STUDY OF SURGICAL MANAGEMENT OF DIAPHYSEAL FRACTURES OF HUMERUS BY OPEN REDUCTION AND INTERNAL FIXATION WITH DYNAMIC COMPRESSION PLATE AND SCREWS

By

DR. SHARAD SHIROL

DISSERTATION SUBMITTED TO

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UNDER THE GUIDANCE OF

DR. ASHOK R. NAYAK M.S. Ortho

PROFESSOR

DEPARTMENT OF ORTHOPAEDICS

B. L. D. E. UNIVERSITY'S SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE

VIJAYAPUR 586103

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Date:

Place: Vijayapur **Dr. SHARAD SHIROL**

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Date:

Place: Vijayapur

Dr. ASHOK.R.NAYAK$_{M.S}$

Professor,

Department of Orthopaedics

BLDEU'S Shri B.M Patil

Medical College Hospital and

Research Centre, Vijayapur.

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Date:

Place: Vijayapur

Dr. O B PATTENSHETTY

Professor and HOD,

Department of Orthopaedics,

B.L.D.E.U's Shri. B. M. Patil

Medical College Hospital &

Research Centre, Vijayapur.

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Date:

Place: Vijayapur

DR. S. P. GUGGARIGOUDAR $_{\text{MS}}$

Principal,
B.L.D.E.U.'S Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapur.

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DR. SHARAD SHIROL

LIST OF ABBREVATIONS

AG	Arbeitsgemeinschaft Fur Osteosynthesefragen
ASIF	Association for the Study of Internal Fixation
cm	Centimeter
ASES	American Shoulder and Elbow Surgeon Score
DCP	Dynamic Compression Plate
LCDCP	Limited Contact Dynamic Compression Plate
OTA	Orthopaedic Trauma Association
POP	Plaster of Paris
RTA	Road Traffic Accident

ABSTRACT

INTRODUCTION: Fractures of the humeral diaphysis has been estimated previously as representing between 3% and 5%. Operative treatment for humerus fractures has usually been reserved for the treatment of nonunion, associated with fractures of forearm, for polytrauma patients, and for those with neuro-vascular complications. Surgical fixation when indicated has the options of plating and intramedullary fixation. Dynamic compression plate is gold standard for surgical treatment of humeral diaphysis fracture.

OBJECTIVES: To study the effectiveness of dynamic compression plate in achieving anatomical reduction and stability of fixation .To study the functional outcome of surgical management of diaphyseal fracture humerus with dynamic compression plating.

MATERIALS AND METHODS : We used dynamic compression plate for 26 patients who were admitted between November 2015 to March 2017 in BLDEU'S ShriB.M.Patil's Medical College, Hospital and Research Centre, Vijayapur for stabilization of fracture of the humeral diaphysis. Both anterolateral approach and posterior approach were used. A 4.5 mm narrow DCP was used.

RESULTS: A male preponderance of 73% was seen, The mean age of patients presenting with humerus fractures in SBMPH was 39.2 years. Majority (77%) of fractures united within 13 weeks. 42.3% of for fractures united within 10 to 11 weeks. Mean duration of union was 12.1 weeks. Among 26 patients, 23.1% had excellent outcome, 61.5% had a good outcome and 11.5% had fair outcome

CONCLUSION: For patients with indications for operative management of humeral shaft fractures, plating can be done because of good functional outcomes and healing potential. The limitations of the study are that the sample size is small and no patients were managed operatively by nailing

KEYWORDS: Humerus shaft fracture, DCP, anterolateral approach, posterior approach,ASES score.

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INTRODUCTION

Shaft or diaphyseal fracture of the humerus is defined as extra articular fractures of the humerus excluding 5 cm in each ends. Fractures of the humeral diaphysis has been estimated previously as representing between 3% and 5% of all fractures but a more accurate figure is around 1%.[1] Fractures of humeral shaft have traditionally been regarded bengin, with high percentage of primary healig with conservative methods, using either a hanging arm cast or a functional brace. However loss of reduction in the plaster cast invariably leads to malunion. Operative treatment for humerus fractures has usually been reserved for the treatment of nonunion, associated with fractures of forearm, for polytrauma patients, and for those with neuro-vascular complications.[2] The advantages of operative management are early mobilization and patient comfort but operative management carries the risk of technical errors and post operative complications like infections, nerve injuries etc.[3] Most of the studies have used fracture union as the major determinant of the outcome and very few studies have examined the functions at the shoulder and elbow.

The ideal method of humeraldiaphysis fracture fixation still remains in debate. Two techniques under study include intramedullary nailing and dynamic compression plate fixation.

Plating with Dynamic compression plate givesacceptable results but necessitates extensive dissection, and meticulousprotection of radial nerve. The plate may fail in osteoporotic bone.

Surgical fixation when indicated has the options of plating and intramedullary fixation.The theoretical advantage of intramedullary nailing included less invasive surgery, an undisturbed fracture hematoma and use of a load sharing device support.

However, the phenomenon success of interlocking nailing in long bones like femur and tibia is not seen in humerus.Moreover,they have their pitfalls related to shoulder such as stiffness, rotator cuff injuries and elbow joint morbidity.

According to recent studies Dynamic compression plate is gold standard for surgical treatmenthumeral diaphysis fracture.

The present study is an attempt to study the functional outcome of open reduction and internal fixation using dynamic compression plate for diaphyseal humerus fracture.

OBJECTIVE OF THE STUDY

- To study the effectiveness of dynamic compression plate in achieving anatomical reduction and stability of fixation.
- To study the functional outcome of surgical management of diaphyseal fracture humerus with dynamic compression plating.

ANATOMY OF HUMERUS AND ARM

The shaft of the humerus, bone of the arm, expands above into an upper end whose articular surface looks up and back. The lower part of the shaft curves gently forwards to a flat lower end projected into medial and lateral epidcondyle, between which lies the articular surface of the elbow joint. The medial epicondyle projects in the same direction as of the head of humerus and is much more prominent than the lateral epicondyle. The humerus at rest lies with its articular head facing backwards as well as medially.

The articular surface of head of the humerusarticulates with the glenoid cavity of the scapula. The head forms about one third of a sphere and is about four times the area of the glenoid cavity.

The articular margin of the head is the anatomical neck of the humerus. Below the neck are the lesser and greater tuberosities separated by the bicipital groove. The lesser tuberosity projects prominently forwards, and is continued downwards as the medial lip of the bicipital groove. An undulating area of smooth bone indicates the insertion of the tendon of subscapularis.

The greater tuberosity is bare bone, perforated by vessel, except at it projecting junction with the head. Here three smooth facets receive the tendons of scapular muscles. Superiorly is the facet for supraspinatus. Behind this lies a smooth facet for infraspinatus, whiel posteriorly the lowest facet receives teres minor. Below this tendon the bare bone lies in contact with the axillary nerve and its vessels. The lateral lip of the bicipital groove extends down from the anterior margin of the greater tuberosity to run into the anterior margin of the deltoid tuberosity.

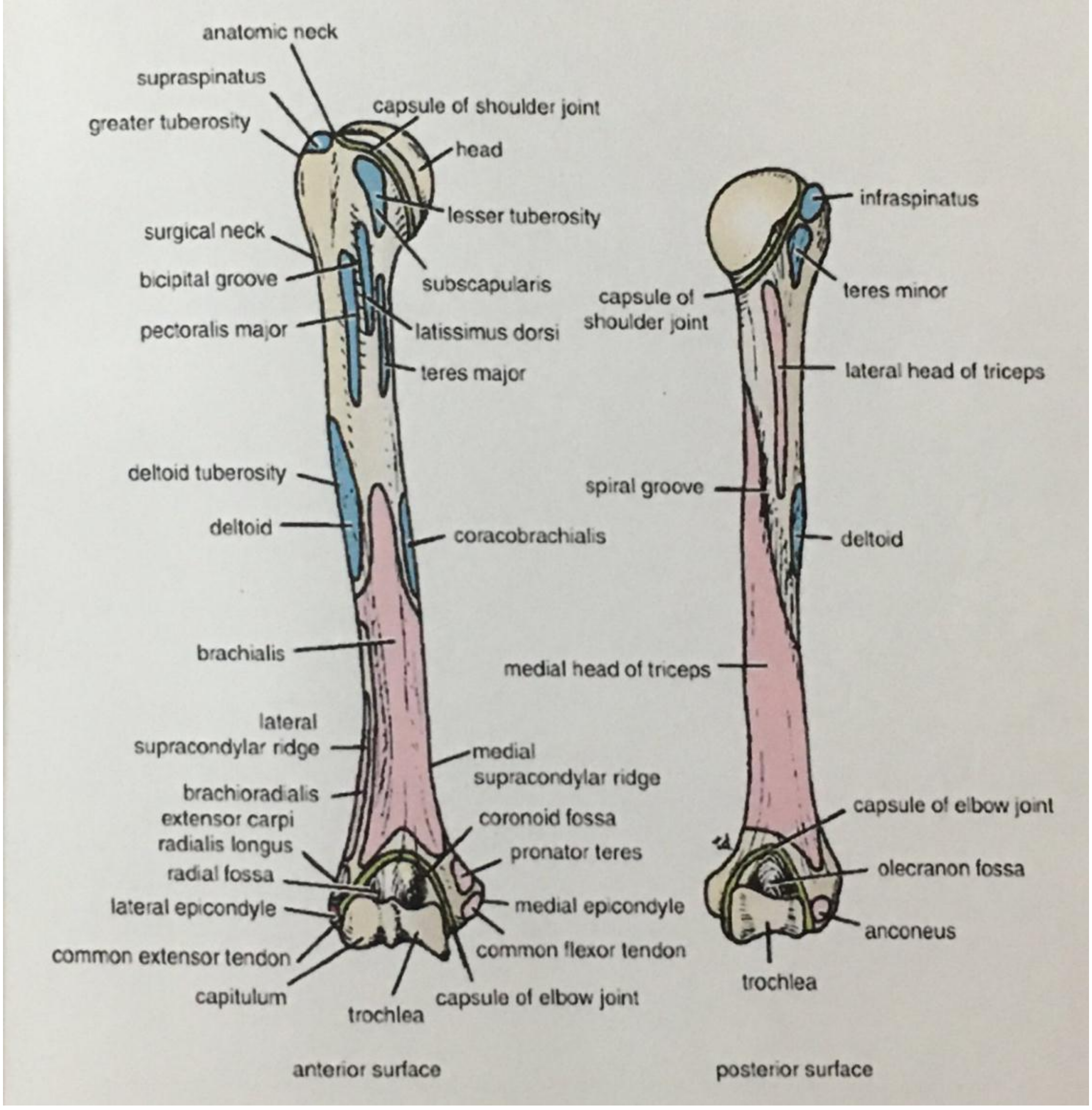
The deltoid tuberosity is a V-shaped prominent ridge, with a smaller ridge in between giving attachment to the fibrous septa in the multipennate acromial fibers of the deltoid.

Below the deltoid tuberosity the lower end of the radial groove spirals down. The posterior margin of the groove runs down as the lateral supra condylar ridge and curves forwards into the lateral epicondyle.

The lateral supra condylar ridge gives to the lateral intramuscular system.

The medial lip of the bicipital groove continues down into the medial supracondylar ridge, which at its lower end curves into the prominent medial epicondyle. The medial supracondylar ridge gives attachment to the medial intermuscular system. Level with the lower part of the deltoid tuberosity the nutrient foramen, directed down towards the elbow lies just in front of this medial border of the humerus.

Figure 1 : Anatomy of Humerus



Above the foramen, opposite the deltoid tuberosity, coracobrachialis is inserted. Flexor surface of the humerus, between the supracondylar ridges, gives origin to the brachialis muscle. Spiral groove lies below deltoid tuberosity posteriorly, which accommodates the radial nerve.

Lower end of the humerus carries the articular surface for the elbow joint and bears medial and lateral epicondyles for attachment of muscles for the flexor and extensor compartment of the forearm respectively.

The articular surface, coated with hyaline cartilage, shows the conjoined capitulum and trochlea.

The capitulum articulates with the head of the radius. The pulley shaped trochlea articulates with the trochlear notch of the ulna.

