DISSERTATION ON

<u>RETROSPECTIVE STUDY OF FUNCTIONAL AND RADIOLOGICAL OUTCOMES IN LOCKING COMPRESSION PLATE FIXATION OF PROXIMAL HUMERUS FRACTURES</u>

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Dr.A.GURUPRASATH

Boolean Education
(A division of Quexst Solutions Pvt., Ltd.,)
USAIM M.Ch(Orth)

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INTRODUCTION

Fractures of the proximal humerus are challenging to diagnose and treat. They are not uncommon, accounting for 4% to 5% of all Fractures 42, 43.

It is important to recognise these fractures early. If neglected they may result on pain, stiffness, arthritis, loss of muscle strength and function.

Fractures of proximal humerus have gained more attention recently.

Diagnosis has been facilitated with adaptation of three-right angled trauma27, 33, 35, 43 supplemented with CT or MRI. With more standard use of four-segment classification system for fracture and fracture dislocation4, 38, 41, a protocol for management and comparison of long term outcome of similar injuries had been made possible.

Emphasis is placed on complete and accurate diagnosis and formulation of safe and simple techniques for restoration of stability, fracture healing, cuff integrity, motion and function.

There have been improvements in fixation techniques during open reduction and in the understanding of the role of prosthetic replacement time during which stiffness develops.

The elderly no longer need be denied effective surgical treatment, especially at a time in life, when the shoulders are often needed for ambulation with canes and crutches. Maintenance of good shoulder function may make a good difference for their independent life style.

In this study we have treated 20 cases of fractures of proximal humerus surgically and analysed the outcome.

REVIEW OF LITERATURE

HISTORICAL REVIEW

Hippocrates is credited with documenting the first fracture of the proximal humerus in 460 B.C. He also described a method of light traction that aided in bone healing.

However, little was written about this subject until later part of 19^{th} Century.

In 1896, **Kocher** developed an anatomic classification in an attempt to improve diagnosis and treatment but this simplified scheme was not descriptive enough and lacked consistency.

The first prosthetic arthroplasty of the shoulder is credited to **Peam** in 1893. He described replacement of proximal part of the humerus with a plantinum and rubber prosthesis in a young man who had tuberculosis that involved the glenohumeral joint.

In early 20^{th} century, various methods of closed reduction, traction and abduction splints were developed to maintain alignment of these fractures with inconsistent results.

In 1932, Roberts reported that the use of an elaborate apparatus and prolonged immobilisation was less satisfactory than treatment with simpler forms of fixation and early motion. Open reduction of severe displaced fracture dislocation gained popularity during the same period, in an effort to provide better anatomic alignment and function.

In 1934, **Codman** made a significant contribution by dividing proximal humeral fractures into four parts namely head, lesser tuberosity, greater tuberosity and shaft along old epiphyseal lines or scars. This became the basis of Neer's four part classification.

In 1949 Widen first reported on intramedullary nailing of transcervical fractures and credited Palmer with the development of the technique.

The use of humeral head prosthesis for fractures of proximal humerus was first reported in the early 1950s.

In 1950, Rush described his method of intramedullary nailing which later became popular as Rush pins.

The original Neer I prosthesis was designed in 1951.

In 1955, **Neer** reported good results with the use of metal humeral head prosthesis in 26 patients with dislocation.

In 1970, Charles Neer of New York proposed his classic four part classification based on Codman’s four parts.

In early 1970s AOASIF group popularised the use of AO plates and screws for displaced fractures and fracture dislocations.

In 1973, the original Neer I prosthesis was revised by Neer, as Neer II prosthesis, to improve the results.

Percutaneous pinning and minimal fixation have now become the order of the day with the principles of biological fixation.

ANATOMICAL CONSIDERATIONS

DEVELOPMENTAL ANATOMY:

The primary ossification centre for humerus appears as early as sixth week of fetal life. In infants proximal humeral epiphysis is spherical 32, 43. There are three centres of ossification25, 43.The central or major center of ossification appears within 4 to 6 months of birth in humeral head. The center for greater tuberosity appears at three years and that for lesser tuberosity appears by five years. These coalesce between 4 and 6 years and close between 18 and 20 years [25,32,34,43].

RELEVANT ANATOMY:

It is important to understand the complex anatomy of shoulder because; optimum function of humeral joint is dependent on proper alignment and interaction of its anatomic structures.

Humerus is the longest and largest bone in the arm. It has an expanded proximal end called '***proximal humerus'***, a shaft and distal end.

The proximal humerus consists of

- Humeral head
- Greater tuberosity
- Lesser tuberosity
- Bicipital groove and
- Proximal humeral shaft.

HEAD

It is the proximal end and is slightly less than half a spheroid. It has an articular surface covered by hyaline cartilage. It is directed posteromedially and upwards to the glenoid cavity in the pendant arm.

GREATER TUBEROSITY

It is the most lateral part of humeral proximal end and lies posteriorly and superiorly on humeral shaft, providing attachment to infraspinatus, supraspinatus and teres minor.

It is covered by deltoid producing the shoulder’s round contour.

LESSER TUBEROSITY

It lies on the anterior aspect of humerus and is smaller than the greater tuberosity.Subscapularis is attached to it.

INTER TUBERCULAR SULCUS

Also called “bicipal groove”. It lies between greater and lesser tuberosities and is on the anterior aspect of proximal humerus.

The biceps tendon lies in the groove and it is covered by transverse humeral ligament. Floor of groove receives ribbon-like tendon of lattismus dorsi.

ANATOMICAL NECK

It is a slight constriction, adjoining the articular surface, at the junction of head and tuberosities.It indicates the line of capsular attachment of glenohumeral joint.

SURGICAL NECK

The surgical neck is the tapering portion of proximal humerus into the shaft below the greater and lesser tuberosities.The boundaries are variable without a distinct line.

GLENOID

The glenoid is a shallow, convex structure, shaped like an inverted ‘Comma”, approximately one third to one fourth the surface area of the humeral head.

It articulates with the humeral head and provides attachment at its im for the glenoid labrum and capsule.

