DISSERTATION ON
OUTCOME ANALYSIS OF INTERNAL FIXATION OF PROXIMAL HUMERUS FRACTURES

Submitted for

M.S.DEGREE EXAMINATION

BRANCH II – ORTHOPAEDIC SURGERY

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CHENNAI

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CERTIFICATE

This is to certify that this dissertation entitled "**Prospective study on the OUTCOME ANANLYSIS OF INTERNAL FIXATION OF PROXIMAL HUMERUS FRACTURES.**" submitted by **Dr.R.ANAND KUMAR** appearing for Part II, M.S. Branch II - Orthopaedics degree examination in april 2011 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfilment of regulations of The Tamil Nadu Dr. M.G.R. Medical University, Chennai.

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CONTENTS

AIM

To evaluate and analyse the **FUNCTIONAL OUTCOME OF PROXIMAL HUMERUS FRACTURES TREATED BY INTERNAL FIXATION** in the Institute of Orthopaedics and Traumatology ,Madras Medical College over a period of two and half years from June 2008 to October 2010 .

INTRODUCTION

Proximal humerus fractures constitute 4-5% of all fractures and they account for 45% of all humeral fractures. When considering adults over the age of 40 years, this increases to 76% [(1).]

These fractures have a dual age distribution occuring either in young people following high energy trauma or in those older than 50 years with low velocity injuries like simple fall [(2)] .Most proximal humerus fractures are either nondisplaced or minimally displaced and can be treated nonsurgically[.(3)]

Up to 80% of proximal humeral fractures can be treated nonoperatively, resulting in satisfactory results[(4).] Nonsurgical options focus on early functional exercises with the goal of achieving a functionally acceptable range of motion (ROM). For the 15% to 20% of displaced proximal humerus fractures that may benefit from surgery, no single approach is considered to be the standard of care. However, Various methods of internal fixation [(5)] using k wires and screws, blade plates, external fixators, T-plates, intramedullary devices, locking compression plates and shoulder arthroplasty have been reported but none of these methods has been consistently successful. For full functional recovery anatomical reduction, stable fixation and early mobitisation are required.

The blood supply of the head of the humerus is at risk however, not only from the injury, but also from dissection of the soft tissues at open reduction and fixation.[6] The incidence of malunion, nonunion, and avascular necrosis (AVN) after ORIF have been reported. Extensive exposure and the insertion of implants increase the risk of the development of AVN and limited exposure and dissection of the soft tissues at the fracture site with minimal internal fixation have been recommended. Stable reduction is essential for healing of the fracture and allows early movement of the shoulder

With these requirements in mind, we treated such fractures with Screws, AO T-plates or Locking compression plates or osseous suturing.

The purpose of this study was to examine a group of patients who had fracture of the proximal part of the humerus, representative of the individuals who commonly sustain this fracture, treated by rigid internal fixation after a near anatomic reduction, emphasizing on the functional results, range of motion, strength, and complications

HISTORICAL REVIEW

Hippocrates first documented a proximal humerus fracture in 460 BC and treated it with traction. In 1869, to improve treatment, Krocher classified fractures of the proximal humerus. In 1934, Codman developed a classification that divided the proximal humerus into 4 parts, based on epiphyseal lines. In 1970, Neer‘s classification expanded on the 4-part concept and included anatomic, biomechanical, and treatment principles, providing clinicians with a useful framework to diagnose and treat patients with these fracture[(7).]Treatment initially consisted of closed reduction, traction, casting, and abduction splints.

In the early 1930s, operative treatment for displaced fractures gained popularity, which continued in the 1940s and 1950s. Humeral head replacement for severely displaced fractures of the proximal humerus was introduced the 1950s. In the 1970s, the AO/ASIF (Arbeitsgemeinschaftfürosteosynthesefragen/Association for the Study of Internal Fixation) group popularized plates and screws for fracture fixation, and humeral head prostheses were redesigned. Currently, fixation methods that involve limited fixation and limited dissection are becoming more popular, and prosthetic replacement for severe fracture is being refined further. [(8)]

Anatomy of proximal humerus [9]

The upper extremity consists of a large rounded *head* joined to the body by a constricted portion called the **neck,** and two eminences, the **greater** and **lesser tuberosities**

The Head

The head, nearly hemispherical in form, is directed upward, medialward, and a little backward, and articulates with the glenoid cavity of the scapula. The circumference of its articular surface is slightly constricted and is termed the **anatomical neck,** in contradistinction to a constriction below the tubercles called the **surgical neck** which is frequently the seat of fracture.

The **Anatomical Neck** is obliquely directed, forming an obtuse angle with the body. It is best marked in the lower half of its circumference; in the upper half it is represented by a narrow groove separating the head from the tubercles. It affords attachment to the articular capsule of the shoulder-joint, and is perforated by numerous vascular foramina.

The Greater Tuberosity

The greater tuberosity is situated lateral to the head and lesser tubercle. Its upper surface is rounded and marked by three flat impressions: the highest of these gives insertion to the Supraspinatus; the middle to the Infraspinatus; the lowest one, and the body of the bone for about 2.5 cm. below it, to the

Teres minor. The lateral surface of the greater tubercle is convex, rough, and continuous with the lateral surface of the body.

The Lesser Tuberosity

The lesser tuberosity, although smaller, is more prominent than the greater: it is situated in front, and is directed medialward and forward. Above and in front it presents an impression for the insertion of the tendon of the Subscapularis.

The tuberosities are separated from each other by a deep groove, the **intertubercular groove** (*bicipital groove*), which lodges the long tendon of the Biceps brachii and transmits a branch of the anterior humeral circumflex artery to the shoulder-joint. It runs obliquely downward, and ends near the junction of the upper with the middle third of the bone. In the fresh state its upper part is covered with a thin layer of cartilage, lined by a prolongation of the synovial membrane of the shoulder-joint; its lower portion gives insertion to the tendon of the Latissimus dorsi. It is deep and narrow above, and becomes shallow and a little broader as it descends. Its lips are called, respectively, the **crests of the greater and lesser tubercles** (*bicipital ridges*), and form the upper parts of the anterior and medial borders of the body of the bone.

Anatomic relationship

The critical anatomical relationships of the proximal humerus are those of the articular segment to the shaft and the tuberosities.(10)

These include

Retroversion,

Inclination angle

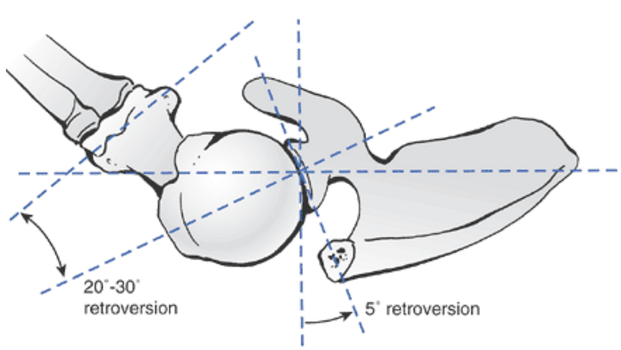
Translation of the head relative to the shaft, and

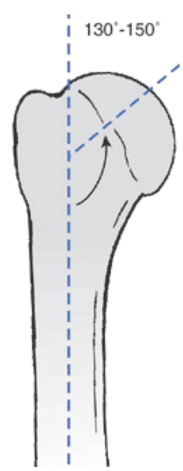
The relationship of the head to the greater tuberosity.

The articular segment is retroverted 30° relative to the forearm. The range is quite large (0-70°) and can vary from one side to the other.

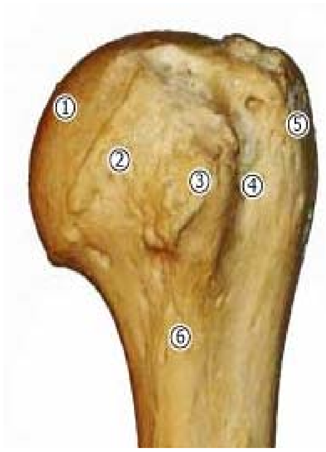
Inclination of the articular segment also can vary (from 120-140°). (11)

The head segment can lie directly over the medullary canal but often is translated either posteriorly or medially. (12)



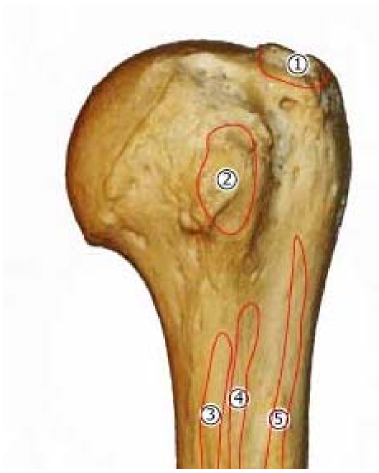


Proximal humerus anatomy



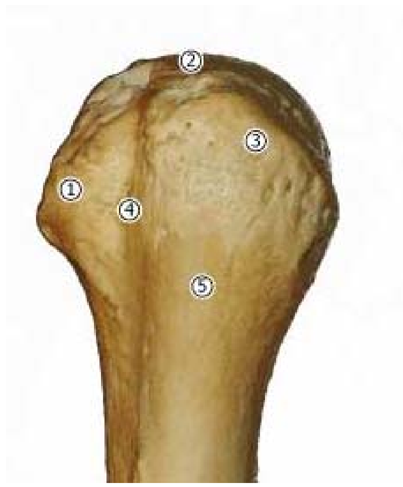
Proximal Humerus - Anterior view bony anatomy

1. Humeral head
2. Anatomic neck
3. Lesser tuberosity
4. Intertrubercular groove
5. Greater tuberosity
6. Surgical neck



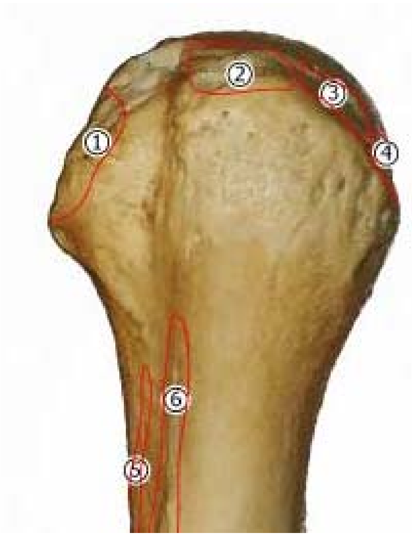
Proximal humerus - Anterior view muscular attachments

