CHART

## Key to master chart

| | | |
|---|---|---|
| - | - | Absent |
| + | - | Present |
| E | - | Excellent |
| F | - | Fair |
| F | - | Female |
| G | - | Good |
| M | - | Male |
| P | - | Poor |
| RTA | - | Road traffic accident |
| R | - | Right |
| L | - | Left |
| GA | - | General Anaesthesia |
| BB | - | Brachial Block |
| STF | - | Stiffness |
| M | - | Malunion |
| VM | - | Varus malunion |

| SERIAL NUMBER | IP NUMBER | AGE(YEARS) | SEX | NATURE OF TRAUMA | SIDE | FRACTURE CLASSIFICATION | DURATION SINCE INJURY | ANAESTHESIA | SURGICAL APPROACH- DELTOPECTORAL | POST-OPERATIVE FOLLOW-UP | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1ST FOLLOW UP(6 WEEKS) | | | | | | | | 2ND FOLLOW UP(3MONTHS) | | | | | | | | 3RD FOLLOW UP(6MONTHS) | | | | | | | | |
| | | | | | | | | | | | | | | RANGE OF MOVEMENT | | | | | | | | RANGE OF MOVEMENT | | | | | | | | | DASH SCORE |
| | | | | | | | | | | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATIONS | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | |
| 1 | 213096 | 65 | M | RTA | L | 3PART | 1 | BB | + | - | + | nil | - | 80 | 100 | 40 | 40 | + | - | - | + | 90 | 100 | 50 | 50 | + | - | - | + | 100 | 110 | 60 | 60 | 72 |
| 2 | 226953 | 65 | M | FALL | R | 2PART | 2 | BB | + | - | + | nil | - | 90 | 110 | 40 | 50 | + | - | - | + | 100 | 110 | 60 | 60 | + | - | - | + | 110 | 120 | 70 | 80 | 76 |
| 3 | 273681 | 30 | M | RTA | R | 3PART | 1 | GA | + | - | + | nil | - | 110 | 120 | 50 | 50 | + | - | - | + | 120 | 120 | 50 | 60 | + | - | - | + | 130 | 120 | 60 | 60 | 68 |
| 4 | 278370 | 76 | F | FALL | R | 4PART | 2 | BB | + | - | + | nil | - | 60 | 70 | 40 | 30 | - | + | VM | - | 60 | 80 | 40 | 40 | + | - | | + | 90 | 90 | 50 | 40 | 92 |
| 5 | 215849 | 36 | F | RTA | R | 2PART | 1 | GA | + | - | + | nil | - | 110 | 110 | 50 | 60 | + | - | - | + | 110 | 120 | 60 | 60 | + | - | - | + | 120 | 120 | 60 | 70 | 70 |
| 6 | 284236 | 65 | F | FALL | R | 3PART | 2 | GA | + | - | + | nil | - | 90 | 100 | 30 | 40 | + | - | - | + | 100 | 110 | 40 | 50 | + | - | - | + | 110 | 120 | 50 | 60 | 82 |
| 7 | 301034 | 42 | M | RTA | R | 2PART | 1 | GA | + | - | + | nil | - | 100 | 110 | 40 | 50 | + | - | - | + | 110 | 110 | 50 | 60 | + | - | - | + | 110 | 120 | 70 | 80 | 60 |
| 8 | 308363 | 70 | M | FALL | R | 2PART | 1 | BB | + | - | + | nil | - | 70 | 80 | 20 | 40 | + | - | - | - | 90 | 90 | 40 | 50 | + | - | - | + | 110 | 120 | 60 | 60 | 84 |
| 9 | 102014 | 55 | F | RTA | L | 3PART | 1 | GA | + | - | + | nil | - | 100 | 110 | 40 | 40 | - | - | - | + | 120 | 120 | 50 | 60 | + | - | - | + | 120 | 130 | 60 | 70 | 66 |
| 10 | 105321 | 80 | M | FALL | L | 3PART | 3 | BB | + | - | + | nil | - | 50 | 60 | 20 | 30 | + | + | STF | - | 60 | 80 | 30 | 30 | + | + | STF | + | 80 | 90 | 40 | 40 | 90 |
| 11 | 999062 | 30 | F | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 110 | 120 | 50 | 60 | + | - | - | + | 110 | 130 | 60 | 60 | + | - | - | + | 120 | 130 | 60 | 70 | 68 |
| 12 | 118843 | 65 | M | RTA | R | 3PART | 2 | BB | + | - | + | nil | - | 90 | 100 | 40 | 50 | + | - | - | + | 90 | 110 | 50 | 50 | + | - | - | + | 110 | 110 | 60 | 60 | 80 |
| 1 | 172209 | 55 | M | RTA | R | 4PART | 1 | GA | + | - | + | nil | - | 100 | 100 | 40 | 40 | + | - | - | + | 110 | 110 | 40 | 50 | + | - | - | + | 120 | 130 | 60 | 60 | 62 |