GLENOHUMERAL JOINT

The shoulder joint is a multi-axial spheroidal joint with the greatest range of motion of any joint in the body. Skeletally the joint is weak and depends for support on surrounding structures which stabilize the joint.

The four muscles act to stabilize the head and provide a fulcrum for abduction, which is controlled mostly by the deltoid.

SURGICAL ANATOMY

Since the rotator cuff muscles are attached to the tuberosities, it is important to understand the direction of pull of their fibers, because, this facilitates an understanding of displacement of tuberosity fragments.

In fractures of greater tuberosity, the fragment will be pulled insertion. Reduction by straight abduction helps reduce the fragment and a tension band fixation neutralises initial displacement forces.

On the other hand in fractures of lesser tuberosity, the fragment will be pulled anteriorly and medially by subscapularis muscle. Horizontal fixation best neutralises these fractures.

The long head of biceps is a significant structure to consider in closed reductions, because it can act as a tether and block reduction. Also during operative procedures, it is a crucial landmark from which rotator interval can be identified, so that bone fragments are properly identified and rotator muscles preserved. Also adequate tension in long head of biceps is used to asses alignment in prosthetic replacement.

The deltoid inserting into the deltoid tuberosity can cause displacement of fracture of proximal humeral shaft at the surgical neck.

The pectoralis major inserting into the lip of bicipital groove can displace proximal shaft fracture medially, as is usually seen in surgical neck fractures.

The brachial plexus and axillary artery are just medical to coracoids process and care should be taken to prevent injury when osteotomising coracoid for better exposure.

Axillary nerve leaves the posterior wall of axilla by penetrating the quadrangular space. Then it winds around humerus and enters deltoid muscle posteriorly, about 7cm from tip of acromion .Because of the nerve’s course, care should be taken during dissection of deltoid.

superiorly and posteriorly because of supraspinatus, infraspinatus and teres minor

BLOOD SUPPLY

The major blood supply to the humeral head is from anterior humeral circumflex artery, a branch of third division of axillary artery.

Laing was the first to describe the arcuate artery which is a continuation of ascending branch of anterior circumflex artery. This tortous artery supplies blood to a large portion of humeral head. It enters the bone in the area of inter tubercular sulcus.

Also a small contribution comes from branches of posterior circumflex humeral artery and from vascular rotator cuff through tendinous osseous anastamoses.

When anterior circumflex artery is injured close to its entrance to humeral head, it is likely that the blood supply to the head will be compromised resulting in avascular necrosis of head will be compromised resulting in avascular necrosis of head of humerus.

NERVE SUPPLY

The shoulder joint is richly supplied by branches from the axillary, musculocutaneous and suprascapular nerves following the Hilton's law[25].

The glenohumeral joint has the greatest range of motion of any joint in the body and also may be the least stable[3].

It is a load bearing joint with significant forces across glenohumeral articulation. When the arm is held in 90^0 of abduction, the joint reaction force equals 90% of the body weight [3,43].

The shoulder joint is not located in the sagittal or coronal plane of the body.Its axis of motion begins on the curved chest wall, 35^0 to 45^0 away from the sagittal plane of the body.

The humeral head is retroverted 30^0 to 40^0 to articulate with the scapula and the average adult humeral head has a radius of curvature of 44mm[43].Only 25% to 30% of humeral head articulates with the glenoid at any one time and the glenoid labrum increases the area of contact.

The intact humeral head is the fulcrum through which the rotator cuff and the long head of biceps act. The resulting force coupled with the action of deltoid provides elevation of the arm while fixing the head within the glenoid cavity. Rotation and elevation are lost if the head fulcrum is destroyed by fracture, dislocation, avascular necrosis or surgical resection.

Avulsion of greater tuberosity is pathognomonic of concomitant rotator cuff tear43.Tearing of the rotator cuff with a displaced greater tuberosity avulsion, destabilises the shoulder and allows superior subluxation to occur with attempted elevation.There is also loss of lever arm and loss of active power.There is also subacromical impingement with loss of normal gliding motion of shoulder[22].

Thus pain, poor motion, loss of strength and endurance can result after proximal humeral fractures, if near normal anatomy is not restored.

CLASSIFICATION

A classification system must be comprehensive enough to encompass all factors, yet specific enough to allow accurate diagnosis and proper management. Also it must be flexible enough to accommodate variation and allow logical deductions for treatment.

KOCHER'S CLASSIFICATION

Devised in 1846 based on different anatomic levels for fracture namely,

a. Anatomic neck
b. Epiphyseal region
c. Surgical neck

Limitations:

a. Does not allow for multiple fractures at different sites.
b. Does not differentiate between displaced and undisplaced fractures

WATSON-JONES CLASSIFICATION

Watson-Jones based his classification on mechanism of injury. Its divided into two types namely,

a. Abduction type
b. Adduction type

Limitations

Depending on whether x-rays are taken in internal rotation or external rotation fracture can become either an abduction or adduction fracture and hence not very reliable.

CODMAN CLASSIFICATION

In 1934 Codman made a significant contribution to the understanding of proximal humeral fractures by proposing,that fracture can be separated into four distinct fragments,occurring roughly along the anatomic lines of epiphyseal union into,

a. Anatomical head
b. Greater tuberosity
c. Lesser tuberosity and
d. Shaft

This formed the basis for future Neer's classification.

Limitations:

It does not describe about biomechanical forces causing displacement or plan for treatment.

NEER'S FOUR PART CLASSIFICATION

In 1970 Neer Charles of New York proposed the first truly comprehensive system that considered the anatomy and biomechanical forces and related it to diagnosis and treatment. It is based on Codman's four parts.

When any of the four major fragments is displaced >1 cm or angulated more than 45 then the fracture is considered displaced.

It is classified as

a. Undisplaced fracture
b. 2 part fracture
c. 3 part fracture
d. 4 part fracture

NEER'S FRACTURE DISLOCATION

A fracture dislocation exists, when the head is displaced outside the joint space, not merely rotated and there is in addition a fracture.