1. Supraspinatus
2. Subscapularis
3. Teres major
4. Latismus Dorsi
5. Pectoralis major



Proximal Humerus - Lateral view bony anatomy

1. Lesser tuberosity
2. Humeral head
3. Greater tuberosity
4. Intertubercular groove
5. Surgical neck

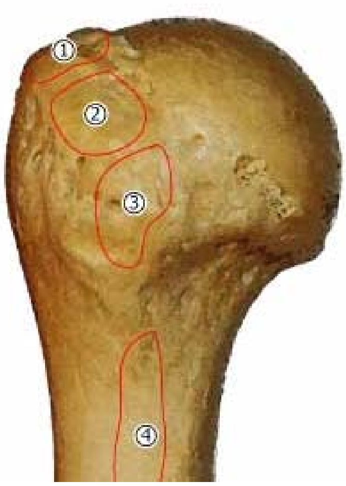


Proximal humerus - Lateral view muscular attachments

1. Subscapularis
2. Supraspinatus
3. Infraspinatus
4. Teres minor
5. Pectoralis major

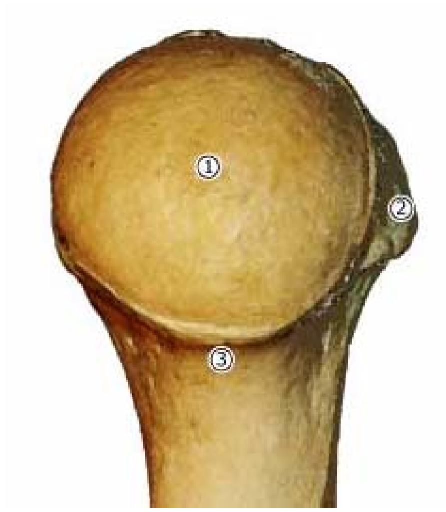
Proximal Humerus - Posterior view bony anatomy

1. Humeral head
2. Anatomic neck
3. Greater tuberosity
4. Surgical neck



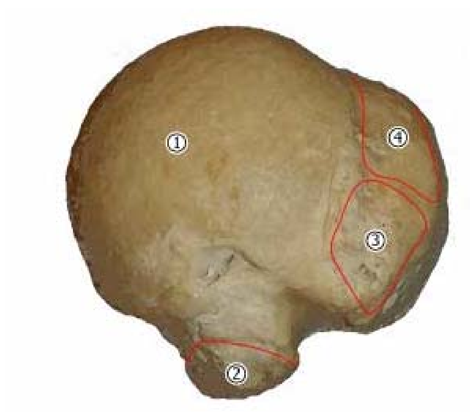
Proximal humerus - Posterior view muscular attachments

1. Supraspinatus
2. Infraspinatus
3. Teres minor
4. Triceps (lateral head)



Proximal Humerus - Medial view bony anatomy

1. Humeral head
2. Lesser tuberosity
3. Anatomic neck



Proximal humerus - Superior view muscular attachments

1. Humeral head
2. Supraspinatus: anatomic footprint of the supraspinatus is 25mm from anterior to posterior and 12mm from medial to lateral.
3. Infraspinatus

VASCULATURE OF PROXIMAL HUMERUS

The main arterial supply to the humeral head is via the ascending branch of the anterior humeral circumflex artery and its intraosseous continuation, the arcuate artery.

There were significant intraosseous anastomoses between the arcuate artery and:

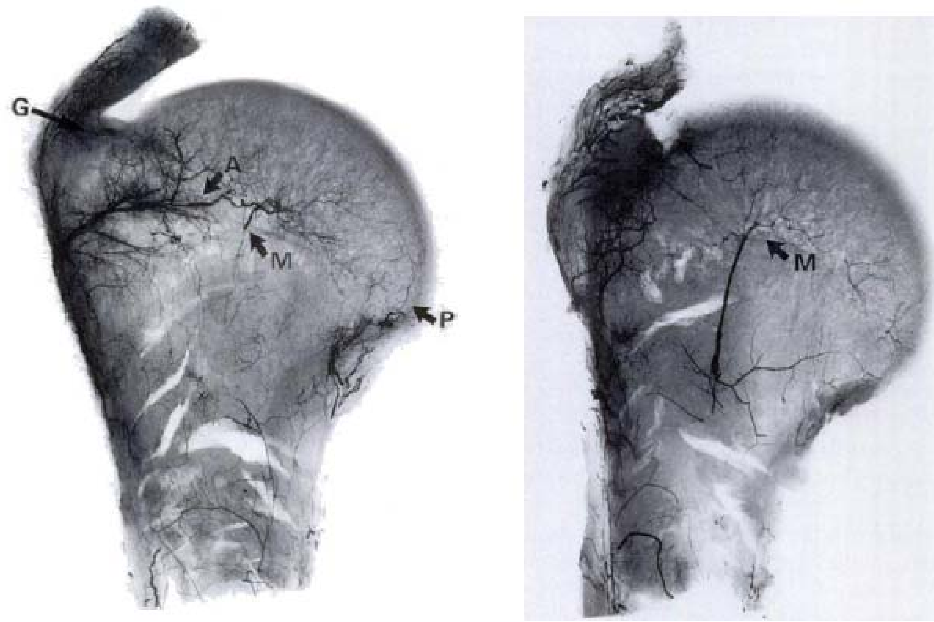
1) The posterior humeral circumflex artery through vessels entering the posteromedial aspect of the proximal humerus;

2) Metaphyseal vessels; and

3) The vessels of the greater and lesser tuberosities

After a four-part fracture, when the blood supply from the anterior humeral circumflex artery, the greater tuberosity, the lesser tuberosity and any metaphyseal arterial anastomoses have all been lost, perfusion of the humeral head via the arcuate artery may continue if the head fragment includes part ofthe medial aspect of the upper part of the neck.

A low incidence of avascular necrosis of the humeral head is seen in four-part fractures in which the humeral head was impacted and in valgus. In this type of fracture the medial aspect of the humeral head is little displaced, and may thus retain its vascularity from the posteromedial vessels. When the medial fracture line is at the junctionbetween the articular surface and the neck this anastomosis will be lost and the head will be avascular .[15,16,17]



Perfusion angiograms of consecutive coronal 10 mm sections of the humeral head showing : the arcuate artery (A) ; the metaphyseal anastomosis (M); the posteromedial anastomosis (P); and the greater tuberosity anastomosis (G).

MODE OF VIOLENCE

The most common mechanism for proximal humerus fractures is a fall on an outstretched hand from a standing height.[18]

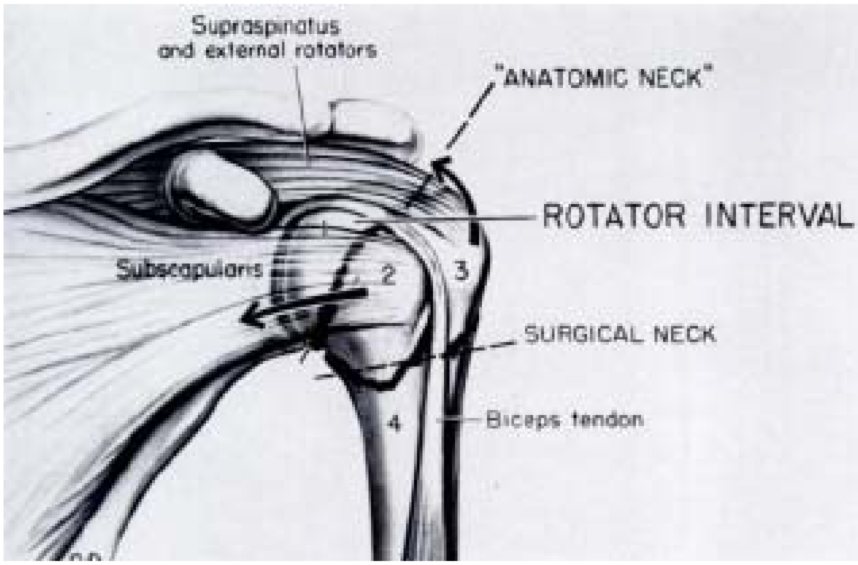
In younger patients, high-energy trauma is a more frequent cause, and the resultant injury is more devastating.

Additional mechanisms include violent muscle contractions from seizure activity, electrical shock (fracture dislocations) and athletic, boxing injuries.

Finally, a direct blow to the proximal humerus may also lead to fracture.[19]

Fracture mechanism

Tendinous insertions contribute to the pattern of fracture displacement around the proximal humerus by transmitting deforming muscular forces to the bony fragments. The insertions of the supraspinatus, infraspinatus, and teres minor tendons onto the greater tuberosity contribute to the typical posterior and superior retraction of this fragment. The rotator interval functions as a checkrein on the humeral head fragment and limits displacement of two-part fractures and most three-part fractures. Functionally significant tears of the rotator interval are uncommon. The pull of the subscapularis muscle tends to retract lesser tuberosity fragments medially. When the lesser tuberosity remains attached to the head fragment, the head fragment is rotated internally. Although the bone at the tendinous insertion tends to be very dense and strong, thus providing a potential site for fracture fixation, it is important when using suture fixation to remember that the tendons are even stronger than the bone.(13)



The quality of the proximal humerus may be insufficient for rigid fixation in some elderly individuals. Indeed, several studies have identified age as the most important prognostic factor for implant failure and outcome after operative fixation of fractures. This is due to the correlation of bone quality and age with increasing degrees of osteoporosis. (14)

In general, two specific groups of patients can be identified based on bone quality. In group 1, the patients tend to be younger, with either minimally displaced fractures or more comminution of dense bone as a result of greater trauma . These individuals are generally better suited to rigid fixation due to good-quality bone.

In group 2 patients, the bone is more osteoporotic due to advanced age and decreased bone density, and usually less trauma is required to generate a fracture. These fractures are more often displaced than impacted, and for this reason reduction and stable fixation can be a challenge given the poor bone quality

RADIOGRAPHIC EVALUATION[20 , 21]

Adequate radiographs are essential for the proper classification and treatment of proximal humeral fractures.

A standard trauma series should include a true AP radiograph of the scapula, a lateral scapular view, obtained with the patient in a 60Â° anterior oblique position, and an axillary view.

Computed tomography scans provide the most reliable information and are helpful in several circumstances including the evaluation of intraarticular fractures to assess the degree and nature of damage to the joint surface and the evaluation of fracture displacement, particularly the greater and/or lesser tuberosity

TREATMENT [22, 23]

Non operative

Conservative treatment may be preferred for

1) Elderly patientswith severe comorbid illness
2) Only minimally displaced fractures
3) Impacted fractures.