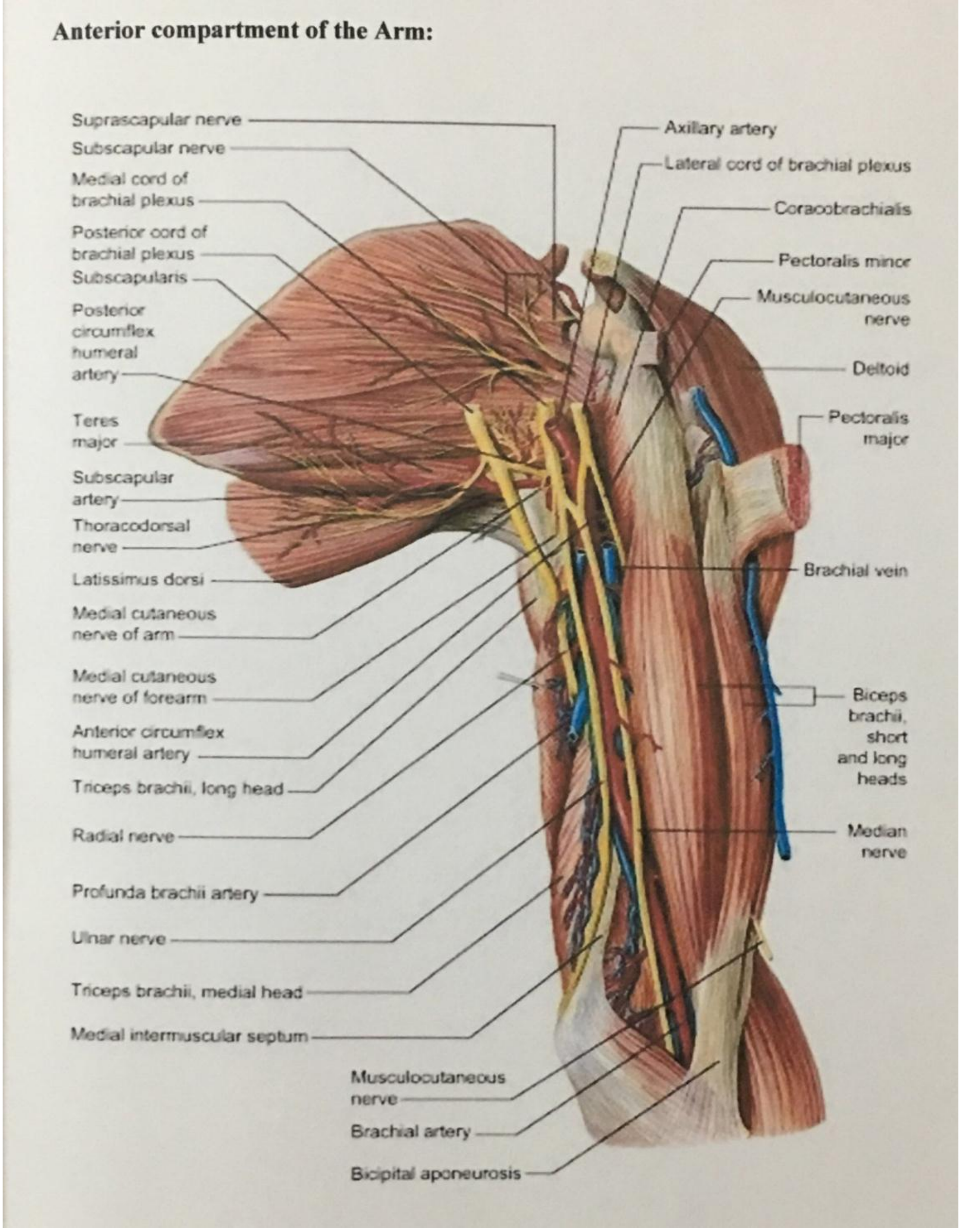
Above the capitulum is the radial fossa, which during flexion of elbow receives the head of radius.

Above the trochlea anteriorly is the coronoid fossa, which receives the coronoid process of the ulnawhen elbow is flexed. Above the trochlea posteriorly is the olecranon fossa, which receives the olecranon process of the ulna when the elbow is extended.

The upper arm is enclosed in sheath of deep fascia. Two fascial septa, one on the medial side and one on the lateral side, extend from this sheath and are attached to the medial and lateral supracondylar ridges of the humerus respectively.

Thus the upper arm is divided into an anterior and a posterior fascial compartment each having its muscles, nerves and arteries.

Figure 2 : Anterior compartment of Arm



Anterior compartment muscles of the arm are:

1. **Biceps brachii:** The biceps brachii has two heads of origin.

    i. Long head arises from the supraglenoid tubercle of the scapula.

    ii. Short head arises from the lateral part of tip of the coracoid process.

The tendon of the long head crosses the humeral head within the capsule of the shoulder joint and comes out from the joint surrounded by a synovial sheath and lieswithin the bicipital groove of the humerus between pectoralis major and latissmusdorsi muscle insertion. It is joined in the middle of the upper arm by the short head.

The biceps brachii is inserted at elbow by forming aaponeurotic band known as Lacertusfibrosus which continues with deep fascia of medial forearm and by forming distal biceps tendon which inserts into tuberosity on proximal radius.

Biceps Brachii is supplied by the Musculocutaneous nerve.

Action: It is the prime supinator of the flexed forearm. It also flexes the elbow joint.

2. Coraco Brachialis:

It originates from the tip of the coracoid process and is inserted into the medial side of the shaft of the humerus at its middle.

It is supplied by the Musculocutaneous nerve.

Action: Flexion of the arm and is also a weak adductor.

3. **Brachialis:**

It originates from the anterior surface of the shaft of lower half of the humerus.

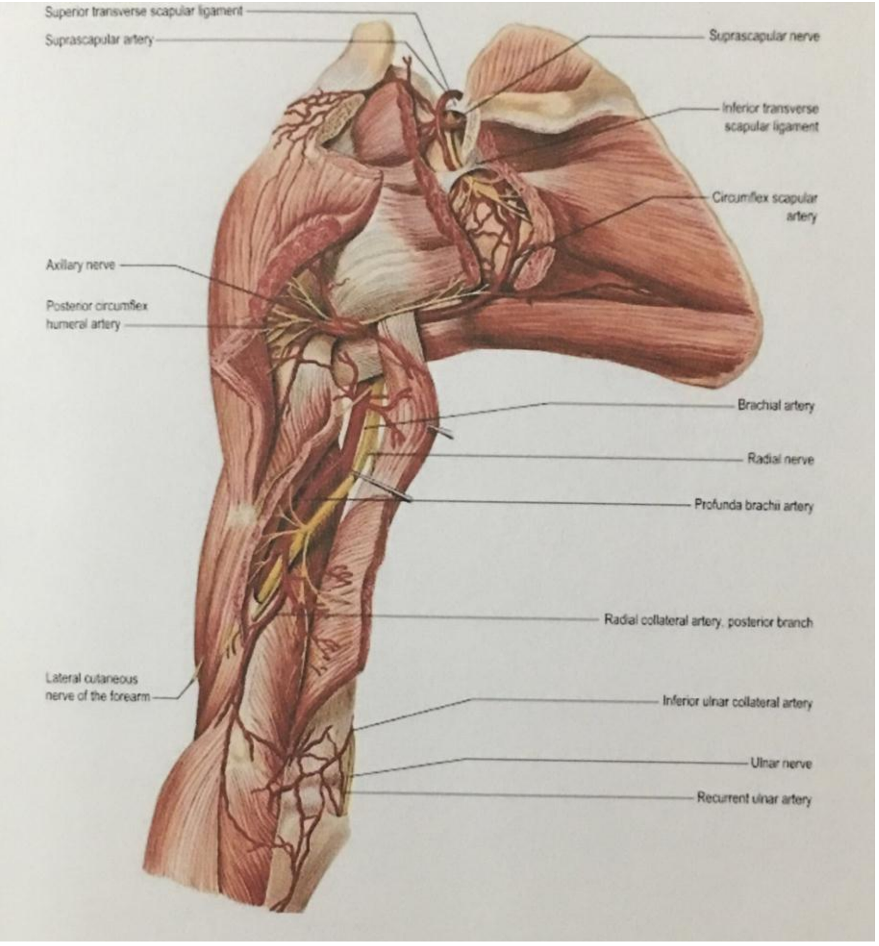
It is inserted into the anterior surface of the coronoid process of the ulna.

It has got dual nerve supply. The medial part of the muscle is supplied by Musculocutaneous nerve and lateral part of the muscle is supplied by Radial nerve.

Action: Major flexor of the elbow joint.

Blood supply to the anterior compartment of the arm is by the brachial artery.

Figure 3 : The Posterior Compartment of the Arm:



Posterior Compartment Muscles are: Triceps:

It has three heads of origin:

- Long head arises from the infraglenoid tubercle of the scapula
- Lateral head arises from the upper half of the posterior surface of the shaft of humerus above and along the spiral groove,
- Medial head arises from the posterior surface of the lower half of the shaft of the humerus below the spiral groove.

All three heads form a common tendon which is inserted into the upper surface of the olecranon process of the ulna. It is supplied by the radial nerve.

Action: Triceps is the major extensor of the elbow joint.

Blood supply of the posterior fascial compartment of the arm is by the profundabrachii and ulnar collateral arteries.

Course of the brachial artery in the arm:

The brachial artery is a continuation of the axillary artery which begins at the inferior border of teres major muscle. It lies in the anterior compartment of arm throughout, on medial aspect in its upper part and anterior in its distal part. It ends about a centimeter distal to the elbow joint by dividing into radial and ulnar arteries.

Relations:

The artery is entirely superficial in the anterior compartment, covered anteriorly by skin, superficial and deep fascia. The median nerve crosses it from lateral to medial near the insertion of coracobrachialis.It crosses anteriorly at the elbow joint where it lies immediately medial to bicipital tendon.

Posterior are:

The long head of triceps, separated by the radial nerve and profundabrachii artery and then successively by; the medial head of triceps, the attachment of coracobrachialis and the brachialis.

Lateral are:

Proximally, the median nerve and coracobrachialis and distally, the biceps.

Medial are:

Proximally, the medial cutaneous nerve of the forearm and ulnar nerve, distally, the median nerve and basilica vein.

Branches:

1. Muscular branches to the anterior compartment of the arm.
2. The nutrient artery to the humerus.
3. ProfundaBrachii artery arises from lateral and posterior part of the brachial artery just below lower border of teres major and follows the radial nerve into the spiral groove of the humerus.
4. Superior ulnar collateral artery arises near the middle of the arm on medial side and follows the ulnar nerve after piercing medial intermuscular septum.
5. Inferior ulnar collateral artery arises near the termination of the artery, 5 cm proximal to elbow joint and takes part in the anastomosis around the elbow joint.

Course of the Median Nerve in the Arm:

The median nerve arises from two roots from the lateral (C 5, 6, 7) and medial (C8, T1) cords of brachial plexus, which embrace the third part of the axillary artery, uniting anterior or lateral to it.

The median nerve enters the arm at first lateral to the brachial artery, near the insertion of coracobrachialis it crosses in front of the artery, descending medial to it to the cubital fossa where it is posterior to the bicipitalaponeurosis and anterior to the brachialis separated by the latter form the elbow joint.

Branches in the Arm:

These are vascular branches to the brachial artery and a branch to the pronator teres, at a variable distance proximal to the elbow joint.

Cutaneous Branches

- Posterior and lower lateral cutaneous nerve of the arm.
- Articular branches to the elbow joint.

CLASSIFICATION

There is no universally accepted classification for humeral shaft fractures. Classically they have been classified on the basis of factors that influence treatment like

Fracture location – Based on the part of the diaphysis involved it is classified as

1. Proximal third
2. Middle third
3. Distal third

Based on the relation of the fracture line to the muscle insertion.

1. Proximal to pectoralis major insertion.
2. Distal to pectoralis major insertion but proximal to deltoid insertion.
3. Distal to deltoid insertion.

Direction and Character of Fracture line –

1. Transverse
2. Oblique
3. Spiral
4. Segmental
5. Comminuted

Associated soft tissue injury – Open fractures / closed fractures.

Associated periarticular injury – glenohumeral joint or elbow joint.

Associated nerve injury – Radial, Median or Ulnar nerves.

Associated Vascular Injury – Brachial artery or vein.

Intrinsic Condition of Bone – Normal / Pathologic

AO/OTA Classification[2]

It is essentially an extension of the AO/ASIF classification. The Humerus is designated Bone "1" and is further subdivided into

Proximal – 11

Shaft – 12

Distal -13

Shaft fractures are further subdivided into

A – Simple fractures with two main fragments, proximal and distal. Cortical fragments of less than ten % of circumference are ignored.

A 1 – Spiral Fracture

A 1.1 – Fracture in proximal diaphysis.

A 1.2 – Fracture in middle diaphysis.

A 1.3 – Fracture in distal diaphysis

A 2 – Oblique fracture with the fracture line ≥ 30 degrees with respect to the transverse plane.

A 2.1 – Fracture in proximal diaphysis

A 2.2 – Fracture in middle diaphysis

A 2.3 – Fracture in distal diaphysis

A.3 – Transverse fracture pattern

A 3.1 – Fracture in proximal diaphysis.

A 3.2 – Fracture in middle diaphysis

A 3.3 – Fracture in distal diaphysis

B-Wedge fractures where there is one or more intermediate fragments but after reduction cortical continuity is present between the proximal and distal fragments.

B1-Spiral wedge

B 1.1 – Fracture in proximal diaphysis.

B 1.2 – Fracture in middle diaphysis.

B 1.3 – Fracture in distal diaphysis.

B 2 – Bending wedge

B 2.1 – Fracture in proximal diaphysis.

B 2.2 – Fracture in middle diaphysis.

B 2.3 – Fracture in distal diaphysis.

B 3 – Fragmented wedge

B 3.1 – Fracture in proximal diaphysis

B 3.2 – Fracture in middle diaphysis.

B 3.3 – Fracture in distal diaphysis.

C – Complex fractures where there are one or more intermediate fragments and after reduction cortical continuity cannot be achieved between the proximal and distal fragments.

C 1 – Spiral

C 1.1 – With two intermediate fragments.

C 1.2- With three intermediate fragments.

C 1.3 – With more than three intermediate fragments.

C 2 – Segmental fractures

C 2.1 – With one intermediate fragment.

C 2.2 – With one intermediate fragment and one wedge fragment.

C 2.3 – With two intermediate fragments.