It is classified according to direction of dislocation as

a. Anterior dislocation

b. Posterior dislocation

Or based on number of fracture fragments as

a. 2 part fracture dislocation

b. 3 part fracture dislocation

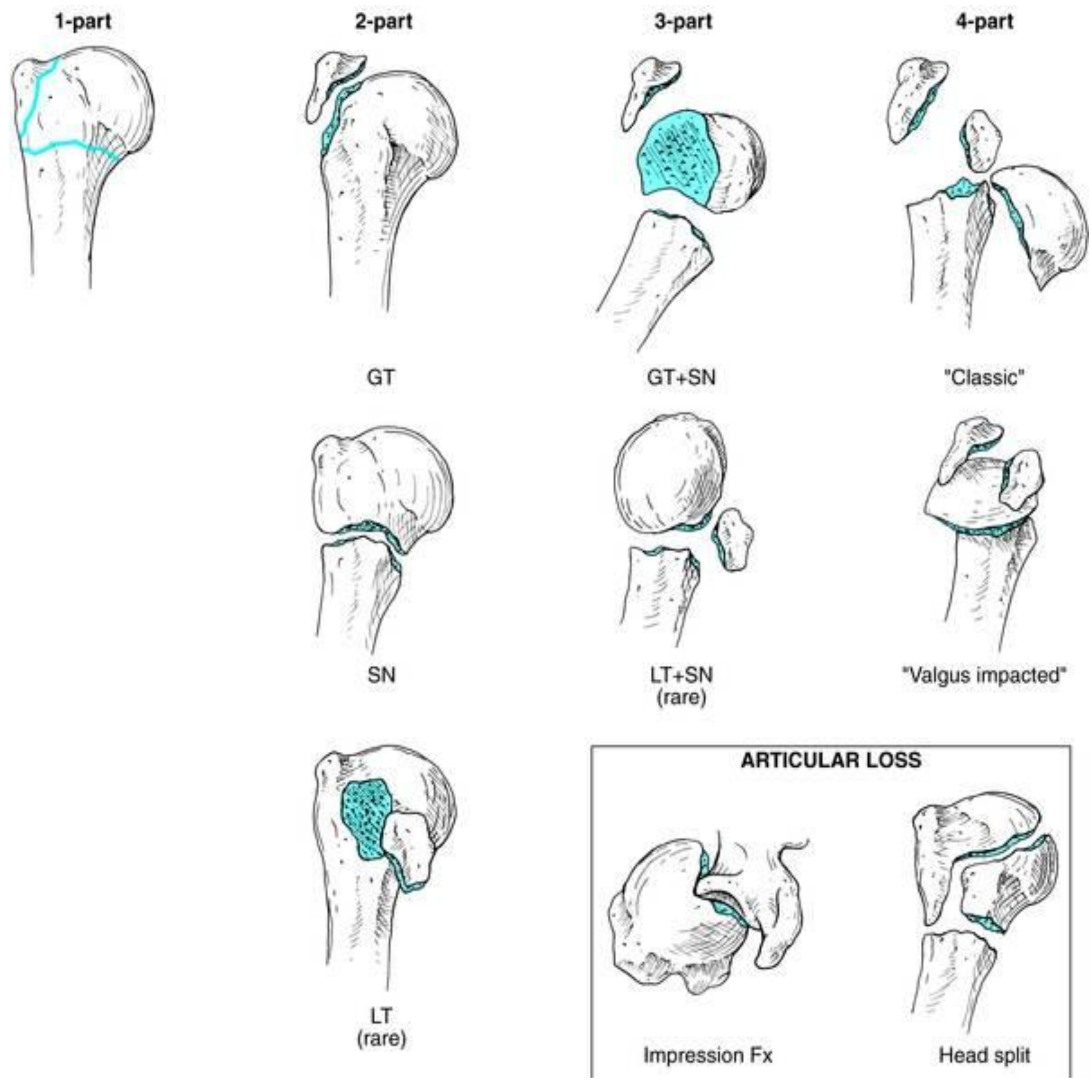
c. 4 part fracture dislocation

Or as special fractures as

a. Head splitting fractures

b. Impression fractures

NEER'S CLASSIFICATION



CONCLUSION

AO CLASSIFICATION

Jacob & Colleagues and AO-ASIF group have applied AO system to proximal humeral fractures.The system is divided into 3 types according to increasing severity of injury.

Type A

- Extracapsular
- Involves two of the four fragments
- No vascular isolation of articular segment
- No avascular necrosis.

Type B

- Partial intra capsular
- Involves three of four fragments
- Low risk of avascular necrosis
- Partial vascular isolation of head
- More severe

Type C

- Intracapsular
- Involves all four fragments
- Total vascular isolation of articular segment
- High risk of avascular necrosis
- Most severe

In addition each alphabetical type is subgrouped numerically with higher numbers reflecting greater severity.

Of all,the Neer's classification has stood the test of time and still the most commonly followed the world over.

We also have followed the Neer's classification in our study.

MECHANISM OF INJURY

The most common mechanism of injury is fall on a outstretched hand from a standing height or less[27,29]. In elderly, trauma is only trivial because bones are osteoporotic. These patients may have associated distal radial fractures.

In younger patients, high energy trauma like RTA is frequently involved resulting in serious injuries with significant soft tissue disruption and multiple trauma.

Another mechanism of injury described by Codman, is excessive rotation of the arm, especially in the abducted position when a fracture occur. Moreover the humerus locks against the acromion producting a pivotal position,facilitating a fracture.

Proximal humeral fractures may also result from a direct blow to the side of the shoulder.

An often ignored aetiology for fracture dislocation of proximal humerus is electric shock or convulsion episode. They may have bilateral fracture dislocations.

CLINICO RADIOLOGICAL EVALUATION

HISTORY

A detailed history should include patient's health, handedness, occupation and details of injury. A good understanding of patient's general health (i.e. whether he or she has osteoporosis or metabolic disorder or seizures)is of critical importance as it will predict the outcome of surgical fixation. Patients with seizures and on phenytoin may have osteomalacia with brittle bones, leading to poor fixation. Some patients may have recurrent dislocations or chronic cuff tear complicating an acute fracture.