Closed reduction of significantly comminuted or displaced fractures can be difficult to maintain and manage; often functional results are less than satisfactory.[24 ,25]

If nonoperative treatment is selected, a sling or U slab is usually applied for 2 to 3 weeks. Elbow and hand motion is encouraged immediately to reduce the risk of extremity swelling. Passive motion is allowed after 2 weeks when the movement of the shoulder is not associated with pain and that the humerus moves as a single unit.[26]

Operative

Surgery may be recommended if one or more of the fracture fragments is displaced or angulated.

Indications for surgery:

1) Displacement of a fracture fragment by 1 cm,

2) Angulation between fracture fragments of 45° or greater,

3) Greater tuberosity should be reduced if it is displaced 5 mm or more.

However, other factors such as bone quality, fracture orientation, and soft tissue injuries, the age and health status of the patient, and the surgeon's level of compfort in treating these injuries all have a tremendous effect on specific treatment indications.

Preoperative Planning

A thorough preoperative evaluation should be performed, including patient history and physical examination, radiographic evaluation, and surgical planning. Key components of the history include the mechanism of injury as well as the patient’s age, handedness, preinjury shoulder function, functional demands, and comorbidities. Physical examination of the shoulder should evaluate for the presence of an open or closed fracture, the location of tenderness and amount of localized swelling, the position of the humeral head on palpation (ie, located, subluxated, dislocated), active and passive shoulder range of motion (ROM), neurovascular status of the extremity, and associated cervical spine or other distracting injuries.

Standard plain radiographic views (ie, AP, axillary, scapular Y) should be obtained to determine fracture location and severity as well as humeral head position . Finecut coronal and sagittal CT scans of the shoulder should be obtained when intra-articular involvement is suspected, including articular comminution of the humeral head or suspected glenoid involvement, and when the fracture pattern is difficult to appreciate on plain radiographs The information obtained from both plain radiographs and CT regarding the characteristics of the fracture is vital in developing a surgical plan, which includes determining intraoperative reduction maneuvers and choosing the appropriate method of internal fixation.

Methods of fixation

1) k wires

2) Plates – T plate or LCP

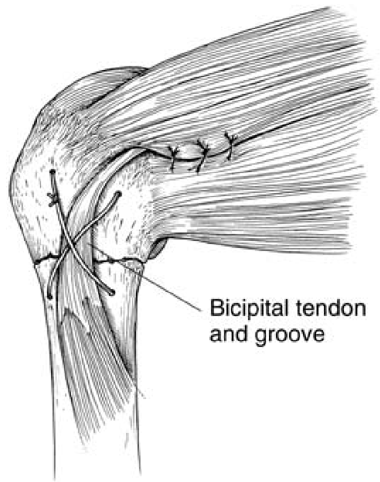
3) Screws – cortical / cancellous

4) Trans osseous suture fixation

Implants and fixation methods

Transosseous Suture Fixation

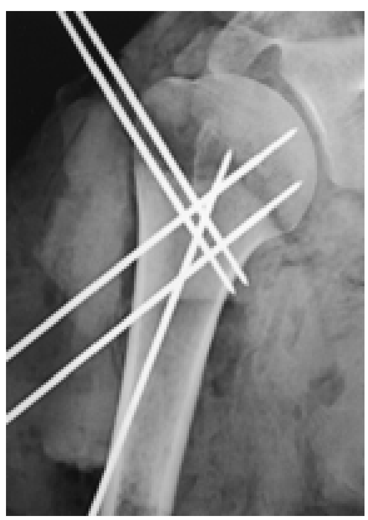
For isolated greater tuberosity fractures with >5 mm of displacement, Flatow et al describe a transosseous suture fixation technique using a lateral approach to the shoulder. Four or five no. 2 nonabsorbable sutures are passed through the supraspinatus tendon, and drill holes are created in the humerus to secure anatomic reduction of the greater tuberosity fragment. Transosseous suture fixation also can be done on two-part surgical neck fractures and three-part proximal humerus fractures.[27,28,29]



Trans osseous suture fixation

Percutaneous k wire fixation

The advantage of closed reduction with percutaneous fixation is that it requires minimal surgical dissection with less disruption of the remaining vascular supply (biological fixation) . Adequate cortical purchase is required; thus, osteoporotic bone with extensive comminution is a relative contraindication.



Percutaneos k wire fixation

Locking Compression Plates, T plates , Blade plates

Advantages include

- improved fracture stability because of the fixed-angle construct, particularly in more comminuted fracture patterns and in osteoporotic bone;
- a short period of immobilization with the opportunity for earlier rehabilitation;
- lower risk of damage to the rotator cuff or need for implant removal;
- reduced hardware complications; and,
- in patients with more complex fractures, the potential to avoid the use of hemiarthroplasty.

LCP Design

The 3.5 mm LCP Proximal Humerus Plate is part of the Small Fragment LCP System.

- Anatomically-shaped
- Ten suture holes around the perimeter of the proximal end
- Proximal locking holes accept 3.5 mm Locking Screws
- Locked construct in humeral head

- Distal shaft consists of three or five locking compression holes in the shaft, including one elongated hole to aid in plate positioning. These holes accept 3.5 mm Locking Screws in the threaded portion, and 3.5 mm Cortex Screws, 4.0 mm Cortex Screws, and 4.0 mm CancellousBone Screws in the compression portion.

"Diverging" screw pattern

"Converging" screw pattern

Final construct

MATERIALS AND METHODS

This study was conducted at Institute of Orthopaedics and Traumatology, Govt General Hospital, Madras Medical College, Chennai. This study is a prospective study from JUNE 2008 to OCTOBER 2010 with a sample size of 29 cases. Informed consent was obtained from each patient, and ethical clearance was obtained from institutional ethical committee.

MATERIALS

Twenty nine patients were randomly selected from among the admissions to the Orthopaedic ward in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, GOVERNMENT GENERAL HOSPITAL, CHENNAI and recruited into the study prospectively based on the following criteria.

INCLUSION CRITERIA

1) Proximal 3rd displaced humeral fractures (NEER classification) which needs to be internally fixed.

2) Patients who give consent to be included in the study.

3) Patients with skeletal maturity.

EXCLUSION CRITERIA

1) Skeletal immaturity with open physis
2) Pathological fractures
3) Undisplaced fractures
4) Medically unfit for surgery
5) Unwilling for surgery

Demographic data (age, gender and profession), mechanism of injury, severity of the injury (NEER classification), associated injuries, initial management and time to definitive treatment were recorded.

Intra-operative events and difficulties, post operative local or systemic complications, time to union and time required to return to pre-injury activities were documented. All patients at their final assessment, underwent radiological and functional evaluation using the CONSTANT score.

In our study ,the sample size was 29 patients,out of which 5 were females and 24 were males.The age grouip varied from 19 years to 83 years with a median age of 42 years. Almost all the patients are victims of RTA, except one who had sustained fracture after a fall. Longest duration of follow up was 26 months with a mean follow up of 14 months.3 patients lost follow up and one patient died due to natural causes.

All the patients in our study were right handed persons and in our study 17 patients had a fracture of the right proximal humerus and 12 patients had a fracture of the left proximal humerus. This can be attributed to the left side driving in the roads and subsequent RTAs.

Chart 1 :Sex incidence

Male	Female
83%	17%
24	5

Chart 2: Age Incidence

Age	No. of Cases	Males	Females
11 – 20	1	1	-
21 – 30	7	6	1
31 – 40	5	4	1
41 – 50	9	7	2
51 – 60	3	3	0
61 – 90	4	3	1