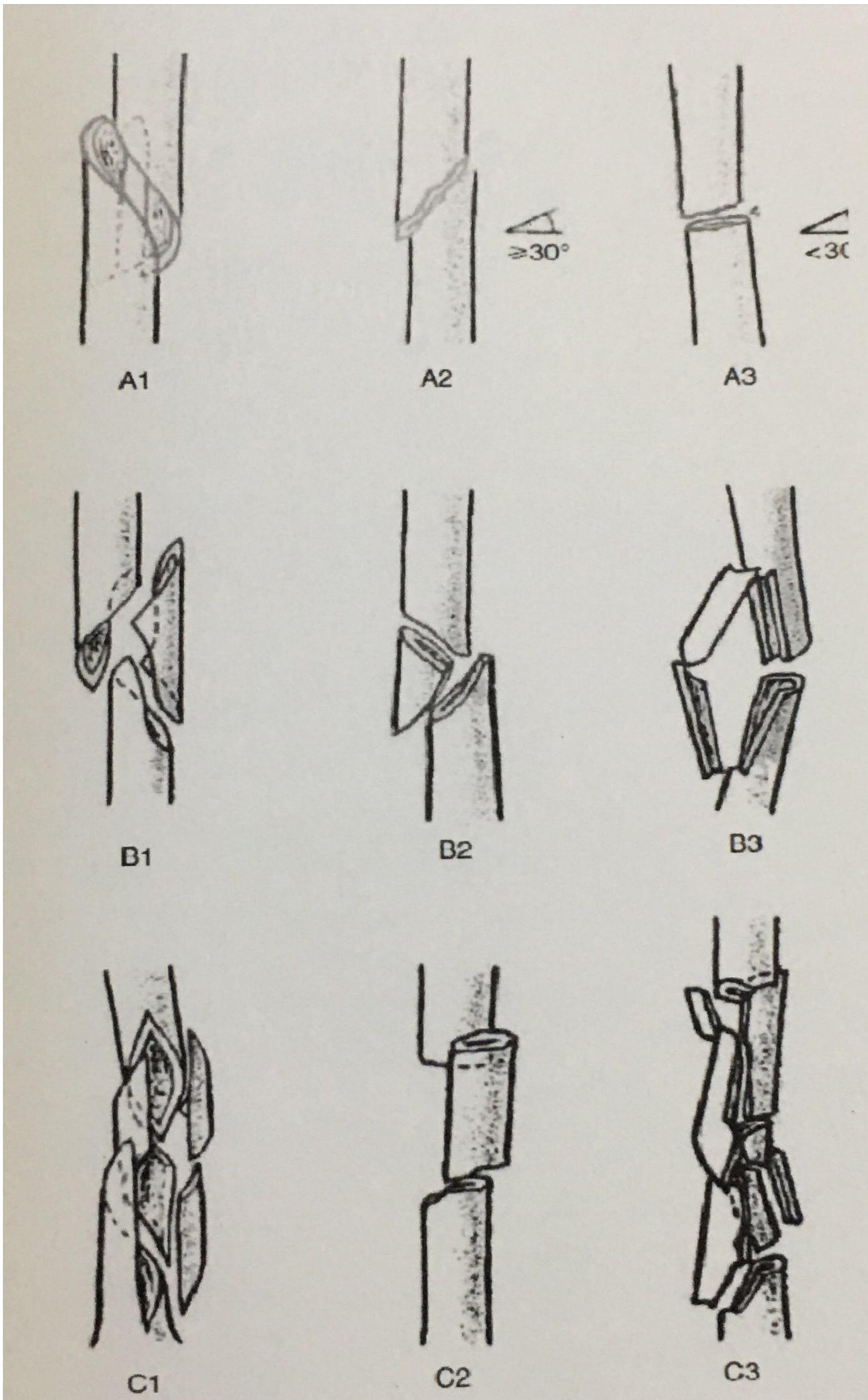
C 3 – Irregular Fractures.

C 3.1 – With two or three intermediate fragments.

C 3.2 – With limited shattering.

C 3.3 – Extensive shattering (> 4 cm).

Figure 4 : AO/ASIF Classification



Classification of the fracture guides us in choosing the treatment modality. A simple oblique fracture yields good results with conservative management. A transverse fracture precludes the use of hanging arm cast due to risk of distraction and potential complications[68]. Spiral fractures in the distal third also called as Holstein-Lewis fracture is often complicated by Radial nerve palsy either primarily or post closed reduction[69].

Segmental fractures usually need internal fixation. Comminuted fractures are better managed by closed means Osteopenic bones are better managed by intramedullary nailing than by plating.

MECHANISM OF INJURY

Humeral diaphyseal fractures most commonly occur due to direct trauma, although indirect trauma may also be the cause[3]. Direct trauma may be due to road traffic accidents, fall and direct blow on the arm. This usually causes a transverse or comminuted fracture.

Indirect violence include fall on outstretched hand, twisting injuries and violent muscular contraction. These usually cause a spiral oblique fracture. Humeral diaphyseal fractures resulting from muscular violence are uncommon. However such fractures have been reported following arm wrestling and throwing of baseball and hand grenades. These fractures usually are located between the middle and distal third of the humerus.[71,72,73,74]

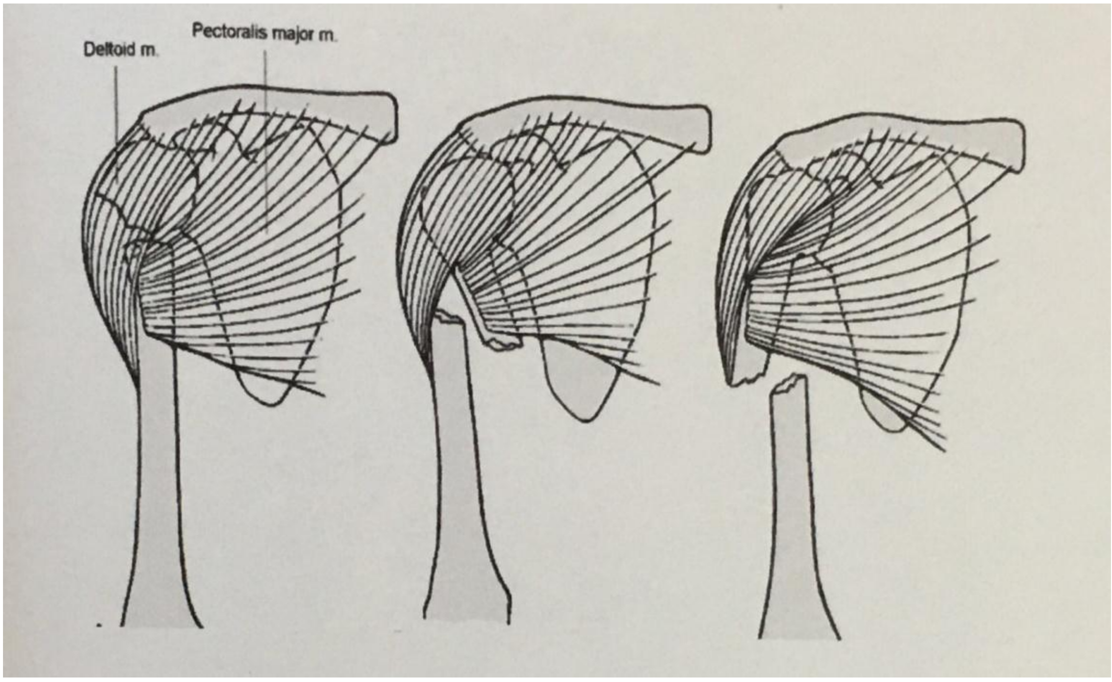
In general transverse fractures are caused by bending and compressive forces[3]. Spiral fractures are caused by tortional forces[3,68]. A combination of bending and tortional or bending and compressive forces causes an oblique or wedge fracture.[3,68,69]

Elderly patients who suffer a fall usually have less comminution. Higher energy fractures are associated with greater degree of comminution and soft tissue injury.

The displacements of the fragments depend on the relationship of the fracture line to the muscle insertions. In fractures above the insertion of the pectoralis major insertion, the proximal fragment is abducted and externally rotated due to the supraspinatus and the unopposed action of the external rotators (Infraspinatus and Teres Minor)[2].

In fractures occurring between Pectoralis major insertion and the Deltoidinsertion, there will be adduction of the proximal fragment and proximal and lateral displacement of the distal fragment[2]. In fractures distal to the insertion of deltoid, the proximal fragment is abducted is abducted by the deltoid and the distal fragment will be displaced proximally[2].

Figure 5 : Displacement as per fracture level due to muscle pull



Surgical Anatomy:

The brachial artery and vein, as well as the median and ulnar nerves, traverse the anterior compartment in the medial bicipital groove.

The radial nerve runs through the triceps muscle, occupying the radial groove in the midshaft area and perforating the intermuscular septum further down.

The axillary nerve and posterior circumflex humeral artery originate posteriorly and wind round the surgical neck about 5-6cm below the acromion

COMPLICATIONS

The primary complications resulting from the management of humeral shaft fractures are malunion, nonunion, infection, radial nerve deficit.

Malunion

An angular malunion of 20-30^{o} or shortening of 2-3cm rarely presents a problem. The wide range of motion of shoulder joint may minimize the effect of rotational malunion of up to 15^{0}.

Cosmoses should seldom be considered an indication for operative intervention. However if surgery is indicated, osteotomy with stable internal fixation may provide a satisfactory method of reconstruction.

Nonunion

Nonunion of humeral shaft fractures develop in 2-5% of nonoperatively managed injuries and in up to 25% of fractures managed by primary open reduction and internal fixation.[86, 21] Most fractures of the shaft of humorous treated conservatively are clinically united by about 6 weeks. Non unions occurs more frequently in open fractures, high velocity injuries, segmental fractures, poorly reduced fractures and fractures with inadequate operative stabilization. Other causative factors include poor soft tissue coverage, metastatic carcinoma, alcoholism, corticosteroid treatment and polytrauma with resulting osteoporosis. The objective of treatment of non union should be reduction with stable internal fixation supplemented by liberal use of cancellous bone graft. Interlocked intramedullary nail fixation is preferred in patients with osteoporotic or pathological fractures, whereas compression plate stabilization is recommended for those patients with adequate bone stock. At least ‘8’ cortices should be placed both proximal and distal to the non union site. The use of corticocancellous on-lay grafts opposite the plate may increase the rigidity of fixation and aid in screw purchase. Satisfactory results can be obtained with a stable fixation of humeral non union. Boyd and coworkers.[28]

Campbell[70], Mast and Associates[19], Muller[83] and Kuntscher[87] reported union in approximately 90% of cases.

Infected nonunion:

A direct correlation has been shown between instability and infection.[28, 50] Stabilization of the nonunion with complete debridement of infected nonviable tissue including bone, irrigation of the wound, and systemic antibiotics will lead to union in majority of cases. Intramedullary stabilization or plate and screw fixation is often contra indicated in infected cases but may be utilized when infection has been eradicated.

Non-unions with bone loss:

A non-union with a bone deficit of 5 cm or more should be considered a reconstructive case. Methods of reconstruction include: full thickness corticocancellous auto grafts, vascularized bone transfer and humeral allograft.

Neurological Complications

Radial nerve injury is the most common neurologic complication associated with the humerus fractures. Transient neuropraxia injuries are most commonly noted following transverse or short oblique fractures of the humerus. Transaction of the radial nerve has been noted most commonly with open fractures, fractures associated with penetrating injuries. Radial nerve palsy may occur in up to 18% of closed humeral shaft fractures, of these, more than 90% constitute neuropraxia, which will recover spontaneously within 3-4 months of injury. In the complete absence of clinical evidence of return of function, radian nerve dysfunction should be evaluated 6 weeks after injury by electromyography and nerve conduction studies. The search for objective evidence of return should be directed toward motor response, primarily in brachioradialis and extensor carpi radialislongus and brevis muscles. If action potentials are present, conservative management is continued however, if denervation fibrillation or complete denervation is noted on these tests, surgical exploration and repair, with or without cable grafts, are indicated.

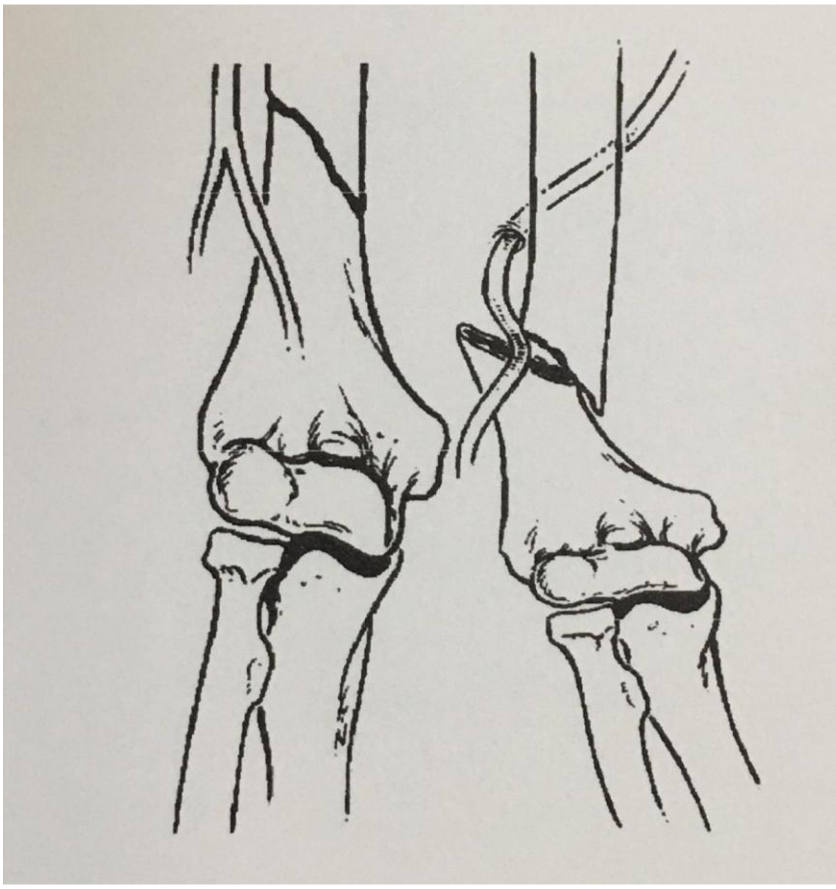
Indications of Primary Exploration Include:

Open fractures, Fracture associated with penetrating injury and Holstein-Lewis fracture.