| SERIAL NUMBER | IP NUMBER | AGE(YEARS) | SEX | NATURE OF TRAUMA | SIDE | FRACTURE CLASSIFICATION | DURATION SINCE INJURY | ANAESTHESIA | SURGICAL APPROACH- DELTOPECTORAL | POST-OPERATIVE FOLLOW-UP | | | | | | | | | | | | | | | | | | | | | | DASH SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1ST FOLLOW UP(6 WEEKS) | | | | | | | | 2ND FOLLOW UP(3MONTHS) | | | | | | | | 3RD FOLLOW UP(6MONTHS) | | | | | | | |
| | | | | | | | | | | | | | | RANGE OF MOVEMENT | | | | | | | | RANGE OF MOVEMENT | | | | | | | | RANGE OF MOVEMENT | | | | |
| | | | | | | | | | | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATIONS | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | 176855 | 73 | F | FALL | R | 3PART | 2 | BB | + | - | + | nil | - | 70 | 80 | 30 | 30 | - | + | - | + | 80 | 80 | 40 | 40 | + | - | - | + | 100 | 90 | 40 | 40 | 67 |
| 15 | 173139 | 57 | F | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 100 | 100 | 40 | 40 | + | - | - | + | 110 | 110 | 60 | 60 | + | - | - | + | 110 | 120 | 60 | 70 | 39 |
| 16 | 118843 | 65 | M | FALL | R | 2PART | 2 | BB | + | - | + | nil | - | 80 | 80 | 30 | 20 | + | - | STF | + | 80 | 90 | 40 | 40 | + | - | STF | + | 90 | 90 | 50 | 40 | 56 |
| 17 | 158711 | 45 | F | RTA | R | 3PART | 1 | GA | + | - | + | nil | - | 100 | 110 | 40 | 50 | + | - | - | + | 110 | 120 | 60 | 60 | + | - | - | + | 120 | 130 | 60 | 70 | 36 |
| 18 | 218803 | 45 | F | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 100 | 90 | 40 | 40 | + | - | - | + | 100 | 100 | 50 | 50 | + | | - | + | 100 | 100 | 60 | 60 | 69 |
| 19 | 81519 | 67 | F | FALL | L | 2PART | 3 | BB | + | - | + | nil | - | 80 | 80 | 30 | 30 | + | - | - | + | 90 | 80 | 40 | 50 | + | - | - | + | 100 | 90 | 60 | 60 | 81 |
| 20 | 38384 | 52 | M | RTA | R | 2PART | 1 | GA | + | - | + | nil | - | 90 | 100 | 30 | 40 | + | - | - | + | 100 | 120 | 40 | 50 | + | - | - | + | 120 | 130 | 60 | 60 | 64 |
| 21 | 69551 | 40 | M | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 80 | 100 | 30 | 40 | + | - | - | + | 90 | 100 | 40 | 40 | + | - | - | + | 100 | 110 | 50 | 60 | 78 |
| 22 | 85028 | 30 | F | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 90 | 100 | 40 | 50 | + | - | - | + | 100 | 110 | 50 | 50 | + | - | - | + | 120 | 130 | 60 | 60 | 74 |
| 23 | 76106 | 57 | F | RTA | L | 3PART | 1 | BB | + | - | + | nil | - | 80 | 90 | 30 | 20 | + | - | - | + | 100 | 90 | 40 | 30 | + | - | - | + | 100 | 100 | 40 | 40 | 61 |

| SERIAL NUMBER | IP NUMBER | AGE(YEARS) | SEX | NATURE OF TRAUMA | SIDE | FRACTURE CLASSIFICATION | DURATION SINCE INJURY | ANAESTHESIA | SURGICAL APPROACH- DELTOPECTORAL | POST-OPERATIVE FOLLOW-UP | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1ST FOLLOW UP(6 WEEKS) | | | | | | | | 2ND FOLLOW UP(3MONTHS) | | | | | | | | 3RD FOLLOW UP(6MONTHS) | | | | | | | |
| | | | | | | | | | | | | | | RANGE OF MOVEMENT | | | | | | | | RANGE OF MOVEMENT | | | | | | | | RANGE OF MOVEMENT | | | | |
| | | | | | | | | | | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATIONS | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | CLINICAL UNION | PAIN AT THE FRACTURE SITE | COMPLICATION | RADIOLOGICAL UNION | FLEXION | ABDUCTION | EXTERNAL ROTATION | INTERNAL ROTATION | DASH SCORE |
| 24 | 62630 | 57 | M | FALL | L | 2PART | 3 | GA | + | - | + | nil | - | 80 | 90 | 30 | 20 | + | + | STF | + | 90 | 100 | 40 | 40 | + | + | STF | + | 100 | 110 | 50 | 40 | 63 |
| 25 | 88123 | 28 | M | RTA | R | 2PART | 1 | GA | + | - | + | nil | - | 100 | 120 | 50 | 60 | + | - | - | + | 100 | 130 | 60 | 60 | + | - | - | + | 120 | 130 | 70 | 80 | 29 |
| 26 | 89179 | 24 | F | RTA | R | 3PART | 1 | GA | + | - | + | nil | + | 100 | 110 | 50 | 60 | + | - | - | + | 110 | 120 | 60 | 60 | + | - | - | + | 120 | 140 | 60 | 70 | 32 |
| 27 | 90740 | 49 | M | RTA | R | 3PART | 1 | GA | + | - | + | nil | - | 90 | 90 | 30 | 30 | + | - | M | + | 100 | 100 | 40 | 50 | + | - | M | + | 110 | 120 | 50 | 50 | 59 |
| 28 | 89179 | 24 | F | RTA | R | 2PART | 1 | GA | + | - | + | nil | - | 100 | 110 | 50 | 50 | + | - | - | + | 110 | 120 | 60 | 60 | + | - | - | + | 120 | 130 | 60 | 70 | 28 |
| 29 | 96135 | 24 | M | RTA | L | 2PART | 1 | GA | + | - | + | nil | + | 110 | 120 | 50 | 60 | + | - | - | + | 120 | 120 | 60 | 60 | + | - | - | + | 140 | 150 | 70 | 80 | 30 |
| 30 | 260699 | 55 | M | RTA | L | 2PART | 1 | GA | + | - | + | nil | - | 70 | 90 | 40 | 40 | + | + | STF | + | 80 | 80 | 50 | 60 | + | + | STF | + | 100 | 90 | 60 | 60 | 70 |