Chart 1 : Sex Incidence

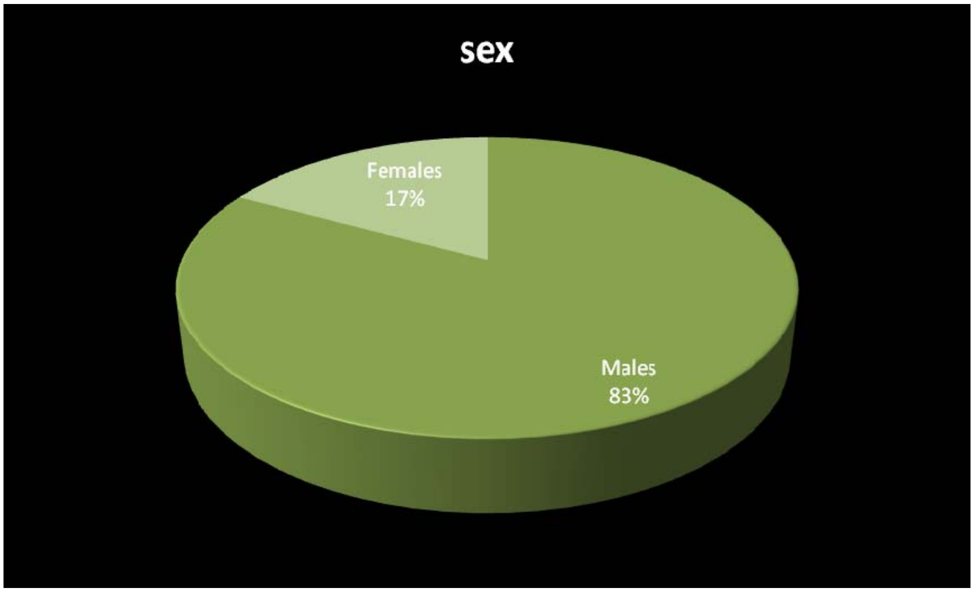


Chart 2: Age Incicence

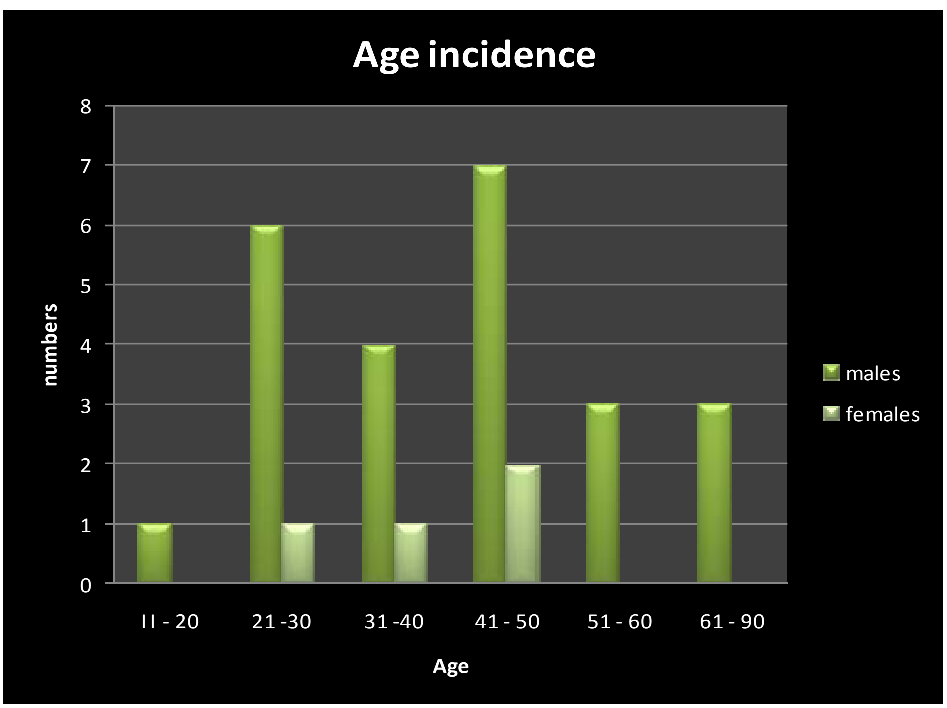


Chart 3: Side involved

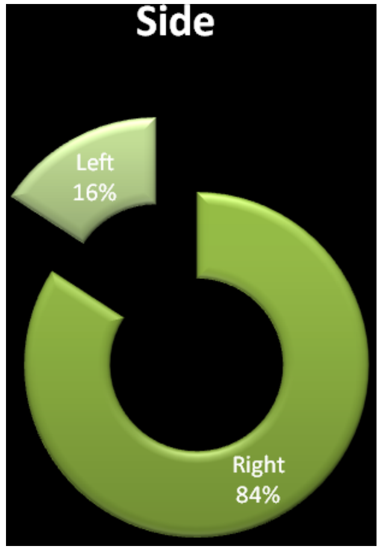
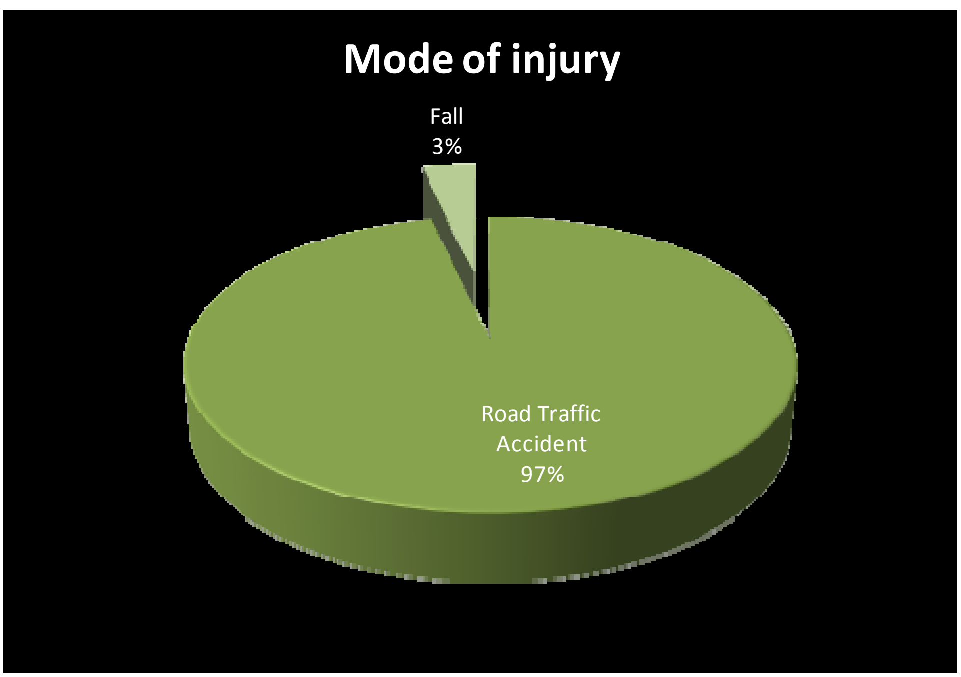


Chart 4: Mode of Injury



The youngest age in our study was 19 years and the oldest age is 83years with a median age of 42 years

Side Involved

Right side was involved in 17 patients and left was involved in 12 patients. This can be attributable to the left side driving rule in our country and subsequent RTAs.(chart 3)

Chart 4 : Mode of Injury

Mode	**RTA**	**Accidental fall**
No	28	1

Mode of injury were 28 cases due to RTA and 1 case due to accidental fall.

METHODS

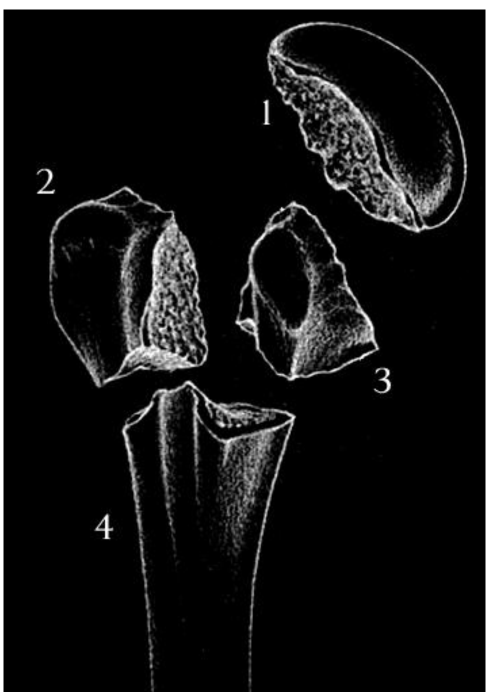
On admission detailed examination of the patients was carried out after hemodynamic stabilization. Patients were then splinted and given cuff and collar. Then standard Antero – Posterior and Axillary view X – Rays are taken and the fracture configuration noted. Computerized Tomography is also taken when needed to assess the exact alignment of the fragments. The fracture is classified using NEER classification.

FRACTURE CLASSIFICATION [4,7]

The Neer classification system is based on displacement criteria of 1 cm or fragment angulation of 45°. The type of fracture then is divided into segments. Four segments are possible, including the articular segment, the lesser tuberosity, the greater tuberosity, and the surgical neck.

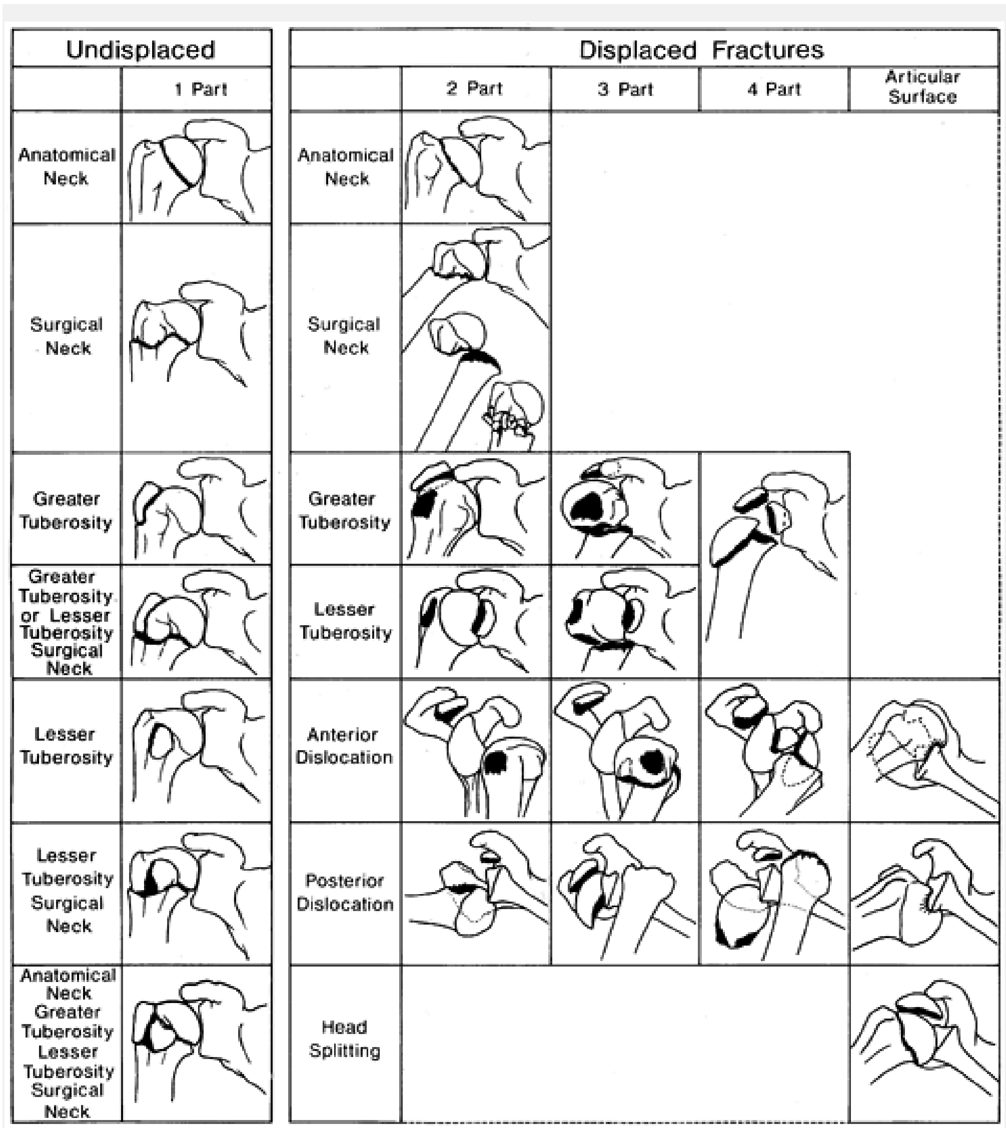
These four parts are separated by epiphyseal lines (bone growth plates) during the early developmental years. When the proximal humerus is broken, the fracture line predictably occurs along one or more of these planes.