CLINICAL PRESENTATION

Most fractures of the proximal humerus present acutely and therefore the most common clinic features are pain, swelling and tenderness about the shoulder, especially in the area of greater tuberosity.

Ecchymosis generally becomes visible within 24 to 48 hours and may spread to chest wall, flank and distally down the extremity.

Crepitus may be present with motion of the fracture fragments,if they are in contact.

A detailed neurovascular evaluation is essential in all fractures of proximal humerus.The brachial plexus and axillary artery are especially at risk,as they lie medical to coracoids.

The easiest way to diagnose a neurovascular complication is to suspect the injury and test for it at the time of initial examination.The most common nerve that is injured with fractures about the shoulder is axillary nerve and hence sensation over deltoid insertion must be checked for.

Dermatomal sensory patterns are recorded,but unfortunately,presence of normal sensation in the axillary distribution in the lateral arm is not a reliable test for concomitant axillary motor function.

IMAGING

Precise radiographs are critical in establishing an accurate diagnosis in shoulder trauma. All too often injuries are missed with radiographs obtained in the plane of body rather than in the plane of scapula.To overcome this limitation, three right angled trauma series was introduced. In addition CT scan,3D CT reconstruction,arthrography,ultrasonography and MRI all allow the shoulder injuries to be more clearly defined.

TRAUMA SERIES

The three view right angled trauma series was popularised by Neer.Trauma series remains the best initial method of diagnosing fracture of proximal humerus.It allows evaluation of fracture in three separate perpendicular planes,so that accurate assessment of fracture displacement can be achieved.It consists of

a. AP view in the plane of scapula

b. Lateral view in the plane of scapula,also called tangential or ‘Y’ view of scapula.
c. Axillary lateral view.

These views can be taken without removing the sling from patient’s arm.They can be done in either sitting,standing or prone position with minimal discomfort to the patient.

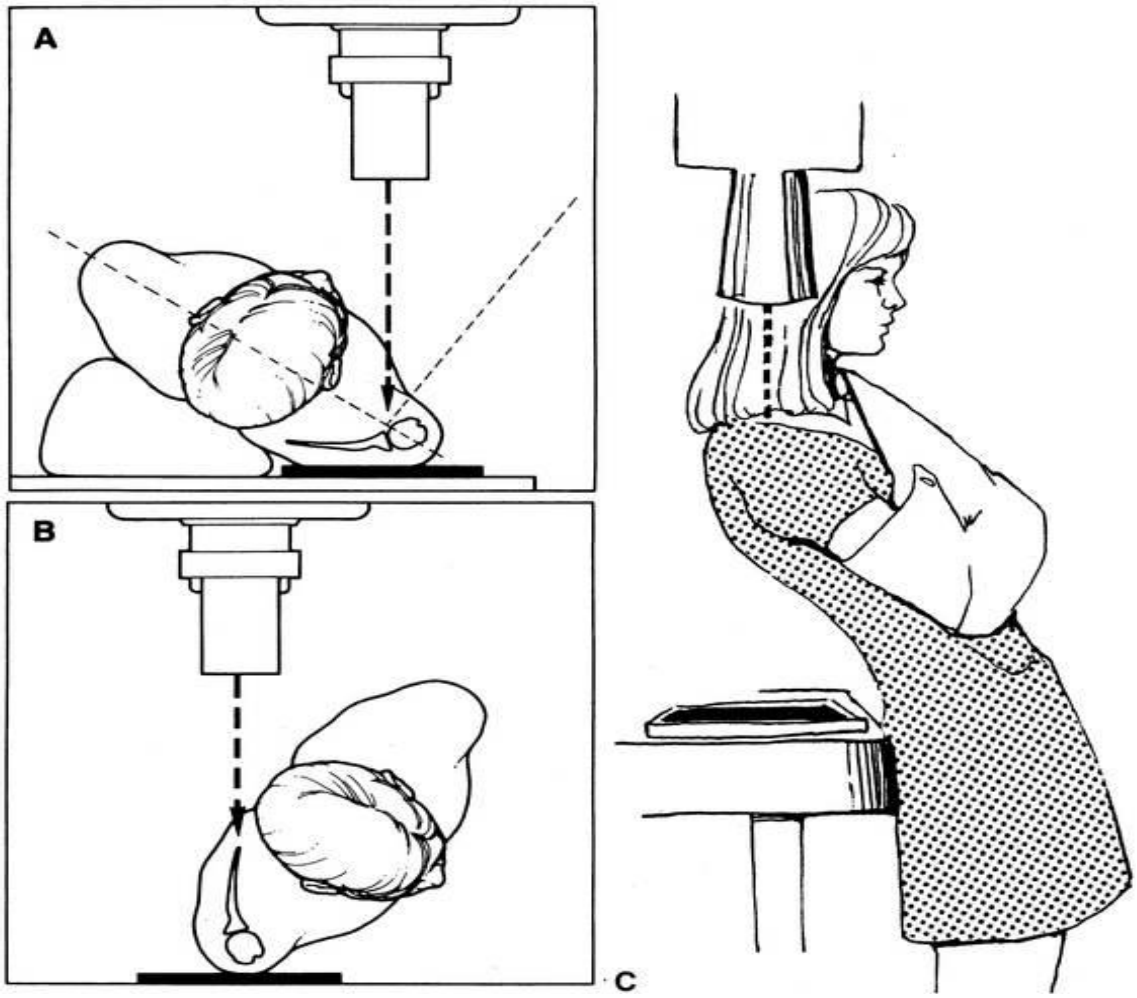
AP View in the plane of scapula:

For AP view in scapular plane,the posterior aspect of the affected shoulder is placed against x-ray plate and the opposite shoulder is rotated out approximately 40^{o}.This allows visualisation of glenohumeral joint space without any bony super imposition.

Lateral View in the plane of scapula:
shoulder out approximately 40^{0}.The x-ray tube is then placed posteriorly along the scapular spine. Here scapula appears ‘Y’ formed by acromion and coracoids with vertical limb formed by scapular body. This provides a true lateral view of the shoulder.

Tuberosity displacements and direction of dislocation can be appreciated with the view clearly.