Vascular Complications

Vascular complications associated the humeral shaft fractures are rare and most often occur in open fractures or with penetrating injuries. If arterial injury is suspected, arteriography should be used to determine the site of injury and to accomplish vascular repair. Vascular reconstruction should be considered an absolute indication for stable fixation of the fracture, either with plate and screw or by external fixation. Fasciotomy of the arm, forearm and hand may be necessary when flow has been reestablished.

Figure 6 : Radial nerve entrapment at the fracture site



Holstein and Lewis Syndrome:

It is a closed spiral fracture of the distal third of the humerus in which radial nerve palsy develops after manipulation or application of a cast or splint. They pointed out that the nerve is least mobile as it passes through the lateral intermuscular septum in the distal third of the arm. These distal third fractures are often oblique and typically angulated laterally with the distal fragment displaced proximally. The radialnerve fixed to the proximal fragment by this lateral inter muscular septum may be trapped between the fragments when closed reduction is carried out. The function of the radial nerve may be normal prior to the manipulation and then is noted to disappear as the fracture is reduced. When this happens, exploring the nerve, extracting it if it is caught between the fragments and internal fixation of the fracture are recommended.

REVIEW OF LITERATURE

Man was never immune to injury and, even in the Neolithic age primitive techniques of bone setting were present.[4]The earliest examples of splinting were seen in mummies found in Egypt near Luxor.

Hippocrates[5] in 460-377 B.C. proposed two principles of fracture management.

1. Traction and counter-traction for fracture reduction.
2. Exercise strengthens, inactivity causes wasting of muscles.

Serefeddin Sabuncuoglu (1385-1468) authored the surgical textbook Cerrahiyyetu'l- Haniyye (Imperial Surgery). It included Sabuncuog'lu's color illustrations of surgical procedures, incisions, fracture dislocation reduction techniques, and instruments.

Gersdorf[6] in 1517 used wooden splints bound by ligatures which were tightened by twisting them with cannulated wooden toggles. This technique was later used by Benjamin Gooch in 1767 to design what must be called the first functional brace which was designed to return the worker to his labors before the fracture consolidated.

Lapujade and Sicre[7] surgeons of Toulouse, France used circlage wires for treatment of long bone fractures.

PhysickPS[8] in 1801 operated on a case of non union fracture humerus and achieved bony union. He used a Seton with a silk thread for the same.

Dr Roberts K[9] in 1827 New York operated on a case of pseudoarthrosis of the humerus by using a silver wire as a bone suture and got good union.

Hansmann[10] of Hamburg first described the use of plates to fix a fracture. He used a malleable plate, the end of which was bent so as to project out through the skin for later removal. Later Arbuthnott lane advocated the procedure for the management of humeral fractures under certain conditions. Plating was finally popularized by the work of AO group.

Antonius Mathijsen[11] in 1852 pioneered the use of plaster of Paris as a plaster impregnated bandage, although the use of plaster of Paris existed in the Arab world for hundreds of years. The functional cast brace in its primitive form was introduced in 1985.

Lambotte[12] who coined the term osteosynthesis also devised many plates and Screws and instruments for internal fixation.

Bohler and colleagues[13] in 1935 described the use of U-slab in the management of fracture shaft humerus and stated that it was a simple technique which overshadowed the complication of hanging arm cast.

Rush and Rush[14] in 1937 contributed description in intramedullary fixation by using Steinmann pins. Rush also developed flexible nail system including four different size diameter pins for use in all the long bones.

Egger[15] in 1949 demonstrated the effect of compression on healing of experimental fractures in lab animals. Perhaps the first use of compression plating was by Danis[15] in 1949, who used as axially oriented screw t achieve compression.

Muller[16] in 1961 developed a plate which could be compressed with an external compressing devise. The first self compressing plate was semi-tubular with oval holes.

Allgower and Perren[17,18] in 1969 reported the ‘dynamic compression plate’ (DCP) as a method for providing rigid internal fixation. The design of the screw holes called for a ramp at the margin of the side of the plate hole which allowed increased compression to be applied to the bone. It is also possible to angulate the screw in the holes thus enabling the placement of an interfragmentary screw through the plate. This was a revolution in treatment of diaphyseal fractures. Good results after plating became the rule rather than the exception.

Mast and Colleagues[19] in 1974 reported a large series of humeral shaft fractures, primarily most of them treated with closed techniques i.e. U-slab, hanging **** cast and thoracobrachialspica where he showed better results from closed techniques than primary internal fixation.

Foster and Colleagues[20] from 1970 to 1983 conducted a multicenteric study in America. 96 patients with fresh fracture or nonunion were included in the study. 27 patients were treated with AO plating methods and there was union in 100 percent of the cases with good functional outcome.

Bell and Colleagues[21] from 1976 to 1983 plated 39 humeral shaft fractures in patients with multiple injuries at the Sunny Brook Medical Center, Toronto. 34 came for follow up and out of these only one developed non union.

Rush brothers[22] advocated intramedullary nailing of the humerus; they usedelastic nails in the proximal diaphyseal fractures. The principle of the nail was that it allows for three point fixation in the intramedullary canal.

Ender[23] in 1978 introduced flexible intramedullary nailing for long bone fixations. Leutenegger and Colleagues[24] from 1980 to 1986 at KantonsspitalChur in Germany operated on 18 patients with humeral shaft fractures with open reduction and internal fixation (ORIF) using the AO plating technique. Follow-up was available for 17 patients of whom 16 suffered from multiple injury trauma. The broad DC plate combined with lag screws was used in most cases. 2 brachial artery transections were repaired at the time of primary osteosynthesis by the same surgeons with full functional recovery. Concomitant nerve injuries were repaired primarily in one case and post-primarily in 3 more cases. The overall result was excellent in 9 patients, good in 5 patients, fair in 2 patients and poor in one patient with complete brachial plexus injury. Bone healing was uneventful in all 17 patients.

Stern and Colleagues[25] documented 70 fractures of the humeral shaft that were treated by intramedullary fixation. Author's results confirmed previous reports, showing significant morbidity in the operative treatment of fractures of the humeral shaft. Operative morbidity associated with the intramedullary fixation of fractures of the humeral shaft could be significantly reduced if proper timing and techniques are employed.

Brumback and Colleagues[26] in 1986 performed intramedullary stabilization with Rush rods and Ender nails and reported 94% rate of union with 62% of excellentclinical results. They stated that this technique was particularly applicable to multiple trauma patients, as it minimizes blood loss and risk to neurovascular structures.

Greind and Colleagues[27] in the University of Mississippi Medical Menter, Jackson, 36 patients with diaphyseal fractures of the humerus were treated with AO plating techniques. 2 were lost to follow up. Out of the remaining 34 patients, 33 showed union. Good functional outcome was seen in all but 6 patients. The authors concluded that even though closed treatment was the mainstay of treatment of fracture of the shaft of the humerus, internal fixation with proper technique will give acceptable results even in the difficult fractures.

Hall and Colleagues[28] undertook a Meta analysis of 52 publications dealing with the non operative and operative methods of treatment of the humeral shaft. They showed that in the series of papers published between 1940 and 1984 involving the non operative management of 2653 patients, the average incidence of pseudoarthrosis was 2.1%. There was a 0.3% incidence of osteomyelitis and a 9% incidence of radial nerve paralysis. In their analysis of 574 operatively managed fractures, the pseudoarthrosis rate was 8.3 with a 3.8% incidence of osteomyelitis and 9.9% incidence of radial nerve lesions. The author examined the results of both plate osteosynthesis and intramedullary nailing and showed that there was a higher incidence of pseudoarthrosis and osteomyelitis after plate osteosynthesis than after intramedullary nailing.

Seidel[29] developed a locked intramedullary nail which was shaped to fit the humeral shaft. It was an unslotted nail which achieved proximal locking with screws and distal locking by means of fins which were expanded using a spreading bolt. 80

humeral shaft fractures stabilized with this implant. Seidal described a union rate of 100% with only minimal reduced mobility at the shoulder.

Siebert and Colleagues[30] between 1990 and 1994 conducted a study in the University of Bonn; plating was done in the treatment of humeral shaft fractures in 62 patients. The average time taken for bony union was 16.2 weeks.

Hee and Colleagues[32] between 1992 and 1997 in Singapore treated 47 humeral shaft fractures by open reduction and internal fixation with DCP using AO principles. 12 patients were lost to follow up. The remaining 35 patients were reviewed after an average of 3.5 years follow-up. There were 8 open fractures, 5 cases with primary radial nerve palsy and 8 cases of failed closed management. There were 2 cases of non union. Both were open fractures. The average time to bony union was 5.3 months. 36 patients had full range of motion of both their shoulder and elbows. 7 patients had residual elbow stiffness. 2 patients had reduced shoulder abduction. 89% were satisfied or very satisfied with their surgical outcome.

Osman and Colleagues[33] in Pairs conducted a study where the authors treated 104 diaphyseal humeral fractures, 28 of whom were treated with plates and screws. The plate and screws group showed union in 26 cases and very good results in 23 cases and good results in 3 cases.

Paris and Colleagues[34] between 1987 and 1997 in Marseilles, France conducted a study of 156 humeral shaft fractures in adults treated by plate fixation, there were 21 cases of multiple trauma and 24 multiple fractures, 8 cases of floating elbow and open fracture in 16. The union rate was 94.2%, sepsis rate was 1.5%. Good or very good outcome was achieved in 86.6% of the cases. Postoperative radial nerve paralysis occurred in 8 cases (5.1%), only 1 patient suffered persistent severe sequelae. There were also 8 non-unions and 3 delayed unions.

Perren[35] in 1989 introduced the limited contact dynamic compression plate (LCDCP).

He described the following aims of this new concept[36]

1. Minimal surgical damage to the blood supply
2. Maintenance of optimal bone structure near the implant.
3. Improved healing in the critical zone in contact with the plate
4. Minimal damage to the bone lining at plate removal with reduced risk of refracture
5. Optimal tissue tolerance of the implant by selection of pure titanium as implant material.

Caldwell[37] conducted a study in the Sunnybrook Health Center, Canada concluded that variables other than bone plate design like Screw torque, object radius of curvature, mode of bone plate application (compression or neutral loading) also influence the interface contact area and average force between a bone plate and object to which it is applied.

Mckee and Colleagues[38] from 1990 to 1993 in Boston used LC-DCP plates to treat upper limb fractures in a series of 114 patients. 3 were lost to follow up. 17 patients had humerus shaft fracture. 16 of the 17 humeral fractures united in an average of 10.5 weeks. 1 fracture in an osteopenic lady took 24 months to unite. In the whole series, 108 of 111 fractures united without any further problems.

Habernek and Colleagues[39] in 1991 reviewed 19 patients with humerus fracture using Siedel's locking nail system and found overall good results with no cases of pseudarthrosis, infection or radial nerve palsy. All patients regained full shoulder movements with no evidence of rotator cuff lesions.

Rodriguez and Colleagues[40] in the same year prospectively studied a comparison between Hackethal nails and compression plates and found that though union occurred in both groups was good, the functional results was better with compression plates. Rommens andColleagues[41] in 1995 performed retrograde locked nailing of humeral shaft fractures and found it to be a better solution for the stabilization of fractures of humerus than ante-grade nailing or plate nad screw fixation.

Chhina and Colleagues[42] in government medical college, Amritsar, used titanium LC-DCP in the treatment of 50 humeral shaft fractures. The time taken for radiological union was <16 weeks in more than 96% of the cases and the functional outcome was good to excellent in more than 96% of the cases.

Chiu FY and Colleagues[46] in 1998 conducted a prospective study on surgical evaluation of closed humeral shaft fractures treatment and concluded that Enders nailing is better than DCP. When DCP is chosen, prophylactic bone grafting is recommended, especially when communition is more.

Meekers and Broos[47] from 1986 to 1999 in the department of trauma, Leuvan, Belgium conducted a study. A total of 161 fractures of the humerus were treated operatively and followed up. 80 were treated with plates and screws which comprised of both DCP and LCDCP. 81 were treated with interlocking nailing. The union rate in the plate group was 92.5 percent. The functional recovery in the plate group was good to excellent in 95 percent of the cases and fair to poor in 5 percent of the cases. In the nailing group, the union rate was lesser, the complication rate was more and the functional outcome was also poorer than the plating group. Therefore they recommend the use of plate and screws as the primary treatment for fractures of the humeral shaft in all operative indications, except for pathological fractures, very obese patients, and open fractures.