More recently, a greater tuberosity that is displaced 5 mm or more has come to be considered a fragment that should be reduced



1	Head
2	Greater tuberosity
3	Lesser tuberosity
4	Shaft of humerus

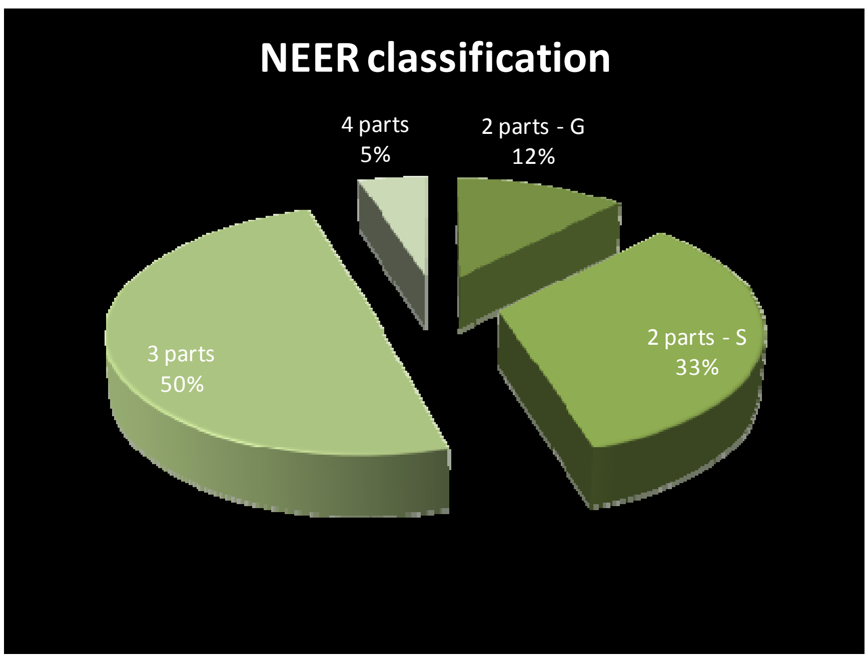
NEER CLASSIFICATION



All 29 patients in our study were classified according to NEER classification.

We had 3 patients with Neer two parts – greater tuberosity fracture ,8 patients with Neer two parts – surgical neck fracture, 12 patients with Neer three parts fracture and 6 patients with Neer four parts fracture.

Fracture type	**Number of patients**
Two parts - greater tuberosity	3
Two parts – surgical neck	8
Three parts	12
Four parts	6



All the patients were internally fixed with either cancellous scerws, AO T-plates or Locking Compression Plates.For all patients deltopectoral approach was used.Cancellous screws alone were used for fixation in 4 cases , Kwire alone in 1 case, AO T-plate and screws were used in 6 patients and locking compression plates in 18 cases.

Average duration of surgery lasted for about 97 minutes.

SURGICAL TECHNIQUE FOR PLATE OSTEOSYNTHESIS – DELTOPECTORAL APPROACH [32]

With the patient in supine position with a sandbag behind the scapula , a deltopectoral approach was used.

Locate the deltopectoral groove. In an obese patient, this groove is located by abduction and external rotation of the shoulder. Start the incision at the clavicle just medial to the coracoid, and extend it distally along the deltopectoral groove to the deltoid insertion for approximately 15 cm

Develop skin flaps to expose the deep fascia. Open the fascia over the deltopectoral groove with blunt scissors, looking for the cephalic vein. This vein serves as an important landmark for identifying the avascular interval between the deltoid and pectoralis major muscles. Bluntly develop this interval, and retract the deltoid laterally and the pectoralis major medially. The vein can be ligated or retracted with the deltoid

The anterior circumflex vessels lie in the middle of the wound, just superior to the pectoralis major muscle; they may need to be isolated, clamped, and coagulated.

Wider exposure is possible if the muscle origins from the coracoid are transected. If more proximal exposure is needed, it may be necessary to transect the origin of the pectoralis minor muscle. In such cases, release the origins of the coracobrachialis and the short head of the biceps from the tip of the coracoid, leaving a cuff on the tip of the coracoid for repair.

Soft-tissue attachments to the fracture fragments were carefully preserved to prevent devascularization of the bone. The biceps tendon is used as a landmark between the greater and lesser tuberosities. The osseous attachments of the rotator cuff are often displaced and had to be identified and retracted with sharp hook retractors. In patients with a fracture-dislocation, the humeral head is reduced by closed manipulation without opening the joint capsule.

A Kirschner wire occasionally is used to temporarily or permanently hold the reduction of the fracture fragments.

If plating is preferred, plate is placed at least 1 cm distal to the upper end of the greater tubercle and fixed to the humeral shaft with screws. Either a locking compression plate or a T buttress plate was used, if plating was preferred.

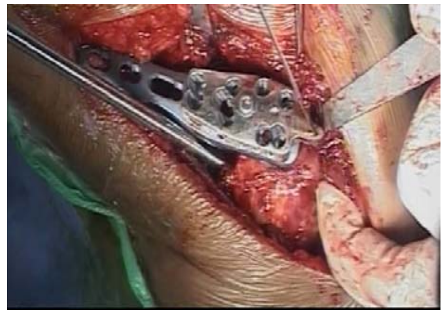
Photos

Locating deltopectoral groove

Incision

Deepening the incision

Cephalic vein in the groove



Plane between deltoid and pectoralis temporarily major

Fixing the plate with kwires

Final plate fixation

Final c arm picture

POST OPERATIVE PROTOCOL[33,34]

Postoperatively, the arm was immobilized in a sling. The drain was removed 2 days after surgery. The timing of shoulder rehabilitation was determined by fracture stability, bone quality, and patient compliance.28 Passive ROM exercises (ie, pendulums, passive forward elevation, external rotation) generally were begun on the first postoperative day provided that a stable reduction was achieved. Active ROM of the elbow, wrist, and hand was also begun immediately after surgery. The patient then progressed through a three-phase rehabilitation program, consisting of passive assisted exercises early, active exercises starting at approximately 6 weeks postoperatively, and strengthening or resisted exercises beginning 10 to 12 weeks after surgery. Early passive assisted exercises help to avoid adhesion formation. No limitation of exercises within the pain-free ROM was necessary during this time provided that bone stock was good and medial buttressing adequate. Shoulder strengthening and resistance exercises were initiated only after bony consolidation was confirmed on plain radiographs and adequate coordination of the extremity had been achieved

Standard AP, axillary, and scapular Y radiographic views were taken immediately after surgery. Routine follow-up radiographs were taken 3, 6, and 12 weeks postoperatively, then again at 6 and 12 months following surgery . Plate removal was generally not necessary

CASE ILLUSTRATIONS

Case – 1

50 years old male

Road Traffic Accident

Neer 3 parts fracture Right side

Open Reduction and internal fixation with AO T- buttress plate.

Duration of surgery – 45 minutes

Radiological fracture union: 14 weeks

Range of Motion:

Flexion – 0 - 170°

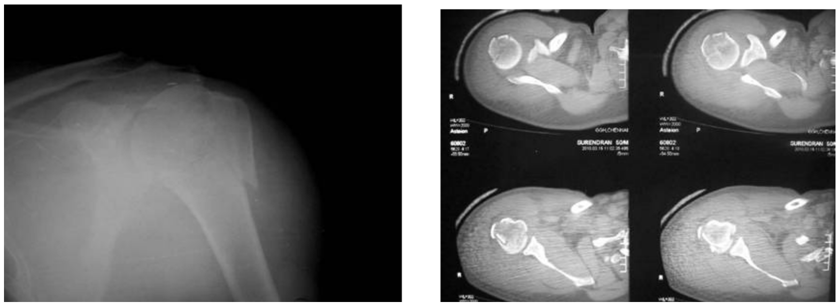
Abduction – 0 - 170°

External rotation – 10 points (constant score)

Internal rotation – 10 points (constant score)

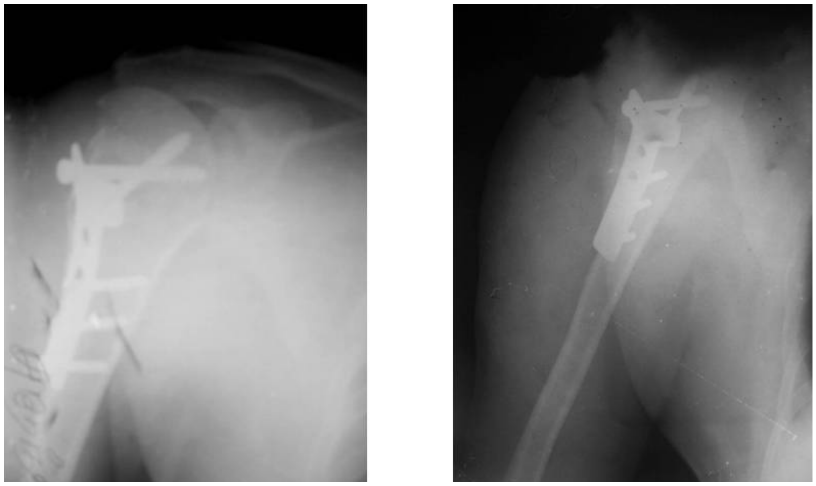
Constant score – 86

Comment – excellent



Pre operative

Immediate post operative



7 months post operative

Functional results

CASE - 2

44 years old male

Road Traffic Accident

Neer 2 parts- greater tuberosity fracture Right side

Open Reduction and internal fixation with cancellous screws

Duration of surgery – 90 minutes

Radiological fracture union: 14 weeks

Range of Motion:

Flexion – 0 - 160°

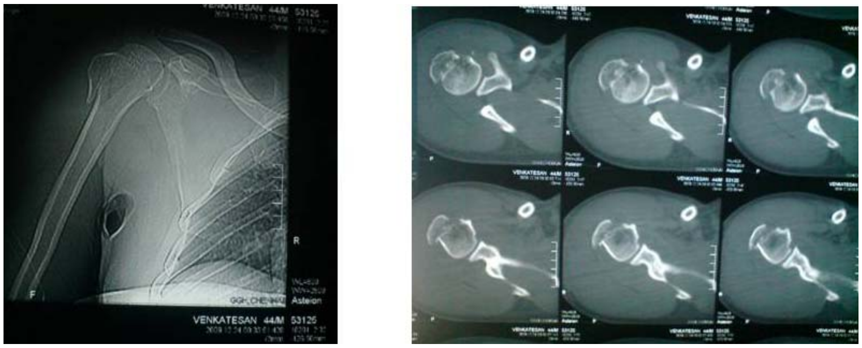
Abduction – 0 - 100°

External rotation – 10 points (constant score)

Internal rotation – 10 points (constant score)

Constant score – 86

Comment – excellent



Pre operative

Immediate post operative

9 months post operative

Functional results

CASE – 3

21 years old male

Road Traffic Accident

Neer 2 parts – surgical neck fracture left side

Open Reduction and internal fixation with Locking compression plate.