Radiographic evaluation of proximal humerus fractures



The lateral view in scapular plane is accomplished by placing the anterior aspect of the affected shoulder against x-ray plate and rotating the other

Axillary View:

This allows for evaluation of the shoulder in the axial plane and is essential for evaluating the degree of tuberosity displacement, the glenoid articular surface and relationship of humeral head to the glenoid.

Here the arm is held in mild abduction of 30^0 and the x-ray plate is placed above the patient’s shoulder.The x-ray beam goes inferior to superior.

Another method is ***Velpeau axillary*** view where the arm is not removed from sling.The patient is seated and tilted obliquely backward 45^0.The plate is placed on table and x-ray beam is shot from above.

Special Views:

Anterior rim fractures or ectopic calcification in many anteroinferior glenoid labral detachments with instability can be delineated with ***West Point*** axillary view or alternatively,the ***Cuello supine axillary*** view with arm in external rotation.

The ***Bloom obata*** apical oblique view is specially for defining whether there is a posterior dislocation or fracture dislocation.

TOMOGRAMS

Tomograms can be useful in evaluating proximal humeral fractures for non union or articular surface incongruity but is largely replaced by CT scan.

CT SCAN

CT scan is now the investigation of choice for evaluating proximal humeral fractures.It helps to find

a. Displacement of tuberosity fragments
b. Amount of articular involvement with head splitting fractures
c. Impression fracture
d. Chronic fracture dislocation
e. Associated glenoid rim fracture

RECONSTRUCTION CT

Though not available in all centers, it is extremely valuable to get a three dimensional reconstruction model of the fracture, which helps in planning treatment, especially in complex fracture patterns.

MRI

MRI is useful in showing relation of tuberosity fragments to rotator cuff tendons.It also helps in assessing coexistent rotator cuff injuries.

METHODS OF TREATMENT

The ultimate goal in the treatment of all fractures is return to usual activities as soon as and to as nearly normal an extent as possible. Many methods of treatment of proximal humeral fractures have been proposed through the years, creating a great deal of controversy and at times confusion. Sound judgement is required to determine the appropriate treatment for each fracture.

The various methods that are available are

a. Closed reduction
b. Initial immobilisation and early motion
c. Percutaneous pinning & External fixation
d. Plaster splint and cast
e. Skeletal traction
f. Open reduction and Internal fixation
g. Prosthetic replacement

a. Closed Reduction:

For years closed reduction has been a popular method of treatment for many types of proximal humeral fracture. However, it is important to differentiate between those fractures, which are suitable for closed reduction and those which or not.

Repeated and forcible attempts at closed reduction may complicate a fracture by causing further displacement, fragmentation or neurovascular injury. Various types of reduction maneuvers have been used with mixed results.

Watson-Jones described a classic technique of hyper-abduction and traction to achieve a closed reduction.

Displaced anatomic neck fractures are difficult to treat by closed reduction because head is small and rotated or angulated in the capsule.

Displaced surgical neck fractures can be reduced with gentle traction with flexion and some adduction but many a time there is soft tissues interposition requiring surgery.

Greater tubersity fractures are retracted posteriorly and superiorly and hence closed reduction is difficult or even if achieved,is unstable resulting in malunion and loss of movements.

Displaced lesser tuberosity fractures can be treated by closed reduction if it does not block internal rotation.

Three and four part fractures are unstable and difficult to treat by closed reduction.Recent literature has reported poor results with closed reduction, with high incidence of pain, malunion and avascular necrosis.

b. Initial immobilisation and early motion:

Initial immobilisation and early motion has been described with varying degree of success for minimally displaced fractures.The shoulder has a large capsule,allowing a wide range of motion that can compensate for even moderate amounts of displacement.The arm is supported by a sling at the side or in the velpeau position.Gentle range of motion exercise are started by 7 to 10 days,when pain has reduced and patient is less apprehensive.

c. Plaster Splints & Casts:

Older literature suggested that reduction in an abducted and flexed position was essential for proper alignment and advocated shoulder spica casts and braces to maintain reduction,which were extremely cumbersome and uncomfortable for the patient.

The use of hanging arm casts for fracture of proximal humerus should be avoided,because of the tendency of distraction at the fracture site leading to non –union or malunion.

d. Percutaneous Pins & External Fixation:

Percutaneous pinning may be used after closed reduction if reduction is unstable.Jacob & co-workers have outlined the technique and reported satisfactory results in 35 of 40 cases.

This method of treatment is technically demanding but it offers advantage of less disruption of soft tissues and minimal fixation thus reducing the prevalence of avascular necrosis.

e. Skeletal Traction:

The use of traction is not commonly indicated but may be helpful in the management of comminuted fracture

The shoulder is flexed to 90^0 and elbow is also flexed to 90^0.A threaded 'K' wire or Steinmann pin is placed in the ulna,and the forearm and wrist suspended in a sling.The goal is to try to hold the shaft fragments in a neutral position.When there is sufficient callus formation,the traction can be discontinued and the patient's arm placed in a sling or spica cast.

f. **Open reduction and Internal fixation**

Closed reduction and external fixation has been unable to correct deformity and maintain reduction sufficiently and hence open reduction and internal fixation has gained popularity.The goal of internal fixation should be stable reduction,allowing for early motion of the shoulder.The current trend is towards limited dissection of the soft tissue about the fracture fragments and the use of minimal amount of hardware required for stable fixation.

Indications for ORIF:

a. Displaced two part anatomic neck fractures in children and young adults
b. Displaced two part surgical neck fractures with soft tissue interposition preventing closed reduction or if reduction is not stable.
c. Greater tuberosity fractures displaced more than 5mm.
d. Displaced isolated lesser tuberosity fracture especially if fragment is large and blocks medial rotation.
e. All displaced three part fractures of proximal humerus
f. Displaced four part fractures of proximal humerus
g. In 20-40% of head impression fractures.

IMPLANTS

a. Two –Part anatomic neck fracture:

Fortunately anatomic neck fractures are rare.The prognosis for survival of head is poor,because it has been completely,deprived of its blood supply.