Hems and Colleagues[49] in 1997 used interlocking nails for humeral shaft fracturesin both pathological and non-pathological fractures and found that they should be used with caution in management of non-pathological fractures.

Crates and Whittle [50] conducted a study on antegrade interlocking nailing of humeral shaft fractures. 73 acute humeral shaft fractures were treated with antegrade Russell Taylor humeral nailing. 94.5% fractures united primarily. 2 7% iatrogenic radial nerve palsies occurred and were transient. 90% had full shoulder function. 2.7% patients had impingement from proximal locking screws and 1.4% had impingement from a prominent nail. Normal elbow function was regained in 96% of patients. Functional results were graded by criteria of Rodriquez-Merchan. They concluded that antegrade Russell-Taylor nailing as an acceptable alternative for the treatment of acute humeral shaft fractures in multiply injured patients.

Lin[51] in 1998 conducted a comparative study of treatment of humeral shaft fractures by interlocking nail and plate fixation. He concluded that interlocking nail offered a less invasive surgical technique and more favorable treatment results than plate fixation.

Habernek and Othner[52] in the same year withdrew their support for the Seidelinterlocking nail quoting that they had not sufficiently addressed the shoulders of their patients and that the patients still had pain in the shoulder after so many years.

Kropfl and Colleagues[53] in 2000 conducted a prospective study of 111 fractures with antegrade interlocking nailing and stated that it is a safe technique regarding consolidation rate with advantages regarding mobilization of the upper limb. Careful suturing of the rotator cuff and counter sinking of proximal nail tip at the entrance point is a prerequisite in avoiding permanent lesions of the rotator cuff and shoulder pain.

Mc Cormack and Colleagues[54] conducted a study at the University of Calgary, Canada, DCP was compared with intramedullary nailing in 44 patients with diaphyseal fracture of the humerus. They achieved union in all but 1 fracture in the DCP group. Nonunion was seen in 2 cases in the interlocking nail group. Complications were also more in the interlocking nail group. They concluded that plating was the best treatment of diaphyseal fractures of the humerus. Intramedullary interlocking nailing may be indicated in specific situations, but is technically more demanding and has higher rate of complication.

Chapman and Colleagues[55] in similar study found that there was no significant difference in shoulder pain, function scores, range of motion and strength. Ante-grade insertion of the nail, if carried out properly, is probably not the main reason for shoulder joint impairment after intramedullary nailing.

Cox and Dolan[56] conducted a retrospective study on closed interlocking nailing ofhumeral shaft fractures with Russel Taylor nail. 37 patients treated with Russel Taylor humeral nail were included in the study. All the nails were inserted with Russel Taylor humeral nail were included in the study. All the nails were inserted in an antegrade fashion. Author noted 4 established non unions, and 4 cases of delayed union. There was 1 infection and one intraoperative fracture. Author concluded that the indications and rationale for intramedullary humeral nailing should be clearly defined-since high rate of union can be achieved by conservative methods.

Dykes and Daryll[57] in 2001 compared efficacy of plate versus intramedullarynails for humeral fractures and concluded plating results in better functional outcome and nailing should be reserved only for special situations.

Niall and Colleagues[58] reviewed 49 patients following plate osteosyntesis of humeral shaft fractures. They found no complications as a result of surgery and concluded open reduction and compression plating remains the treatment of choice for non-pathological humeral shaft fractures that require operative intervention.

Farragos and Schemitsch[63] from 1999 to 2001 conducted a study on complications associated with the use of locking humeral nails and to discuss the prevention and management of these complications. They concluded that the attractive theoretical advantages of locking humeral nails have not been borne out in clinical studies. Complications associated with interlocking nails in the treatment of humeral shaft fractures has yet to be defined. At present, open reduction and compression plating remain the treatment of choice for humeral shaft fractures that require operative intervention.

Chen and Andrew[64] in 2002 compared fixation stability in humeral fractures fixed with intramedullary nail or DCP in 6 matched pairs of human cadaveric humeri during cyclic and physiologic loading. They concluded that for fixation of humeral fractures with a gap, both intramedullary nailing and plate fixation offer similar fixation stability during physiologic loading, with similar stiffness and no significant differences in displacement as a function of applied load or cycling. However, intramedullary fixation has 50% greater strength when compared with platefixation. This may be important for upper extremity weight bearing after surgical fixation of diaphyseal fractures in cases of severe communication of bone loss.

Demirel and Colleagues[65] in 2005 conducted a retrospective study on 114 humerlshaft fractures with interlocking nailing and came to the conclusion that interlocking nailing is superior to plating with respect to rate union, shoulder and elbow function, operating time, soft tissue dissection, requirement of bone grafting, external immobilization and also they stressed the importance of nailing in comminuted, segmental and polytrauma patients.

Virkus and Walter[66] in 2008 at Rush University Medical Center, Chicago, compared the compressive force generated by plating and intramedullary nailing techniques in a transverse diaphyseal humeral fracture model and concluded humeral nail can generate higher compression than plating using eccentric drill holes or the articulated tensioner when used with a short stainless steel screwdriver shaft. They warranted further clinical studies are needed to analyse whether this compression could improve the union rate of humeral fractures and nonunions beyond those of standard nails.

MATERIALS AND METHODS

SOURCE OF DATA:

- Patients admitted in Department of Orthopaedics in BLDEU'S Shri. B. M. Patil's Medical College, Hospital and Research Centre, Vijayapur with diagnosis of diaphysealhumerus fractures.
- The patients will be informed about study in all respects and informed written consent will be obtained.
- Period of study will be from November 2015- March 2017.
- Follow up period will be 1st month, 3rd month, and 6th months.

METHOD OF COLLECTION OF DATA:

- Patients admitted in Department of Orthopaedics in BLDEU'S Shri B. M. Patil's Medical College, Hospital and Research Centre, Vijayapur with diagnosis of diaphysealhumerus fractures.
- By clinical examination.
- By interview.
- Follow up period will be 1st month, 3rd month, and 6th months.

STUDY DESIGN:

A Prospective study design.

INCLUSION CRITERIA

1. Patient aged 18 years to 70 years.
2. Cases of closed diaphyseal fractures of the humerus.
3. Type I and II compound {Gustillo Anderson criteria} diaphyseal fractures of the humerus.
4. Diaphyseal fracture humerus associated with radial nerve injuries.

EXCLUSION CRITERIA

1. Patients below the age of 18 years and above 70 years.
2. Fracture of upper and lower ends of humerus.
3. Patients treated conservatively.
4. Pathological fractures.
5. Type III compound {Gustillo Anderson criteria} diaphyseal fractures of the humerus.
6. Polytrauma.
7. Patients medically unfit for surgery.

The patients who met the inclusion criteria were included in the study after taking written informed consent. A thorough history and clinical examination was done. The status of radial nerve injury was recorded. Roentgenogram of the arm with shoulder and elbow was taken in both antero-posterior and lateral views. Additional roentgenogram were taken if any other injury was suspected. The humeral shaft fracture was temporarily immobilized with a U-slab and arm pouch.

We used dynamic compression plate for 25 patients who were admitted between November 2015 to January 2017in BLDEU'S Shri B.M.Patil's Medical College, Hospital and Research Centre, Vijayapur for stabilization of fracture of the humeral diaphysis.

Both anterolateral approach and posterior approach were used in any patients with fractures of the shaft of the humerus. A 4.5 mm narrow DCP was used.

The age of our patients varied from 20 years to 70 years, the average age was 39.2 years. There were 19 males and 7 females. 16 patients had suffered fractures in motor vehicle accidents, 10 were fall from height. The right arm was involved in 13 patients and left arm in 13 patients.

The fractures of humerus were classified according to the AO classification system into A1, A2, A3, B1, B2, B3, C1, C2 and C3. 5 patients in A1 group (simple spiral fracture), 5 in A2 group (oblique fracture with fracture angulation being > or = 30 degrees), 4 patients were in A3 (transverse fracture with fracture angle less than 30 degrees), 3 patients were in B1 (spiral wedge fracture-butterfly fragment), 3 patients were in B2 group (i.e. bending wedge), 1 patient in B3 group (fragmented wedge), 3 patient in C1 group (complex spiral), 1 patients in C2 group (complex segmental) and 1 patient in C3 group (communited irregular).

An anterolateral approach was used in 19 patients and a posterior approach was used in 7 patents.

STATISTICAL ANALYSIS

All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Chi-square (χ^2)/ Freeman-Halton Fisher exact test was employed to determine the significance of differences between groups for categorical data. The difference of the means of analysis variables between two independent groups was tested by unpaired t test. If the p-value was < 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant. Data were analyzed using SPSS software v.23.0. and Microsoft office.

CLINICAL EVALUATION

When the shaft of humerus is fractured and displaced, the diagnosis is usually obvious. The extremity is shortened, and there is abnormal mobility or crepitus on gentle manipulation associated with swelling and pain. The diagnosis is difficult in incomplete fractures or fractures without displacement and is based on local bony tenderness.

The neuromuscular status of the limb must be evaluated. X-ray examination is confirmatory and must include both ends of the bone, the shoulder and the elbow joints.

TREATMENT

- The goals of treatment of humeral shaft fractures are
  - To achieve acceptable alignment.
  - To restore patients to their prior level of function.
- Management can be of two types
  - Non Operative
  - Operative

NON OPERATIVE TREATMENT

The humerus is well encased by muscle and has robust blood supply. The wide range of motion of the shoulder and the elbow allows for accommodation of certain degrees of angular, axial and rotational malunion[2].

Sir John Charnley has said "humerus is perhaps the easiest of the major long bones to treat by conservative methods"[75]. Because of this fact, closed treatment was the initial treatment of choice for most humeral shaft fractures. A union rate of 90-100% could be expected[4].

The various treatment modalities can be broadly divided into two groups.

1. Dependency traction methods.
2. Thoraco brachial immobilization

Dependency traction – here gravity reduces the fracture and maintains the reduction as long as the arm is dependent.

1. Hanging arm cast.
2. Coaptation splint or 'U' slab.
3. Functional cast bracing.
4. Skeletal traction.

The types of Thoraco brachial immobilization are

1. Joacksonville sling[4] or StockinetteVelpeau shoulder dressing[68].
2. Sling and swathe
3. Open Velpeau type cast.
4. Shoulder spica

Hanging arm cast –

This was introduced by Caldwell in 1933[3,4,68]. It remains a good technique till date. This relies on the weight of the cast to achieve reduction.

The indications for the use of this cast are displaced midshaft fractures with shortening with a spiral or oblique pattern[68]. Transverse fractures have a tendency for distraction and healing complications if treated by this method[68]. The cast ought to be light weighted and applied with the elbow at 90 degree and forearm in mid prone position.

The cast ought to extend from 2 cm proximal to the fracture site to the wrist. Three loops are applied in the distal forearm in dorsal, neutral and volar position. The cast must hang free from the body and the patient must sleep in an erect or semi-erect position.

Circumduction and isometric exercises are initiated to prevent frozen shoulder and subluxation.

This can be used in isolation or it can be converted to a functional cast brace once reduction is achieved.

Coaptation Splint-

This is indicated for fractures with minimal shortening[68]. It consists of a slab extending form axilla, down below the elbow and along the lateral arm, over the shoulder to the root of the neck. It is held in place by bandage.

This allows hand and wrist motion and to a limited extent elbow motion. Disadvantages are axillary irritation and loss of elbow extension. It should be converted to a functional cast brace as soon as possible.

Functional Cast Brace -

This works on the principle of active muscle contraction. The hydraulic effect of soft tissue compression aligns the fracture fragments and the beneficial effects of gravity.

Functional cast bracing in its modern form was described by Augusto Sarmiento in 1977[76]. It initially consisted of a custom made brace extending, medially from 2.5 centimeters below the axilla to 1.3 centimeters above the medial epicondyle, laterally from a point just below the acromion to slightly above the lateral epicondyle. This has now given way to prefabricated braces consisting of two plastic sleeves that

encircled the arm with two adjustable Velcro straps to hold the sleeves together. When the fracture is the result of a low-energy injury and there is minimal swelling of the extremity, the functional brace can be applied at the first orthopedist-patient contact. Otherwise, it is best to use a cast or splint until the acute symptoms and swelling subside. In most instances, the brace is applied approximately 12 days after injury[77]. Sarmiento in the year 2000 treated 920 patients with cast bracing and reported union rates of 94% and 98% for open and closed fractures respectively. Many other authors have also described excellent results with functional cast bracing[78,79,80,81]. This has become the gold standard for non operative treatment2. Loss of motion in shoulder and elbow is minimal because of early mobilization[82].

Jacksonville sling-

This is indicated in minimally displaced fractures in children below 8 years or elderly patients who are unable to tolerate other methods.[4,68]

Shoulder spica cast-

It is rarely used. Its only use is when significant abduction and external rotation of upper extremity is needed to hold reduction[68]. But in most such cases operative.

OPERATIVE TREATMENT

Though majority of the simple fracture are managed non operatively, specific indications exist for operative treatement[2]. The indications can be divided into fracture indications, patient indications, andassociated injuries.

1. Fracture indications

a. Failure to achieve and sustain adequate closed reduction.