Duration of surgery – 90 minutes

Radiological fracture union: 14 weeks

Range of Motion:

Flexion – 0 - 110^{o}

Abduction – 0 - 100^{o}

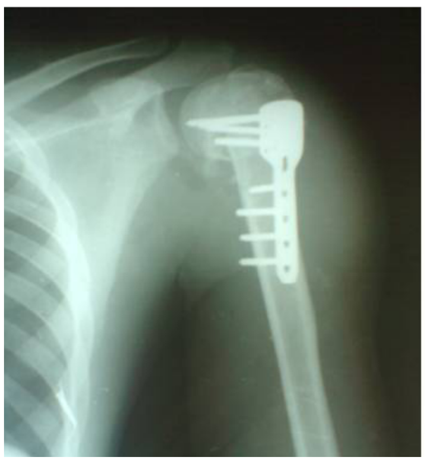
External rotation – 8 points (constant score)

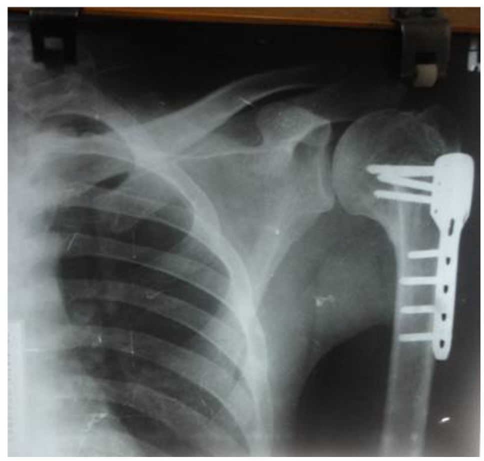
Internal rotation – 8 points (constant score)

Constant score – 68

Comment – moderate outcome

pre operative





Immediate post operative **16 months post operative**

Functional results

CASE – 4

22 years old male

Road Traffic Accident

Neer 4 parts fracture left side

Assoc2iated injury – axillary vien injury

Open Reduction and internal fixation with Locking compression plate .

Duration of surgery – 120 minutes

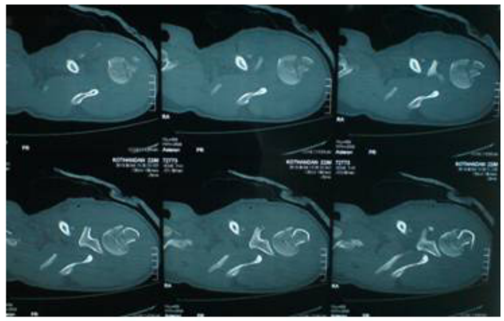
Radiological fracture union: 14 weeks

Range of Motion:

Flexion – 0 - 90^{o}
Abduction – 0 - 90^{o}
External rotation – 10 points (constant score)
Internal rotation – 8 points (constant score)

Constant score – 69

Comment – moderate outcome



Pre operative

Immediate post operative **4 months post operative**

Functional results

CASE – 5

35 years old male

Road Traffic Accident

Neer 4 parts fracture left side

Open Reduction and internal fixation with AO T- buttress plate .

Duration of surgery – 120 minutes

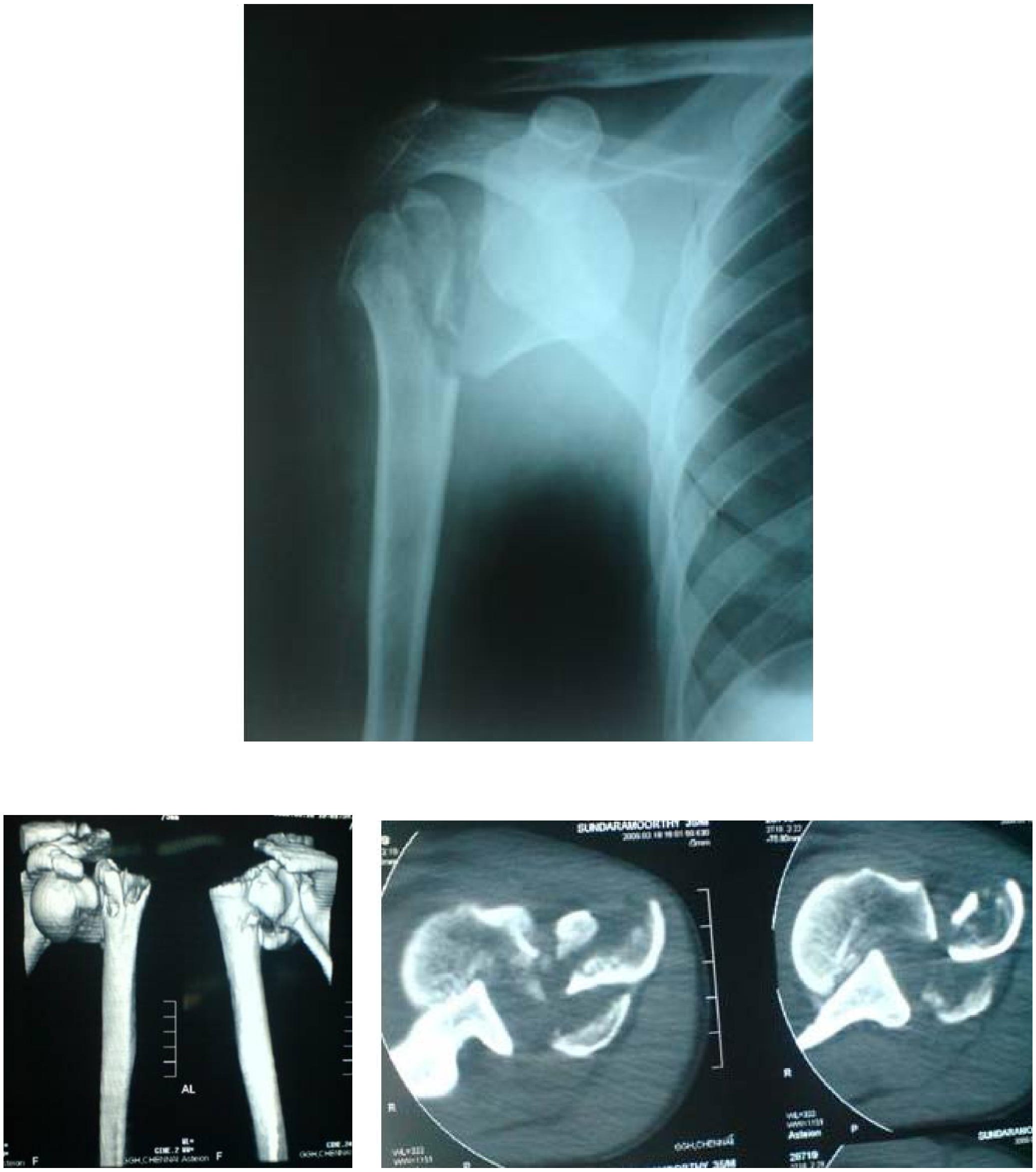
Radiological fracture union: 14 weeks

Range of Motion:

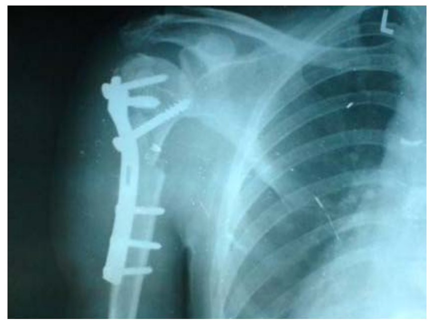
Flexion – 0 - 110^o Abduction – 0 - 110^o External rotation – 10 points (constant score) Internal rotation – 8 points (constant score)

Constant score – 75

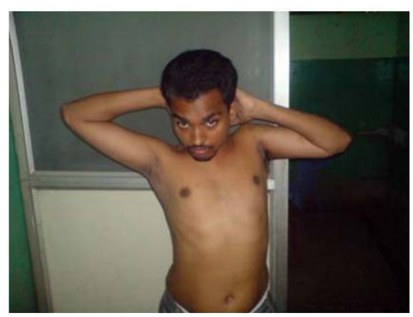
Comment – good outcome



Pre operative



Immediate post op **18 months post op**



Functional results

CASE – 6

33 years old male

Road Traffic Accident

Neer 2 parts- greater tuberosity fracture right side

Open Reduction and internal fixation with cancellous screws.

Duration of surgery – 120 minutes

Radiological fracture union: 14 weeks

Range of Motion:

Flexion – 0 - 160^{o}

Abduction – 0 - 90^{o}

External rotation – 6 points (constant score)

Internal rotation – 6 points (constant score)

Constant score – 86

Comment – excellent outcome

Pre operative

Immediate post operative

6 weeks post op **21 months post op**

Functional results

EVALUATION

A physical examination was performed, the Constant score was calculated, and radiographs of the proximal part of the humerus were made and evaluated for bony healing, signs of malunion, nonunion or avascular necrosis.

The Constant score assigns points for Pain, Range of movements, Power and Activities of daily living. Musclestrength was measured with use of a 1 kg weight in the patient's hand and the shoulder in 90° of abduction, or, if 90° could not be reached, in maximum active abduction as described by Constant. (35)

The Constant score was graded as

Poor	(0 to 55 points),
Moderate	(56 to 70 points),
Good	(71 to 85 points), or
Excellent	(86 to 100 points).