However ,several authors recommend an attempt at open reduction and internal fixation with screws or pins if the patient is young,and prosthetic replacement in older individuals.

b. Two-part surgical neck fracture:

For two part surgical neck fracture,various devices have been proposed for fixation namely,intramedullary nails,like Rush pins and Enders nails,plates and *screws,staples,wires,non-absorbable suture material,tension band wiring,multiple pins or a combination of these implants.*

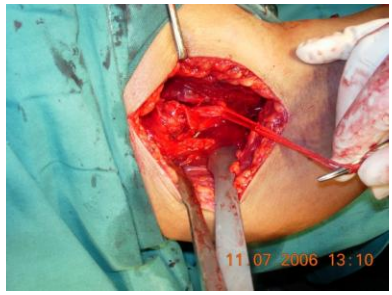
Locking compression plate (cloverleaf)

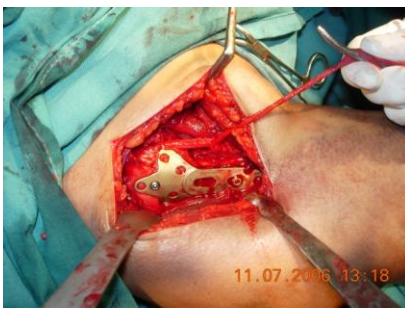
c. Two-part greater tuberosity fracture:

Greater tuberosity fractures displaced more than 5mm require open reduction and internal fixation,because the posterior and superior displacement of the fragment will cause impingement beneath the acromion.

Screws,tension-band-wiring, suture materials,plates and screws,percutaneous pinning have all been proposed.The rent in the rotator cuff that occurs with displaced greater tuberosity fractures must be repaired.

PER-OPERATIVE TECHNIQUE





d. Two-part lesser tuberosity fracture:

Displaced isolated lesser tuberosity fracture requires internal fixation with non absorbable sutures or wires or screws if the fragment is large and blocks medical rotation.

Some authors have described a method of removal of bone fragment and suturing of subscapularis tendon to the cortical edge of fracture site.

e.Three-part fracture:

Open reduction and internal fixation is the treatment of choice for displaced three part fractures of proximal humerus.It is important to avoid extensive exposure and soft tissue dissection of fragment which may compromise blood supply.Intramedullary nails is usually not adequate to neutralise deforming forces.The AO buttress plate gives good results but may require extensive soft tissue stripping.

Hawkins & co-workers reported good results in 14 of 15 patients treated with 'figure of 8' wire for three part fractures.In osteoporotic bones,wire or heavy non absorbable suture can be passed through rotator cuff as well as bone of tuberosity and then attached to shaft.This gives sufficient stability to begin early motion.

f.Four-part fracture:

Open reduction and internal fixation of four part fractures with pins,rods,plates and screws can be done but the results are usually not promising.These fractures usually occur in elderly people in whom osteoporosis and poor bone quality preclude any stable internal fixation.Prosthetic replacement offers a distinct advantage in these fractures,permitting early motion and return to work.

Prosthetic Replacement:

The use of humeral head prosthesis for fracture of proximal humerus was first reported in the early 1950s.The original Neer I prosthesis was designedin 1951.In 1953,Neer reported the first use of this prosthesis for complex fracture dislocation of proximal humerus.The original prosthesis was revised by Neer in 1973(Neer II) to a more anatomic surface design.

The prosthesis has two head sizes-15 to 22 mm in thickness.The larger size gives better leverage and mechanical advantage for forward elevation,but the smaller size may be required for coverage by the rotator cuff.

There are three stem sizes-7,9.5 and 12mm and two stem lengths 125 and 150mm.Longer stem lengths are available if needed to bridge a shaft fracture[40].

Recently modular hemiarthroplasty has been used in treatment of complex fractures of proximal humerus.The modular humeral design offers greater flexibility in head sizes,perhaps allowing more precise tensioning of soft tissues.Moreover,the ability to disassemble the component allows easier access to the glenoid,if revision to a total shoulder replacement is contemplated later[6,7,11,14].

Indications for prosthetic replacement:

a. Displaced anatomic neck fracture in adults
b. Extensive head impression,splitting or crushing fractures
c. Three part fractures that are tenous and unstable after attempted open reduction.
d. Unstable four part fracture dislocations.
e. In chronic cases for avascular necrosis,malunion or non union with joint incongruity.
f. Surgical neck non-union.
g. Greater then 40% head impression fratures and chronic dislocations.

SURGICAL APPROACH

There are many approaches used for treatment of fracture of proximal humerus.An approach which allows greatest visualization for performing a repair or fixation with the least disruption of soft tissues should be chosen for better functional recovery1[6].

The various approaches are

A. Anterior delto-pectoral approach
B. Superior approach without anterior acromioplasty
C. Deltoid splitting approach
D. Posterior approach

POSITION OF PATIENT

Place the patient supine on the operating table. Wedge a sand bag between the spine and medical border of scapula to push the affected side forward while allowing the arm to fall backward thus opening up the front of the joint. Elevate the head of the table 30 to 45 to reduce bleeding and to allow blood to drain away from the operative field. This can be achieved with the Mcconnel gel-padded head rest.

A.Anterior deltopectoral approach:

A 15cm long incision is made from above the coracoid and carried distally in the line of deltopectoral groove to the deltoid insertion.The internervous plane lies between deltoid,which is supplied by axillary nerve and pectoralis major which is supplied by pectoral nerves.The cephalic vein is preserved with either the deltoid or pectoralis major.Rarely it may be ligated.The clavipectoral fascia is incised.The muscles attached to the coracoids are retracted medially.With the arm abducted,anterior 1cm of deltoid is released and retracted laterally and retained with Richardson retractor.The long head of biceps-the key to the anatomy of upper humerus is found under the insertion of pectoralis major.Palpate it as it proceeds upward,but do not dissect it free,for fear of avascular necrosis.If lesser tuberosity is not fractured access is gained to the front of joint by means of a directed subscapularis and capsular longitudinal arthrotomy.Rarely coracoid osteotomy may be required for better exposure.