- Shortening greater than 3 centimeter.
- Rotation greater than 30 degrees.
- Angulation greater than 20 degrees

b. Segmental fractures

c. Pathologic fractures

d. Intra-articular extension

- Shoulder joint
- Elbow joint

2. Patient indications

a) Polytrauma

b) Head injury (Glasgow coma scale lesser than 8)

c) Chest trauma

d) Poor patient tolerance

e) Unfavorable body habitus

Ex:- Morbid obesity

f) Parkinson's disease and other neurological diseases[3].

3. Associated injuries

a. Open wound
b. Vascular injury
c. Brachial plexus injury
d. Ipsilateral forearm fractures
e. Bilateral humeral fractures
f. Lower extremity fractures requiring upper extremity weight bearing (Crutch walking).
g. Burns
h. High velocity gunshot injury
i. Chronic associated joint stiffness of shoulder or elbow.

The main methods employed for internal fixation of humeral shaft fractures are

1. Plate and Screws
2. Intramedullary nailing
3. External fixation

PLATE OSTEOSYNTHESIS

This is the gold standard for fixation of humeral shaft fractures[2]. Plating is associated with high union rate, low complications rate and rapid return to function[2]. The plate is applied on the tension side of the bone in accordance with the tension band principle. In humerus the most commonly used plates are the Dynamic compression plate (DCP).

In transverse fractures the plate is applied in compression mode whereas in other fractures it is applied in neutral mode with a lag screw whenever feasible[2,4]. A minimum of 6 cortices (preferably eight) should be engaged on either side of the fracture when fixing a humeral shaft fracture[2].

INDICATIONS FOR OSTEOSYNTHESIS:

Absolute Indications:

- Multiple trauma
- Compound fractures
- Bilateral humeral fractures
- Pathological fractures
- Vascular injury
- Non-union
- Floating elbow
- Radial nerve palsy after closed reduction

Relative Indications:

- Transverse fractures
- Long spiral fractures
- Brachial Plexus Injury
- Primary Nerve Palsy
- Inability to Maintain Reduction
- Parkinson’s Disease
- Noncompliance due to alcohol or drug abuse
- Obesity

BIOMECHANICAL CONSIDERATIONS FOR SURGICAL MANAGEMENT WITH PLATE OSTEOSYNTHESIS

The cortex of the humerus splinters very easily, therefore even long spiral fractures must be protected after lag screw fixation with a neutralization plate. To prevent longitudinal fissuring whenever the humerus is plated, a broad plate should be used. In patients with normal elbow, the posterior cortex of the humerus is under tension. If a patient has a stiff elbow, the anterior cortex becomes the one under tension. This would mean that in patients with a mobile elbow, the compression or tension band plates should be applied posteriorly and in patients with a stiff elbow, anteriorly. Because the redial nerve lies in the spiral groove posteriorly, the posterior surgical approach to the mid diaphysis is more difficult and the radial nerve is at risk of injury. For this reason, Henrys anterior approach to the upper and mid diaphysis is used for plating. Because humerus is non-weight bearing bone and is not subjected to forces as great as those acting on the femur, this biomechanical infringement does not result in any failure of fixation. Fractures of the distal third should be plated posteriorly. Humerus is flat posteriorly and easy to apply broad dynamic compression plate. Plate can also reach further distally without compromising elbow flexion. No neurovascular structures are encountered in the posterior approach to the distal third of the shaft of humerus.

DCP –

The Dynamic compression plate was developed by the AO group in 1969. Because of the special geometry of the hole, compression can be achieved without any external aids. The axial compression is achieved by interplay between the screw hole and the eccentric placement of the screw in the screw hole.

The screw hole is a combination of an inclined and horizontal cylinder which permits downward and horizontal movement of a sphere, the screw head.

The movement of the screw in an axial direction results in movement of the bone relative to the plate resulting in compression at the fracture site.

Advantages of DCP

1. It achieves compression at the fracture site.
2. The screws can be angled 25 degree in the axial and 7 degrees sideways[2,83] thus enabling placement of an interfragmentary lag screw through the plate in Oblique fractures.
3. It can be used as a compression plate, neutralization plate, tension band plate and a buttress plate.

Disadvantages of DCP

1. Flat undersurface-This result in extensive contact between the plate and the bone so decreases the periosteal blood supply.
2. Inclination – the screw cannot be angled more than 25 degrees, so lag screw placement in short oblique fractures is difficult.
3. Distribution of plate holes – there is an extended segment without screw holes so difficulty arises when fixing a fracture with a zone of fragmentation[83].
4. Refracture after plate removal – plates are not load sharing devices. Thus the bone under the plate weakens. The DCP also causes a notch in the bone when used on the tension side. This notch behaves like a stress riser and may facilitate refracture.

SURGICAL APPROACHES AND TECHNIQUES

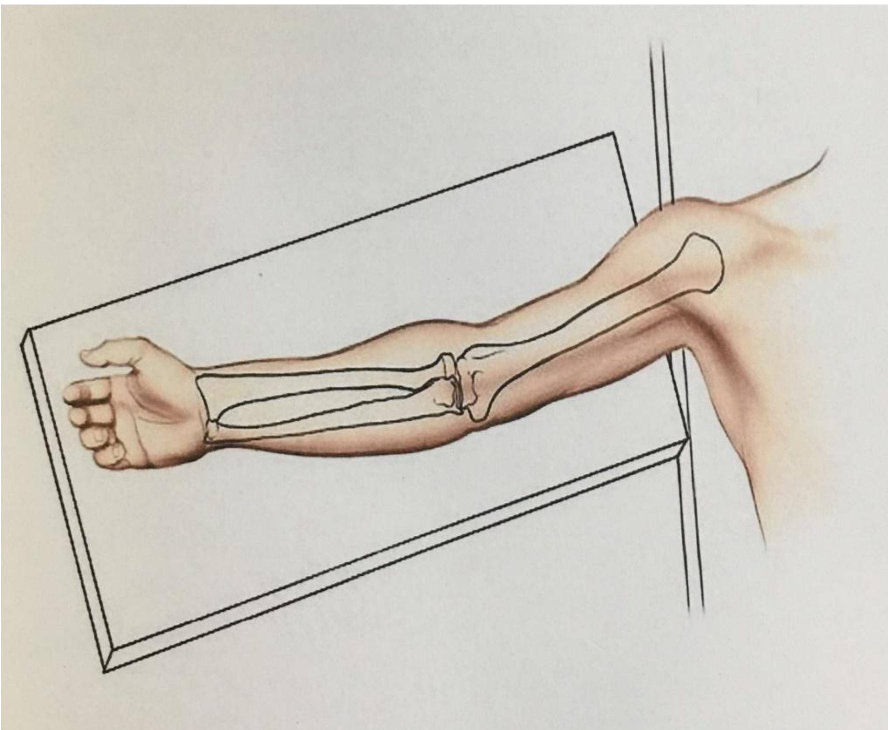
Antero-Lateral Approach (Figure 7)

The antero-lateral approach uncovering the anterior surface of the shaft of the humerus. As in all approaches to the humerus, the radial nerve is the structure at utmostdanger during surgery.

Patient position

Place the patient supine on the operative table, with the arm on an arm board, abducted about 60^{O}. Incline the patient away from the injured arm to lessen bleeding. Most surgeons desire to sit in front of the patient's axilla, with the first assistant on the opposite side of the arm. As tourniquet comes in the way of operative field, it is not used.

Figure 7.1 : Anterolateral Approach – Position of patient



Landmarks and Incision

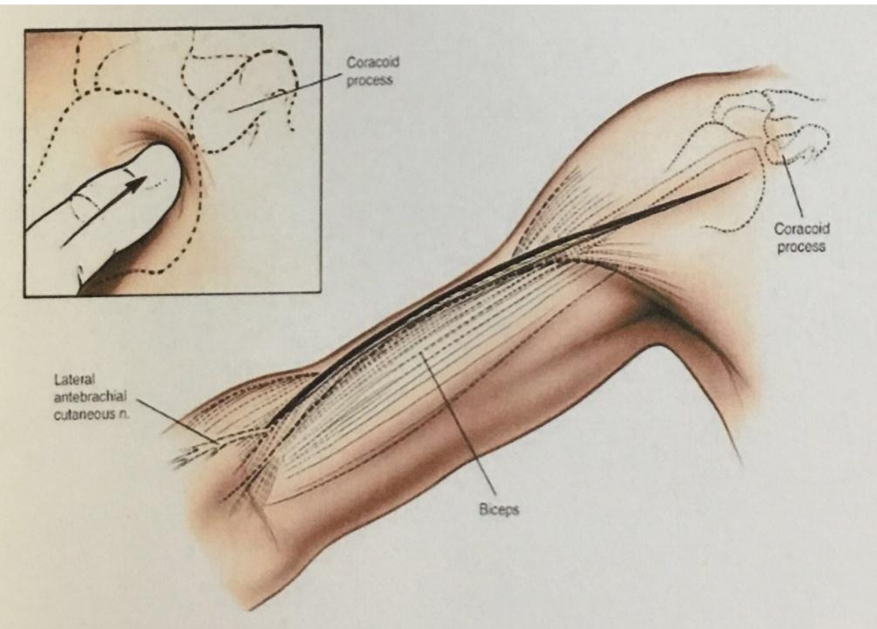
Landmarks

Feel for the coracoids process of the scapula directlyunderneath the intersection of the middle and outer thirds of the clavicle. Palpate the long head of the biceps brachii as it passes the shoulder and turnsdown the arm. The lateral boundary of its easily moving muscular belly rests on the anterior surface of the arm.

Incision

Create a longitudinal incision above the slope of the coracoids process of the scapula. Course it distally and laterally along the deltopectoral groove to the insertion of the deltoid muscle on the lateral side of the humerus, about midway down its shaft. From there, the incision should be continued distally as far-flung as required, next to the lateral limit of the biceps muscle. The incision ought to be at a standstill about 5 cm above the flexion crease of the elbow.

Figure 7.2 : Incision Site

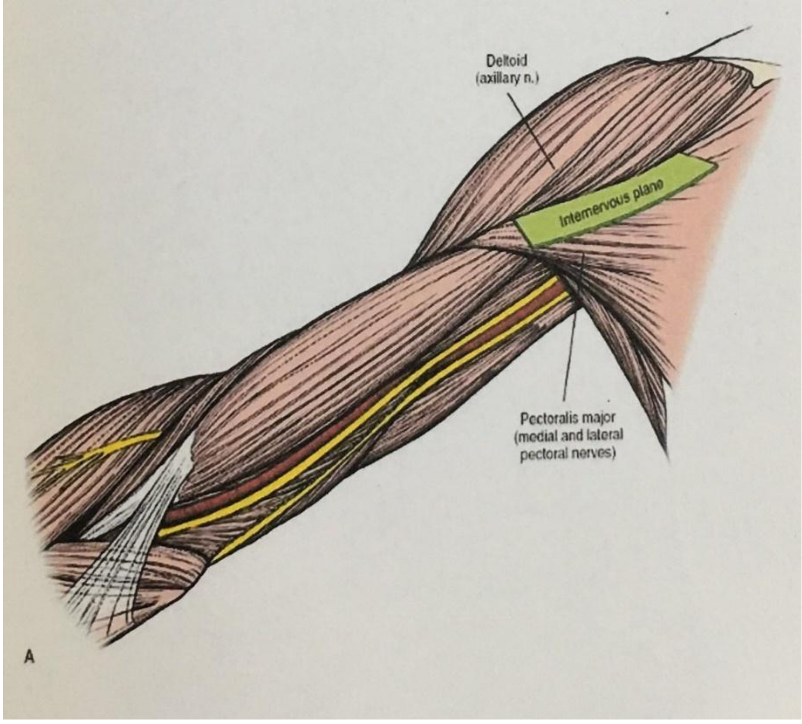


Superficial Surgical Dissection

Proximal Humerus Shaft

Recognize the deltopectoral groove, by means of the cephalic vein as a guide, and detach the two muscles, pull in the cephalic vein eitherlaterally with the deltoid ormedially with the pectoralis major, depending on surgeon preference. Create the muscular interval between the insertion of the pectoralis major muscle into the lateral lip of the bicipital grooveand the insertion of the deltoid muscle into the deltoid tuberosity distally. Be cautiousbefore retracting the deltoid; ardentusage of the retractor may paralyze the anterior half of the muscle by producing a compression damage to the axillary nerve.

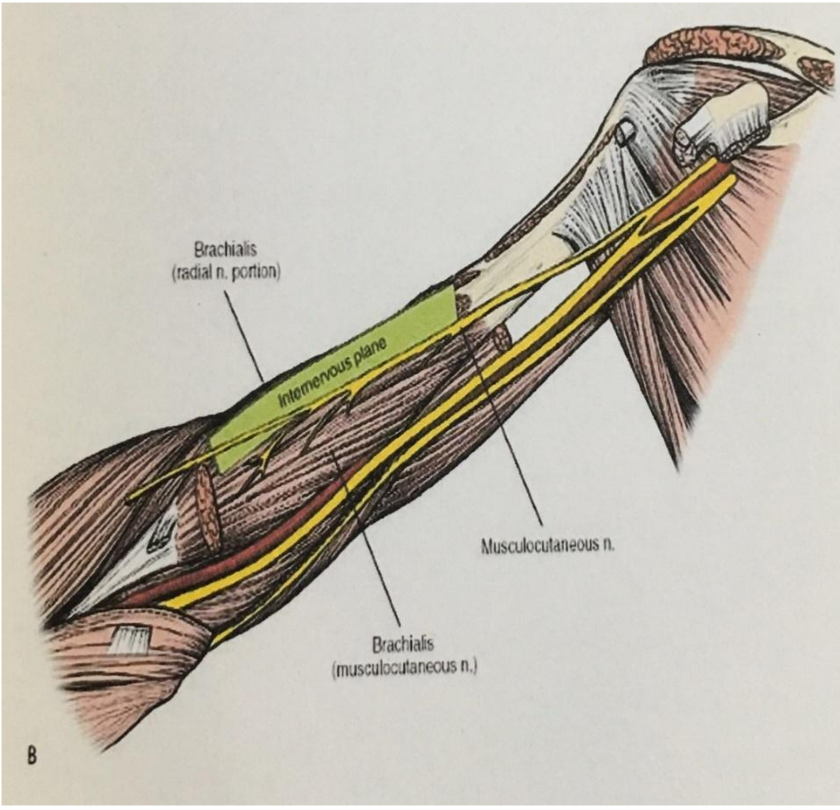
Figure 7.3 (A) : Superficial Dissection



Distal Humeral Shaft

Slit the deep fascia of the arm along with the skin incision. Recognize the muscular interval amid the brachialisand the biceps brachii. Create the interval by withdrawing the biceps medially. Underneath it is the anterior aspect of the brachialis, which wraps the humeral shaft.