CONSTANT SCORE

Patient's Details

Operation/Diagnosis: **Date:** ____

Side: R L

Examination: Pre-op
3 months 6months
1 year 2 years ___ years

A.- Pain (/15): Average (1 + 2) [ ] A

1. Do you have pain in your shoulder (normal activities)?
No =15 pts, Mild pain = 10 pts, Moderate = 5 pts, Severe or permanent = 0. ____

2. Linear scale:
If "0" means no pain and "15" is the maximum pain you can experience, please circle where is the level of pain of your shoulder. (Points given are inverse to the scale. E.g. level 5 in the scale means 10 points)

Level of pain:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Points:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

____

B.- Activities of daily living (/20) Total (1 + 2 + 3 + 4) [ ] B

1. Is your occupation or daily living limited by your shoulder?
No = 4, Moderate limitation = 2, Severe limitation = 0 ____
2. Are your leisure and recreational activities limited by your shoulder? ____
No = 4, Moderate limitation = 2, Severe limitation = 0
3. Is your night sleep disturbed by your shoulder?
No = 2, Sometimes = 1, Yes = 0 ____
4. State to what level you can use your arm for painless, reasonably activities.
Waist = 2, Xiphoid (sternum) = 4, Neck = 6, Head = 8, Above head = 10 ____

C.- Range of movement (leave this for the doctor or physiotherapist) (/40): Total (1 + 2 + 3 + 4) [ ] C

1.- FWD Flexion: ____

0 - 30	0 pts
31 -60	2 pts
61 - 90	4 pts
91 - 120	6 pts
121- 150	8 pts
> 150	10 pts

2.- Abduction: ____

0 -30
31 - 60
61 - 90
91 - 120
121 - 150
> 150

3.- External Rotation: ____

Hand behind head & elbow forward	2
Hand behind head & elbow back	4
Hand above head & elbow forward	6
Hand above head & elbow back	8
Full elevation of arm	10

4.- Internal Rotation: (Dorsum hand to) ____

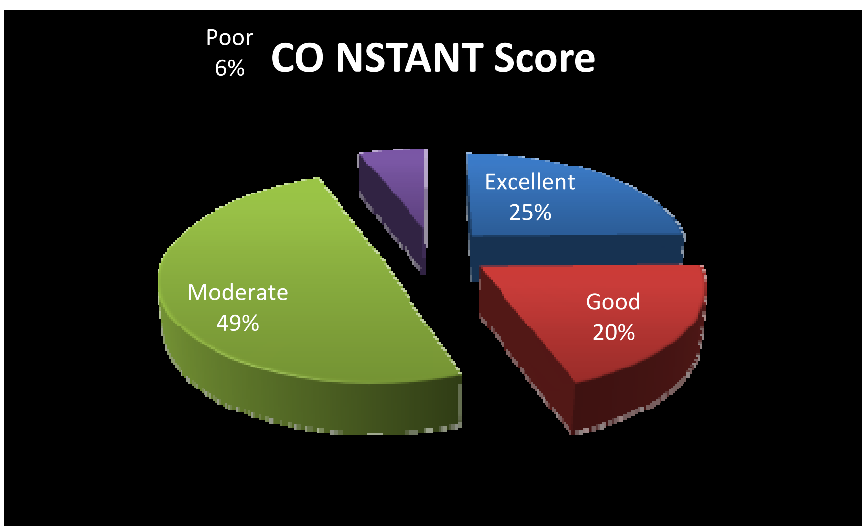
Thigh	0
Buttock	2
SI joint	4
Waist	6
T12	8
Between shoulder blades	10

D.- Power (/25): Points: average (kg) x 2 = [ ] D

First pull: Second pull: Third pull: Fourth pull: Fifth pull:
Average pulls:

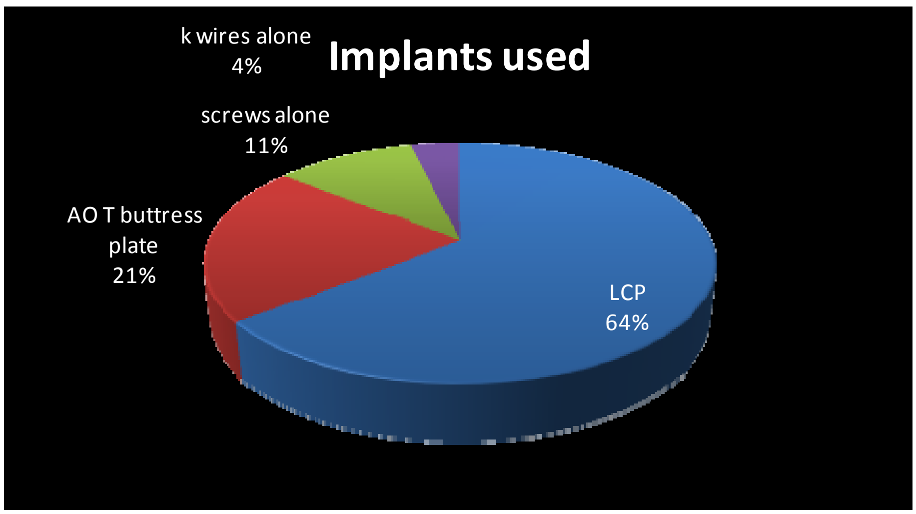
TOTAL (/100): A + B + C+ D [ ]

Results – outcome	**Numbers**
Excellent	5
Good	4
Moderate	10
Poor	6
Lost follow up	3
Death	1



RESULTS

A total of 29 patients were operated , 18 patients with locking compression plate ,6 patients with AO T buttress plate , 3 patients with screws alone and one patient with k wires alone.



Out of the 25 patients followed up, 5 patients had excellent scores, 4 had good scores , 10 had moderate scores and 6 had poor outcome scores. Mean constant score is 63.44 (range 18-86 points). Mean constant score for Neer two part fracture was 74.88 (range 64 – 86), for Neer three parts fracture was 55.9 (range 18 – 86) and for Neer four parts fracture was 58.83 (range 41 – 75).

Correct anatomical repositioning (including tuberosities)		
Fragments (Number)	**Patients (Number)**	**Constant score**
2	10	74.25
3	6	77.2
4	3	67.67

Twenty three out of twenty five patients went in for union at around six weeks follow up (88%) , except those complicated by screw pull out and fixation failure.

Non anatomical repositioning (including tuberosities)		
Fragments (Number)	Patients (Number)	
2	1	80
3	6	38
4	3	50

COMPLICATIONS

The most common complications after surgical treatment of fractures of the proximal humerus are stiffness, persistent pain, postoperative infection, failure of fixation, osteonecrosis and late rupture of the rotator cuff. (36)(37)(38)(39)

One patient with Neer 4 parts fracture presented with axillary vein injury for which emergency repair was done.

Two patients, both with Neer 3 part fractures later presented with osteonecrosis of the humeral head. Overall percentage was 8%.

One patient with Neer 3 part fracture treated with locking compression plate had implant back out with screws pull out from the humeral head on 13^{th} post operative day , for which redo surgery was done . But eventually,the patient landed up in osteonecrosis of humeral head with poor constant score -33.

Postoperative infection is always a possibility and must be borne in mind at all times. To avoid stiffness, the fixation must be stable enough to allow immediate passive movement so that adhesive scarring is limited and recovery of function is allowed. The diagnosis may show that the infection is either acute (<three weeks), intermediate (between 3 and 8 weeks) or chronic (>8 weeks). In acute infection, the implants may be left in place if they contribute to stability.

Two patients encountered deep infection which was noticed in the 5th postoperative day in one patient and 12th post operative day in the other patient for which wound wash was given and appropriate broad spectrum antibiotics were given after pus culture and sensitivity. Both the patients had their infections settled, now with moderate score during their latest follow ups.

Avascular necrosis is not in itself a clinical problem. However, it may end up in partial or total collapse of the humeral head with incongruency. This may result in malfunction and pain, although the x-ray appearance frequently does not correlate with the clinical picture. Osteonecrosis cannot be avoided but a meticulous surgical technique should strive to preserve the blood supply of all fragments. [40]

Various complications seen in our study are,

Complications	No. of patients
Failure of fixation or screw back out	3
Primary screw perforation of humeral head	1
Axillary nerve palsy	0
Wound infection	2
Non-union/Delayed union	0

Photos

Avascular necrosis of a 3 parts Neer fracture

Failure of fixation of 4 parts Neer fracture.

Screw pullout from humeral head in 4 parts Neer fracture

Wound infections treated with antibiotics,went in for secondary healing.

Screw penetration just beneath the articular surface , patient has a good range of movements after 21 months follow up.

DISCUSSION

The treatment of complex humeral 3- or 4-part fractures represents a challenge. The surgeon must obtain an exact anatomical reduction and stable fixation,and at the same time minimise the iatrogenic risk of avascular head necrosis by maximal protection of the periarticular soft tissues

Poor results in these complex fractures are often attributable to one of two causes or to both :

1) Inadequate fracture reduction especially of the tuberosities

2) Unstable fixation

3) Incorrect positioning of the fixation devices .

There is consensus in the literature that, regardless of the procedure and the implant chosen, a good functional final result depends decisively on anatomical reduction of the fracture combined with a stable fixation, and early initiation of functional rehabilitation of the shoulder

In recent years, rigid internal fixation have been increasingly used in the operative care of proximal humeral fractures. It was hoped that these implants despite an early and secure functional postoperative therapy, would reduce the risk of secondary reduction loss, in particular in elderly patients with osteoporotic bone.

In the elderly population with osteoporosis, outcome after conventional plate osteosynthesis was poor. [48] In order to obtain better and reproducible results, the AO/ASIF has developed a special locking compression plate (Philos) for fractures of the proximal humerus. [49] Patients with good bone quality have previously been treated successfully with the conventional plate osteosynthesis. [50]

In an evaluation of a cloverleaf plate, Esser achieved excellent results and an ASES score of 84.6%. [46] A 2006 prospective study reported an average Constant score of 72.4 points using cloverleaf plates, and 59% of the treated patients achieved good or very good results.[56] Paavolainen et al [47] reported satisfactory results in 74.2% of their 41 patients with severe proximal humerus fractures treated with plate and screw devices Kohler *et al* achieved good results using the Neer score in 95% of the cases with a clink plate .[55] With the exclusive use of Kirschner wires good results have likewise been reported . Zingg *et al* reported a Constant-Murley score of 77.1 points, Jiang *et al* even a mean score of 88.2 points. [57] Wachtl *et al* used Prevot nails and found at follow-up a mean Constant-Murley score of 63 points.[50]

The average clinical result obtained in our study, with a mean Constant-Murley score of 63.44 points is satisfactory.