B. Superior approach without anterior acromioplasty:

This operative approach is used for greater tuberosity avulsions.

An incision is made over the lateral border of acromion along Langer’s skin lines.skin is undermined and a point selected just posterior to anterolateral corner of acromion to split deltoid.Acromial branch of the thyrocervical artery is coagulated.Small Richardson retractors are placed to retract the deltoid.Greater tuberosity is visible and fixation can be easily done.

C.Deltoid spkitting approach

Begin the incision at the anterolateral tip of acromion and carry it distally over the deltoid muscle about 5cms.Define the tendinous interval 4 to 5cm long between the anterior and middle thirds of the deltoid;splitting the muscles here provides a fairly avascular approach to the underlying structures.Next,incise the thin wall of the subdeltoid burse and explose the rotator cuff and tuberosities.

D.Posterior Approach:

Here the patient is placed in the lateral decubitus position on the gelfoam mattress and all pressure points padded.An incision is made parallel to scapular spine or perpendicular to this,over the glenohumeral joint level.After undermining,the deltoid is split between 6 and 8cm from posterior spine of scapula without injuring axillary nerve.

Now in the safe interval between infraspinatus and teres minor,make a transverse split.Elevate the corners of these tendons from posterior capsule 1cm medial to their attachment on greater tuberosity.Make a ‘T’ shaped incision in the underlying capsule.This exposure provides access to the posterior and superior portions of the glenoid.

Intra-operative complications:

Intra-operative complications include

a. Fracture of humeral shaft from forceful manipulation.
b. Displacement of previously undisplaced fracture.
c. Poor holding of sutures,’K’ wires,in tuberosities in osteoporptic bones.
d. Damage to deltoid with retraction.
e. Damage to axillary artery.
f. Damage to branchal plexus.
g. Damage to axillary nerve
h. Torrential bleeding.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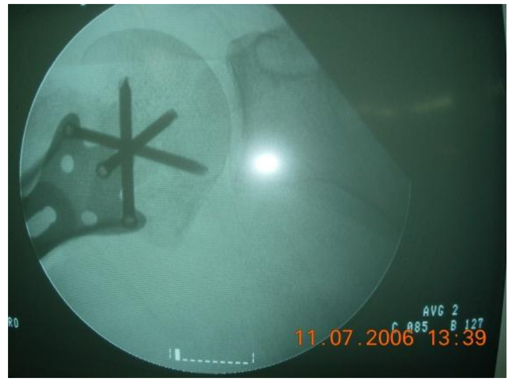
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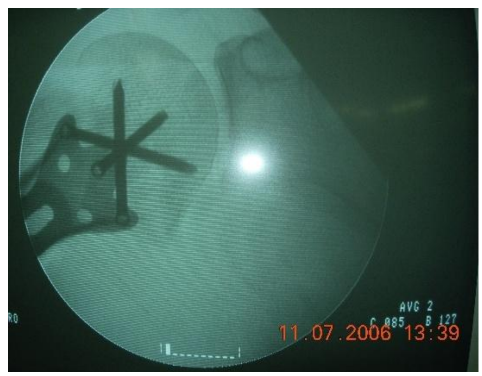
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POST OPERATIVE CARE & REHABILATION

Rehabilitation should be custom tailored to the patient and the fracture type and is easier,more comfortable and more assured with firm internal fixation.If fracture repair is stable then therapy can be started early.The most useful rehabilitation protocol is the three-phase system devised by Hughes and Neer.

Application of this system is variable and depends on the type of fracture,stability of fracture fixation and ability of patient to comprehend the exercise program.

Phase I

Phase I exercise are started early in the post-operative period,if the fracture is treated by closed reduction then exercise are started between 7^{th} and 10^{th} post operative day.First exercise is supine external rotation with a stick.Three weeks after fracture,assisted forward elevation as well as pulley exercise are added.Isometric exercises are started at four weeks.

After stable surgical repair,passive exercise can be started by physician within 24 to 48 hours.The physician should start elbow flexion and extension.Then gently assist the patient with pendulum exercises.Supine external rotation and assited forward elevation are also performed.Assisted pulley exercises can be started after 6 weeks.

PhaseII

This involved early acive,resistive and stretching exercises.The first exercise is supine active forward elevation.3 sets of 10 to 15 repetitions are done at each sessions.Streching for forward elevation on top of door is then done.The extremely important exercise to achieve abduction and external rotation is to place the hands behind the head with arm abducted and externally rotated.

Phase III

Phase III exercises are started at three months.Arm is stretched higher on top of wall by leaning the torso onto the wall.Prone stretching for forward elevation is also useful.Light weight can be used after three months.Weights are started at one pound and increased at one pound increments with the limit being five pounds.Strength can be achieved with functional activity.

A well supervised rehabilitation regimen is essential for successful fracture treatment.Even a perfect surgical repair will not achieve good result without proper rehabilitation efforts.

COMPLICATIONS

Potential complications may occur with any mode of treatment.An awareness of these complications is the first step in protecting them.

It can be divided into

a. Bony Complications
b. Muscle Complications
c. Soft tissue complications and
d. Hardware complications.

A.BONY COMPLICATIONS

MALUNION

Malunion occurs after inadequate closed reduction or failed **ORIF**.Malunion of greater tuberosity leads to impingement syndrome.Malunion of surgical neck fracture with increased anterior angulation can limit forward elevation.Malunion and avascular necrosis of three & four part fracture are more complex and usually require a prosthesis.

NON UNION

Non union can occur due to many reasons namely,

a. Loss of blood supply due to excessive surgical stripping
b. Distraction caused by pin traction or hanging arm cast.
c. Interposition of long head of biceps
d. Inadequate holding power of screws in elderly osteoporotic bones
e. Early mobilisation in the absence of adequate fixation.

AVASCULAR NECROSIS

Avascular necrosis is not uncommon after three and four part fractures and joint.Apart form nature of injury,excessive dissection of soft tissue is also a major contributing factor.

GLENOHUMERAL ARTHRITIS

This can follow malunion or avascular necrosis,non-union,recurrent shoulder instability or significant shoulder stiffness.This results in painful loss of glenohumeral movements.