Figure 7.3 (B) : Superficial Dissection



Deep Surgical Dissection

Proximal Humerus Shaft

To uncover the upper part of the humerusshaft, slit the periosteum longitudinally just on the side to the insertion of the pectoralis major muscle. Carry on the incision proximally, continuing lateral to the tendon of the long head of thebiceps. The anterior circumflex humeral artery passes the field of dissection from medial to lateral path and must be ligated. To bare the bone completely, it may be necessary to detach a portion or all of the insertion of the pectoralis major muscle from the lateral lip of the bicipital groove of the humerus. This must be carried outsubperiosteally. Attempt to preserve as much soft-tissue attachment as conceivable. If it is required to dissect more around the bone, then this dissection ought tostay in a subperiosteal planestringently. This will evadeinjury to the radial nerve, which girdlesmidshafthumerus in spiral groove from medial to lateral direction posteriorly.

In higher up proximal humeral fractures, particularly comminuted fractures, the head and anatomic neck of the humerusshould be exposed. To achieve this, the subscapularis muscle must be separated, with utmost care taken to coagulate the triad of vessels that runs alongside the lower margin of that muscle. Frequently, however, the lesser tuberosity with the attached subscapularis tendon forms a separate fracture fragment, rendering division of the subscapularis tendon unnecessarily.

Figure 7.4 (A) : Deep Dissection

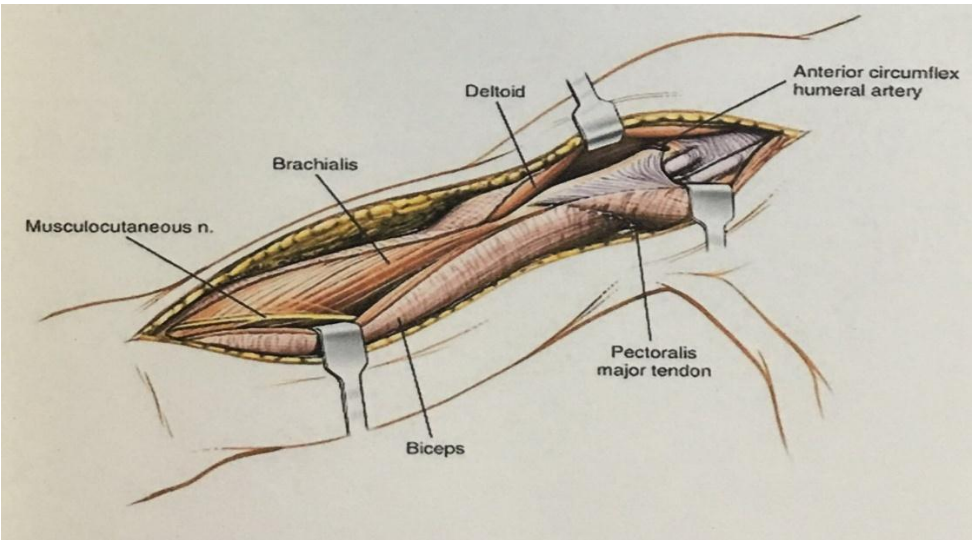
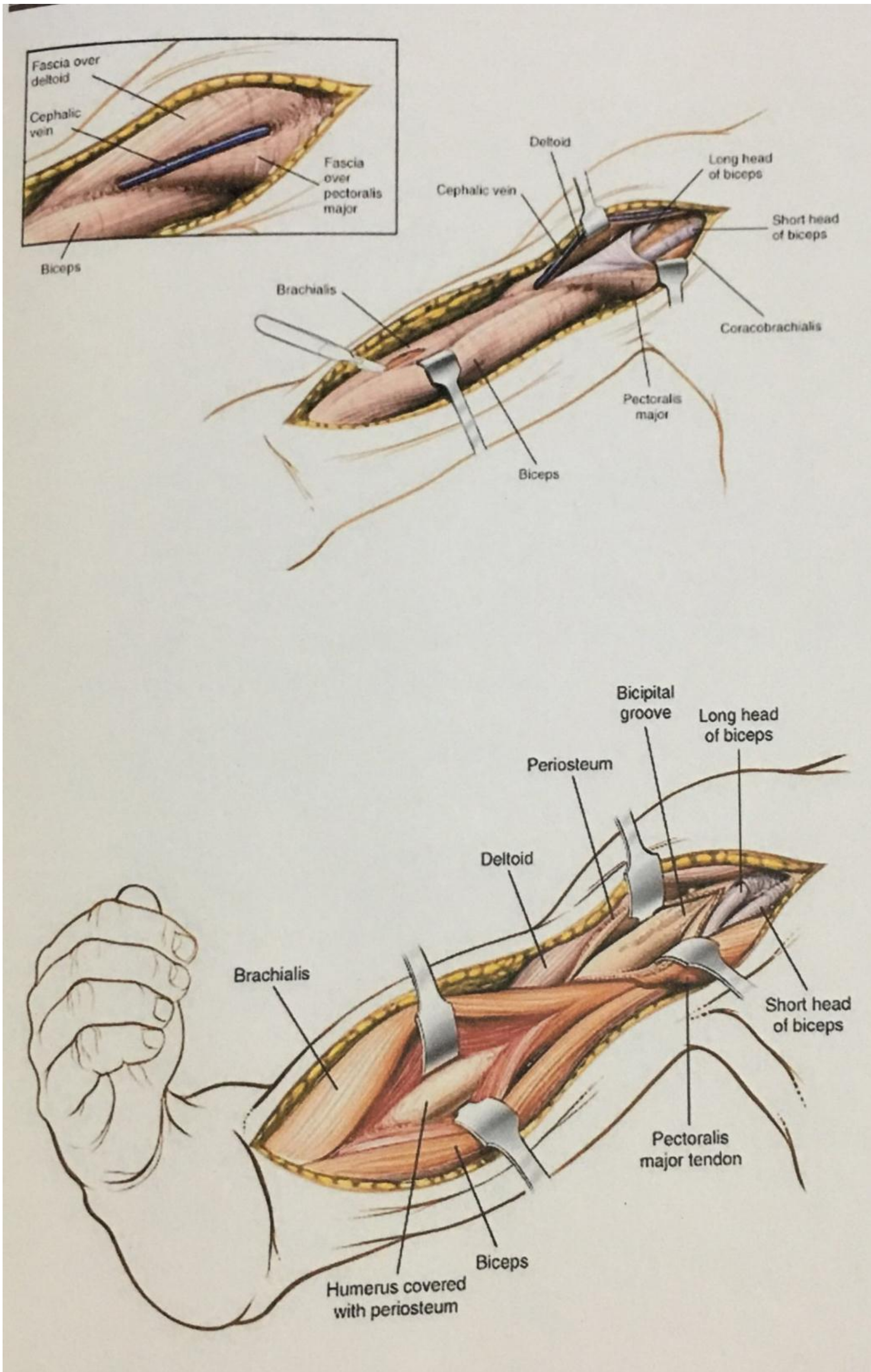


Figure 7.4 (B) : Deep Dissection



Distal Humeral Shaft

Divide the fibers of the brachialis vertically along its midline to uncover the periosteum on the anterior surface of the humeral shaft. Shred the brachialis off the anterior surface of the bone. Attempt to preserve as much soft-tissue attachment as possible. Flex the elbow to release thetautness off the brachialis. The bone is now exposed.

Dangers

Nerves

The radial nerve is at risk at the following two points:

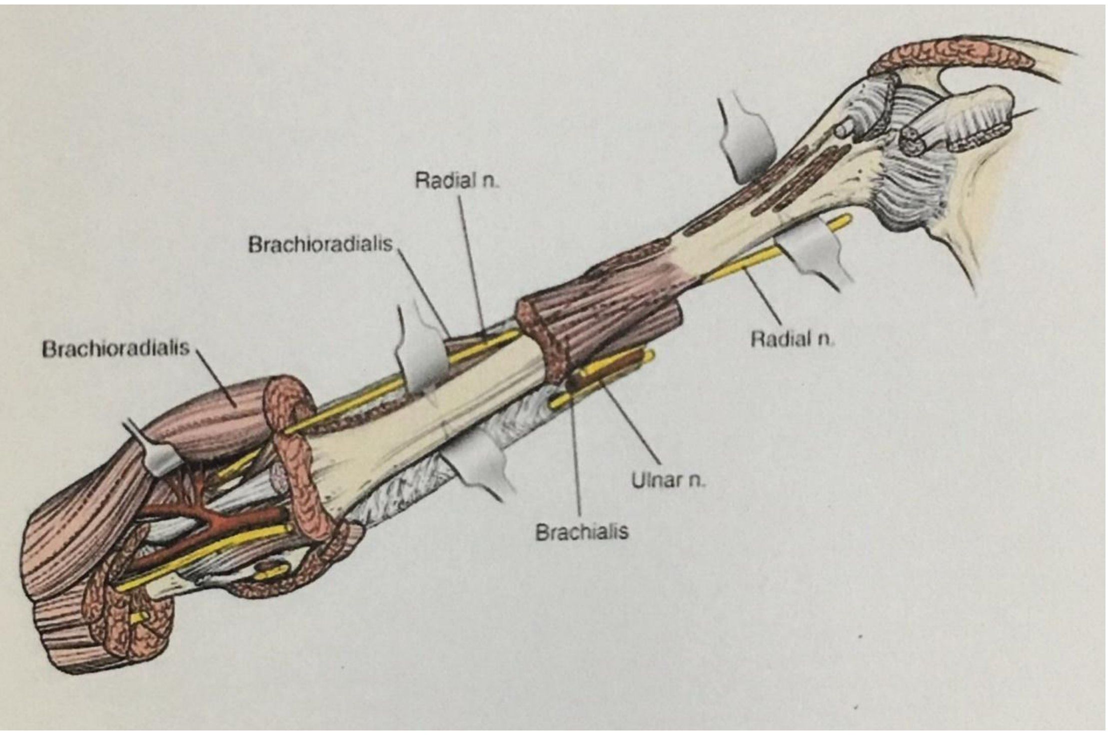
- In the spiral grove on the rear part of the mid third of the humerus, not straying onto the posterior surface of the bone. Summon up that the radial nerve could be injured by drills, taps or screws that are placed in antero-posteriorly when anterior plates are being applied in the mid third of the bone.
- In the anterior compartment of the distal third of the arm. Here, the nerve has penetrated the lateral intermuscular septum and lies between brachioradilais muscle and the brachialis muscle. Note that this plane is oblique and not vertical. To evade injuring the nerve, divide the branchialis at its centre; the lateral part of the muscle then aids as a pad between the retractors that are used in the exposure and the nerve itself.

The axillary nerve, which courses underneath the deltoid muscle, might be injured as a consequence of a compression injury produced by excessive retraction of the muscle. Precaution ought to be taken when the retractors are being placed on the deltoid to evade damaging the nerve.

Vessels

The anterior circumflex humeral artery crosses in the recess between deltoid muscles and the pectoralis major in the upper third of the arm. Since lacerating these arteries cannot be circumvented, they must be cauterized or ligated.

Figure 7.5 : Neurovascular Structures



Technique

After the humerus is exposed and the radial nerve retracted, the fracture is reduced and the plate is placed on the bone such that the appropriate part of the plate is on the fracture site. That is –

- The middle segment of the DCP plate without holes.

Transverse are fixed in compression mode and oblique fractures are fixed in neutralization mode with a lag screw across the fracture site through the plate or separately.

Fixation in compression mode – First the hole nearest to the fracture on one side is drilled in neutral mode with the DCP drill guide and a screw of appropriate length is placed and tightened. To achieve compression the hole nearest to the fracture on the other side is then eccentrically drilled with the drill guide in load mode and a screw of appropriate length placed and tightened.

Then the other screws are placed in neutral or compression mode as required.

Post-operative period:

Post operatively a compression bandage was applied and a broad arm pouch was given. Parenteral antibiotics were given for a period of 5 days. Wound is inspected on the 2, 5, 7 post-operative day. Sutures were removed between the 11^{th} and 14^{th} post-operative days.

After Treatment –

The importance of rehabilitation can be aptly summarized by the much quoted and timeless words of the AO group "Life is Movement, Movement is Life"[85].