Comparable studies of internal fixation of Proximal humerus fractures demonstrate similar short term results. Although the follow-up period of our series was short, studies have shown that early function is comparable to final long term outcome. The outcome seems to correlate with fracture severity, anatomic reduction, etiology, bone quality, length of time elapsed from injury to surgery, concomitant injuries and the exact positioning and fixation of the implant.[54]

Functional scores achieved with different treatment options for proximal humeral fractures in the current literature.[59 to 65]

Küchle *et al* (2006)	Cloverleaf plate	Constant 72.4	2 - / 3 - / 4 - parts
Kettler *et al* (2006)	Angle-stable humerus plate	Constant 70.0 pts	2 - / 3 - / 4-- parts
Lill *et al* (2004)	Angle-stable humerus plate	Constant : 77.6 pts 75.1 pts 64.8 pts	 2 – - parts 3 –- parts 4- - parts
Kollig *et al* (2003) AO	T plate, screws o. K wires	Constant : 72.1 pts	3 / 4 – parts
Wijgman *et al* (2002)	Classic T plate cerclage	Constant : 80.0 pts	3/ 4 – parts
Gerber et al	Internal fixation	Constant : 78 pts	2 / 3 / 4 - parts
Hessman et al	T plate	Constant : 69 pts	2 / 3 / 4 – parts
Our study	Locking plate,t	Constant :63.44	2/ 3/ 4 – parts

	plate, srews		

A correct anatomical reduction with proper plate positioning led to a significantly better result. The Constant-Murley score was significantly lower if anatomical reconstruction did not succeed or a nonanatomical reconstruction was accepted intraoperatively, and/or when the plate was not correctly positioned on the shaft at the proper height to avoid subacromial impingement.

Six patients with poor outcome scores include two cases of osteonecrosis of humeral head, one case of post operative persistant dislocation, one case of screw pull out from the humeral head, two cases of persistant stiffness of the shoulder.

The 8 % (2 / 25 patients) infection rate in our series is comparable to the 2.5% (2 / 41 patients) patientsof Paavolainen et al (1983).

The development of aseptic humerus head necrosis (2 patients or 8%) significantly affected the clinical result ; these patients only achieved a mean Constant-Murley score of 25.50. In the literature the rate of necrosis for 3-and 4-part fractures has been between 0% and 50%, depending on the osteosynthesis procedure. The rate of aeptic necrosis (8%) in our study is acceptable and lies in the lower range reported in the literature.

Aseptic necrosis rates in various studies:

Hessmann et al	2 / 3 / 4 parts	T plates	4%
Fankhauser et al	AO – A ,B ,C	LCP	10%
Gerber et al	2 / 3 / 4 parts	Internal fixation	12%
Our study	2 / 3 / 4 parts	Internal fixation	8%

Besides the degree of primary stability, other factors may have contributed to this low rate of AVN.

Exact anatomical repositioning of the tuberosities and rigid internal fixation was associated with a significantly better functional result. The results attained in our patients underscore the importance of the restoration of the correct anatomical relationship between the individual fragments.

The functional results after rigid fixation of three- andfour-part fractures using a plate or screws were shown to be better than conservative treatment or semi-rigid fixationwithout anatomical reduction of the head fragment. Shoulder function continued to improve as the strength and function of the muscles increased.

CONCLUSION

Although the follow-up time in our study was relatively short and it was not a randomized controlled study, the results are comparable with other published studies.

Accurate anatomical reduction appears to be more important than the implant used, to achieve a good final functional result, and this factor is independent from the implant design and procedure selected.

The options as to the surgical approach or the type of implant used depend on the pattern of the fracture, the quality of the bone encountered, the patient's goals and the surgeon's familiarity with the techniques. The learning curve with the implants chosen certainly also plays a role. An adequate surgical technique will minimise complications and an aggressive rehabilitation regime will ensure the best possible result.

In general, 2- and 3-part fractures can be treated with open reduction and internal fixation (a plate with screws is the choice). Four-part fractures in the younger, active patient also can be treated successfully with open reduction and internal fixation.

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Keys to Master Chart

1) M – male
2) F – female
3) RTA – road traffic accident
4) R – right
5) L – left
6) 2 parts G – 2 parts greater tuberosity fracture
7) 2 parts S – 2 parts surgical neck fracture
8) BB leg – both bones leg fracture
9) Flxn – flexion
10) Abdn – abduction
11) ER – external rotation
12) IR – internal rotation

MASTER CHART - OUTCOME ANALYSIS OF INTERNAL FIXATION OF PROXIMAL HUMERUS FRACTUTRES

case no	Age	Sex	Duration	Mode of in	Side	Type of fra	Associated skeletal injury	Approach
case 1	33	M	23 mnths	RTA	R	2 parts G		deltopectoral
case 2	44	M	9 mnths	RTA	R	2 parts G		deltopectoral
case 3	46	M	23 mnths	RTA	R	2 parts G		deltoidsplitting
case 4	16	M		RTA	L	2 parts S		delto pectoral
case 5	21	M	16 mnths	RTA	L	2 parts S	Intertrochanteric fracture- L	deltopectoral
case 6	26	M	21 mnths	RTA	L	2 parts S		delto pectoral
case 7	46	M	12 mnths	RTA	L	2 parts S		delto pectoral
case 8	40	F	7 mnths	RTA	R	2 parts S		delto pectoral
case 9	50	M	21 mnths	RTA	R	2 parts S		delto pectoral
case 10	57	M	13 mnths	RTA	R	2 parts S		delto pectoral
case 11	22	M		RTA	R	2 parts S		deltopectoral
case 12	37	M	16 months	RTA	L	3 parts		delto pectoral
case 13	45	M	21 mnths	RTA	L	3 parts		delto pectoral
case 14	60	M	20 mnths	RTA	L	3 parts	Fracture bothbones forearm-L	delto pectoral
case 15	64	M	28 mnths	RTA	L	3 parts		delto pectoral
case 16	26	F	26 mnths	RTA	R	3 parts		delto pectoral
case 17	27	M	19 mnths	RTA	R	3 parts		delto pectoral
case 18	42	F	16 mnths	RTA	R	3 parts		delto pectoral
case 19	43	M	24 mnths	RTA	R	3 parts	Fracture bothbones forearm-R	delto pectoral
case 20	50	M	7 mnths	RTA	R	3 parts		delto pectoral
case 21	53	M	14 mnths	RTA	R	3 parts	BB leg# - L ,# Distal Radius- R	delto pectoral
case 22	62	M	6 mnths	fall	R	3 parts		deltopectoral
case 23	83	M		RTA	R	3 parts	Subtrochanteric fracture - R	delto pectoral
case 24	62	F	9 mnths	RTA	R	4 parts		delto pectoral
case 25	22	M	5 mnths	RTA	L	4 parts	Axillary Vein injury	deltopectoral
case 26	23	M		RTA	L	4 parts		delto pectoral
case 27	35	M	20 mnths	RTA	L	4 parts		delto pectoral
case 28	27	M	23 mnths	RTA	R	4 parts		delto pectoral
case 29	43	F	12 mnths	RTA	R	4 parts		delto pectoral

MASTER CHART - OUTCOME ANALYSIS OF INTERNAL FIXATION OF PROXIMAL HUMERUS FRACTUTRES

case no	Operating time	Blood loss	Flxn	Abdn	ER-points	IR- points	Constant score	comments	follow up
case 1	2 hrs	200 ml	160	90	6	6	85	E	
case 2	1 hr 30 mins	200 ml	160	100	10	10	86	E	
case 3	1 hr 30 mins	150 ml	110	100	8	8	67	M	
case 4	1hr	100 ml							lost
case 5	1 hr 30 mins	250 ml	110	100	8	8	68	M	
case 6	1 hr 30 mins	150 ml	110	120	8	8	68	M	
case 7	1 hr 30 mins	200 ml	170	170	10	10	85	E	
case 8	1 hr 30 mins	200 ml	130	90	8	8	80	G	
case 9	1hr 30 mins	100 ml	110	110	8	8	69	M	
case 10	1 hr 30 mins	200 ml	130	120	8	8	64	M	
case 11	1 hr 30 mins	200 ml							lost
case 12	2 hrs	150 ml	120	80	8	8	52	P	
case 13	2 hrs	300 ml	100	80	4	6	35	P	
case 14	2 hrs 30 mins	400 ml	80	70	4	4	33	P	
case 15	1 hr 30 mins	150 ml	130	120	8	8	77	G	
case 16	1 hr	200 ml	170	150	10	10	86	E	
case 17	1hr 30 mins	250 ml	130	120	10	10	81	G	
case 18	2 hrs	250 ml	50	40	4	4	18	P	
case 19	2 hrs	350 ml	80	80	6	4	33	P	
case 20	45 mins	100 ml	170	170	10	10	85	E	
case 21	1 hr 30 mins	200 ml	100	90	8	6	61	M	
case 22	1 hr 30 mins	200 ml	90	90	8	6	57	M	
case 23	1 hr	150 ml							death
case 24	2 hrs 30 mins	400 ml	80	70	6	6	41	P	
case 25	2 hrs	250 ml	90	90	10	8	69	M	
case 26	2 hr 30 mins	500 ml							lost
case 27	1 hr 30 mins	200 ml	110	110	10	8	75	G	
case 28	1 hr 45 mins	350 ml	80	80	6	6	59	M	
case 29	1 hr	200 ml	90	90	6	6	61	M	

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case 9	50	M	21 mnths	RTA	R	2 parts S		delto pectoral
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case 8	1 hr 30 mins	200 ml	130	90	8	8	80	G	
case 9	1hr 30 mins	100 ml	110	110	8	8	69	M	
case 10	1 hr 30 mins	200 ml	130	120	8	8	64	M	
case 11	1 hr 30 mins	200 ml							lost
case 12	2 hrs	150 ml	120	80	8	8	52	P	
case 13	2 hrs	300 ml	100	80	4	6	35	P	
case 14	2 hrs 30 mins	400 ml	80	70	4	4	33	P	
case 15	1 hr 30 mins	150 ml	130	120	8	8	77	G	
case 16	1 hr	200 ml	170	150	10	10	86	E	
case 17	1hr 30 mins	250 ml	130	120	10	10	81	G	
case 18	2 hrs	250 ml	50	40	4	4	18	P	
case 19	2 hrs	350 ml	80	80	6	4	33	P	
case 20	45 mins	100 ml	170	170	10	10	85	E	
case 21	1 hr 30 mins	200 ml	100	90	8	6	61	M	
case 22	1 hr 30 mins	200 ml	90	90	8	6	57	M	
case 23	1 hr	150 ml							death
case 24	2 hrs 30 mins	400 ml	80	70	6	6	41	P	
case 25	2 hrs	250 ml	90	90	10	8	69	M	
case 26	2 hr 30 mins	500 ml							lost
case 27	1 hr 30 mins	200 ml	110	110	10	8	75	G	
case 28	1 hr 45 mins	350 ml	80	80	6	6	59	M	
case 29	1 hr	200 ml	90	90	6	6	61	M	