RECURRENT INSTABILITY

Recurrent instability occurs as a result of overlooked glenoid acture or rotator cuff injuries.

B.MUSCLE COMPLICATIONS

MUSCLE CONTRACTURE & JOINT STIFFNESS

This usually results if post operative motion is not started early.The patient has a stiff,painful,dysfunctional shoulder from prolonged immobilisation which is required for healing.

MUSCLE ATONY

Muscle atony with inferior subluxation of humerus occurs frequently after a fracture or almost universally immediately after ORIF.Support with sling and isometric exercises for deltoid and affected muscles are required.

MYOSITIS OSSIFICANS

Repeated closed reductions or delay in treatment for more than two weeks are associated with increased of this dreaded complication.

ROTATOR CUFF OR DELTOID DEHISCENCE

Rotator cuff dehiscence may occur with disruption of tuberosity repair or as a result of aggressive early rotation.It can also occur with prominent and malunited greater tuberosity.

Deltoid dehiscence is seen after anterior acromioplasty and more so with lateral acromionectomy and is very much disabling.

C.SOFT TISSUE COMPLICATIONS

INFECTION

Infection is a given risk with any open injury .It is seldom a problem with elective surgery provided prophylactic antibiotics are added before skin incision and continued for 24 to 48 hours post-operatively.

VASCULAR INJURY

Injury to the axillary artery accounts for 6% of all arterial trauma.It occurs secondary to fracture of proximal humerus and is the most common vascular injury seen in this fracture.The most common site of injury to axillary artery is proximal to take-off of anterior circumflex artery.

BRACHIAL PLEXUS INJURY

This can occur after fracture of proximal humerus.Stableforth reported an incidence of 6% after fractures of proximal humerus.Any or all components of the plexus may be involved.

AXILLARY NERVE INJURY

Isolated injury to axillary nerve is not uncommon and usually occurs after surgical repair.

D.HARDWARE COMPLICATIONS

Wires,screws,staples and plates may loosen,break,migrate to nearby neurovascular structures or impinge upon glenoid,humeral head or acromion.Similarly prosthesis may get loosened requiring revision surgery.

RESULTS

The patients were followed up at regular intervals (i.e) every first month and 3 months there after. The minimum follow – up period was 32 months. The mean follow-up period in this study was 14.8 months

The Results were evaluated during follow-up by taking into consideration the following factors.

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

American shoulder and elbow surgeon's basic data evaluation form was used to assess the functional outcome of these patients.

The results were graded by using Neer 100 points rating system.This grading system consists

35 points for pain
30 points for function
25 points for motion
10 points for anatomy

Post operative pain was recorded on a scale of 0 to 5 points, where points were given according to the following criteria.

No pain	5
Mild pain	4
Pain after unusal activity	3
Pain at rest	2
Marked Pain	1
Complete disability	0

9(45%) patients said that they had no pain and 7(35%) patients had only mild pain.Pain after unusal activity was present in 3 patients and pain at rest in 1 patient.No patient had disabling pain (Table-XIX)

SL.NO	PAIN	NO. OF PATIENTS
1	No Pain	9
2	Mild Pain	7
3	Pain with unusal activity	3
4	Pain at rest	1
5	Marked Pain	0
6	Complete disability	0

FUNCTION

Function was evaluated with the disability to perform day to day activities like

- Use of back pocket
- Rectal hygiene
- Wash opposite underarm
- Eat with utensil
- Comb hair
- Use hand with arm at shoulder
- Carry 10-15 lbs with arm at side
- Dress
- Sleep on shoulder
- Pulling
- Use hand over head
- Throwing
- Lifting
- Do usual work
- Do usual sport

Points were given according to the following scale.

4 – Normal
3 – mild compromise
2 – with difficulty
1 – with aid
0 – unable
NA-not available

Functioal results were graded by the following criteria.

Good Functional results - 3.5 to 4 points
Fair - 2.5 to 3.4 points
Poor - <2.5 points

9(45%) of the 20 patients had good functional result, 8(40%) had fair functional result and 3 (15%) had poor functional result (Table-XX)

TABLE – XX
FUNCTIONAL OUTCOME

SL.NO	FUNCTIONAL OUTCOME	NO. OF PATIENTS
1.	Good	9
2.	Fair	8
3.	Poor	3

MUSCLE STRENGTH

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

Normal - 5
Good - 4
Fair - 3
Poor - 2
Trace - 1
Paralysis - 0

18(90%) of the patients had normal muscle strength in all the muscle groups evaluated and 1 patient each had good muscle strength and fair muscle strength(Table-XXI).

TABLE – XXI
MUSCLE STRENGTH

SL.NO	MUSCLE STRENGTH	NO.OF PATIENTS
1	Normal	18
2	Good	1
3	Fair	1
4	Poor	0
5	Trace	0
6	Paralysis	0

RANGE OF MOTION

Range of motion evaluated during every follow-up and the improvement and progress recorded. The following table shows the average range of motion observed (Table-XXII)

TABLE – XXII
RANGE OF MOTION

SL.NO	MOTION	RANGE	AVERAGE
1.	Elevation	70° – 170°	128.5
2.	Abduction	60° – 170°	121.25
3.	External rotation	10° – 80°	51.25
4.	Internal rotation	T_2 - L_4	T_{12}
5.	Extension	15° - 45°	27.25

OVER ALL RESULTS

The results at follow-up were rated according to the following criteria.

Maximum number of points 100
Excellent 90 – 100
Satisfactory 80 – 9020
Unsatisfactory 70 – 79
Failure <70

Out of the 20 cases 9(45%) patients had excellent results, 6 (30%) had satisfactory result, 3 (15%) had unsatisfactory result, 2 (10%) failure

(TABLE – XXII).

TABLE – XXII
OVERALL RESULTS

SL.NO	RATING	NO. OF PATIENTS	PERCENTAGE
1.	Excellent 90 – 100	9	45
2.	Satisfactory 80 -89	6	30
3.	Unsatisfactory 70 -7 9	3	15
4.	Failure < 70	2	10