Whenever anatomical reduction is achieved and bone stock is good motion of the shoulder and elbow should be begun as soon as pain permits. Some situation like marked comminution and poor bone stock need protection by a POP splint.

INSTRUMENTS AND IMPLANTS FOR PLATING

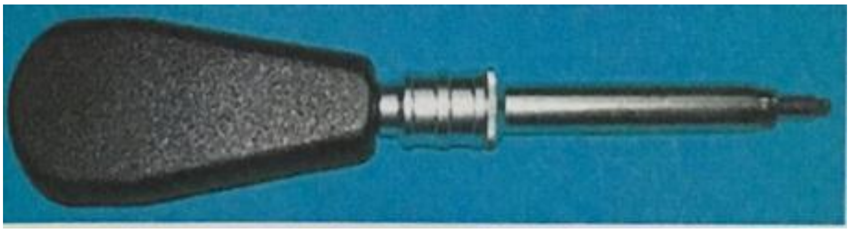
1. Drill
2. Self-retaining forceps
3. Bone hooks
4. Bone levers
5. Fracture reduction forceps
6. Lowman’s forceps
7. Periosteum elevator
8. 3.2 mm drill bit
9. Neutral and eccentric drill guide
10. Depth gauge
11. 4.5 mm tap
12. DCP from 6 hole onwards
13. 4.5 mm hexagonal screws
14. Hexagonal screw driver
15. Counter sink

Figure 8 : Instruments used for Dynamic compression plating

DCP

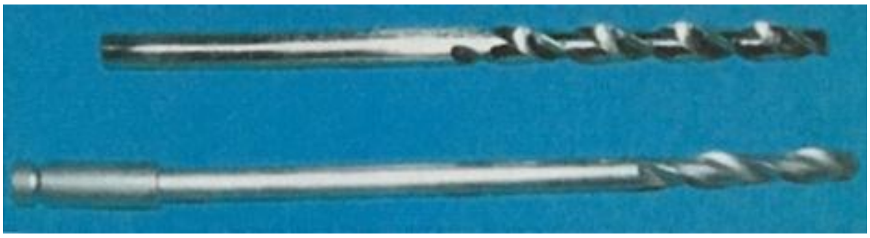
NEUTRAL AND ECCENTRIC DRILL GUIDE

DRILL SLEEVE



HEXAGONAL SCREW DRIVER

COUNTER SINK



3.2 mm DRILL BITS

4.5 mm TAP

4.5 mm HEXAGONAL SCREWS

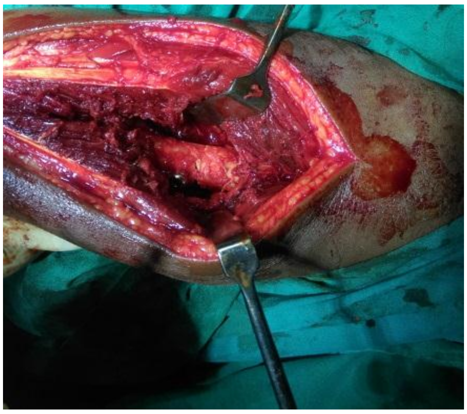
DCP INSTRUMENTATION SET

Figure 9 : Posterior Approach

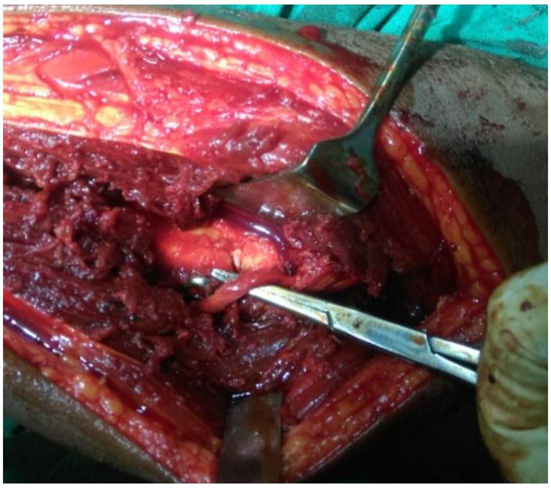
POSITIONING

INCISION

DISSECTION



LAG SCREW FIXATION



RADIAL NERVE IDENTIFICATION

PLATE FIXATION

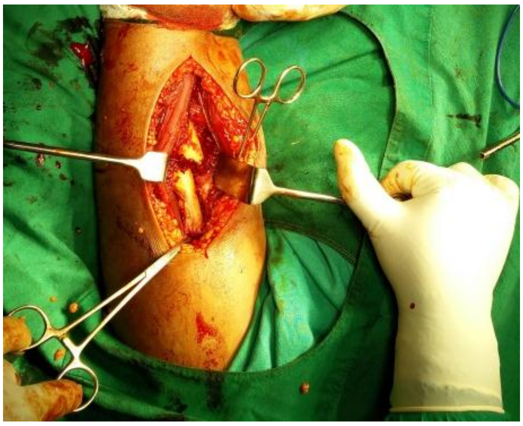
CLOSURE

Figure 10 : Anterolateral Approach

POSITIONING

INCISION\

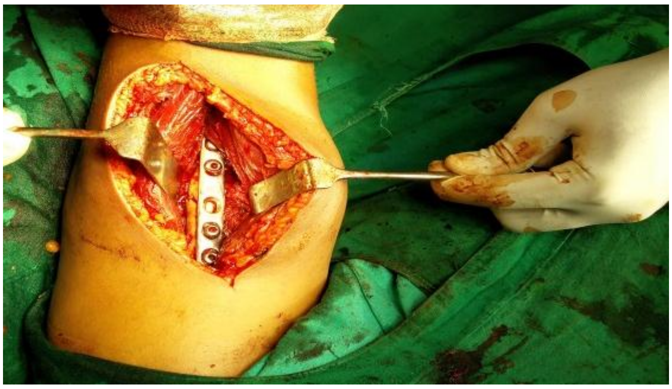
DISSECTION



FRACTURE EXPOSURE

TRAIL REDUCTION

PLATE FIXATION



AFTER SCREW FIXATION

CLOSURE

Figure 11.1 : Case 1 – X-Rays

PRE OP

IMMEADIATE POST OP

6 WEEKS FOLLOW UP

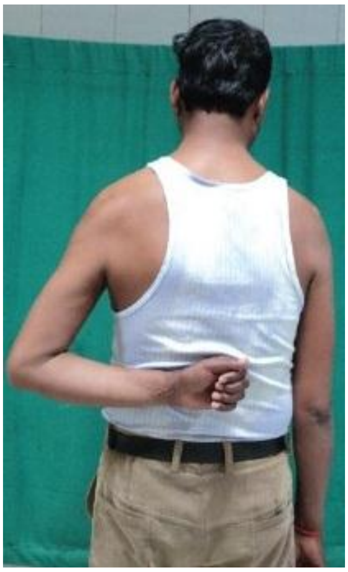
3 MONTHS FOLLOW UP

6 MONTHS FOLLOW UP

Figure 11.2 : Clinical Pictures

SHOULDER ABDUCTION

ELBOW FLEXION

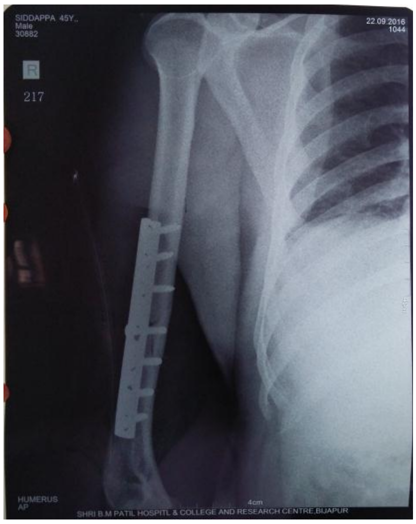


SHOULDER INTERNAL ROTATION

SCAR

Figure 12.1 : CASE 2 – X-Rays

PRE OPERATIVE



IMMEDIATE POST-OP

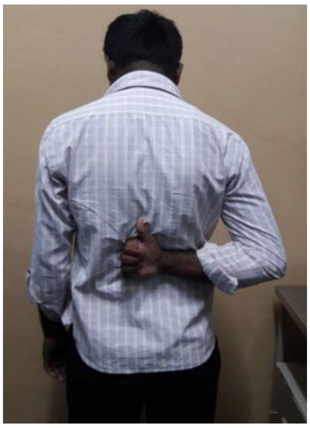
6 WEEKS POST-OP

3 MONTHS POST-OP

6 MONTHS POST-OP

Figure 12.2 : Clinical Pictures

SHOULDER -ABDUCTION



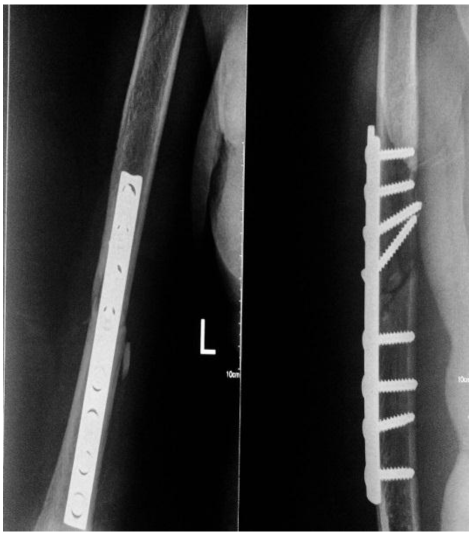
INTERNAL ROTATION

EXTERNAL ROTATION

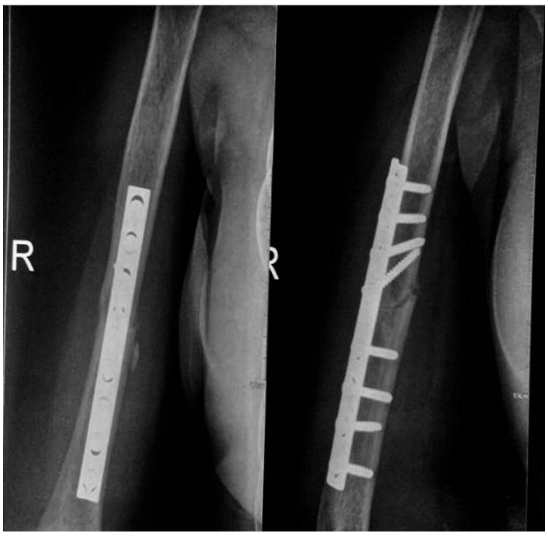
ELBOW FLEXION

ELBOW EXTENSION

Figure 13.1 : CASE 3 – X-Rays



IMMEDIATE POST-OP



6WEEKS FOLLOW UP

6 MONTHS FOLLOW UP

Figure 13.2 : Clinical Pictures

SHOULDER – ABDUCTION

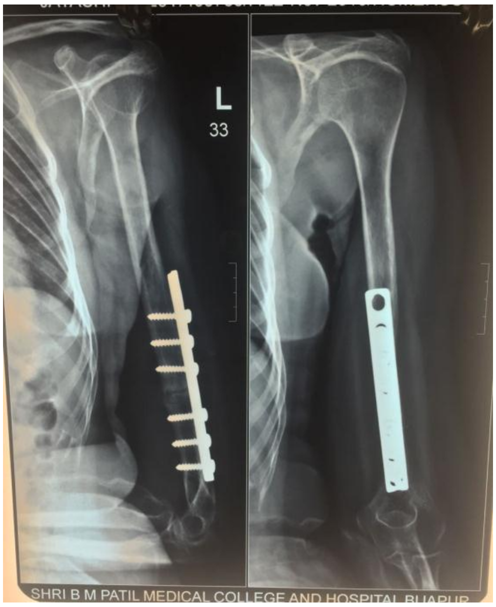
INTERNAL ROTATION

EXTERNAL ROTATION

ELBOW EXTENSION

ELBOW FLEXION

Figure 14 : COMPLICATIONS



NON UNION

INTRA OP COMMUNITION

Post-operative rehabilitation

Dynamic Compression Plating

Post-operative rehabilitation following stable osteosynthesis by plate is straight forward. We start the patient with finger and wrist movements on the 1st post-operative day. Mobilization begins on post-operative day 2 with active-assisted elbow flexion-extension and forearm pronation-supination exercises taking into consideration pain tolerated by the patient. After that if patient is able to tolerate the pain then we start the patient on pendulum exercises of shoulder from post op day 5. Then as the tolerance increases we start the patient with shoulder shrugs and shoulder circling exercises followed up by shoulder abduction stretching exercises. Resistive exercises and load bearing are started only after evidence of bridging callus on radiograph. Thus a good functional range of motion is achieved within 4-5 weeks.

FOLLOW UP AND CRITERIA FOR EVALUATION

The patients were followed up at 1st month, 3rd month, and 6th months post op and then every 2 weekly till radiological union was seen. At every follow up clinical examination was done to assess status of the surgical wound, pain, tenderness, range of motion of shoulder and elbow, stability of the fracture. Roentgenograms were taken in AP and Lateral views to look for signs of radiological union.

The time taken for radiological union was noted. If there are no radiological signs of union by 16-18 weeks, the fracture was categorized as delayed union and if absence of fracture union after 32 weeks after injury was categorized as non union.

We encountered 2 patients who had post-operative radial nerve palsy and they were examined in each visit and power was noted. Return of 5/5 power was regarded as complete recovery.

Functional outcome assessed by American Shoulder & Elbow Surgeons Score

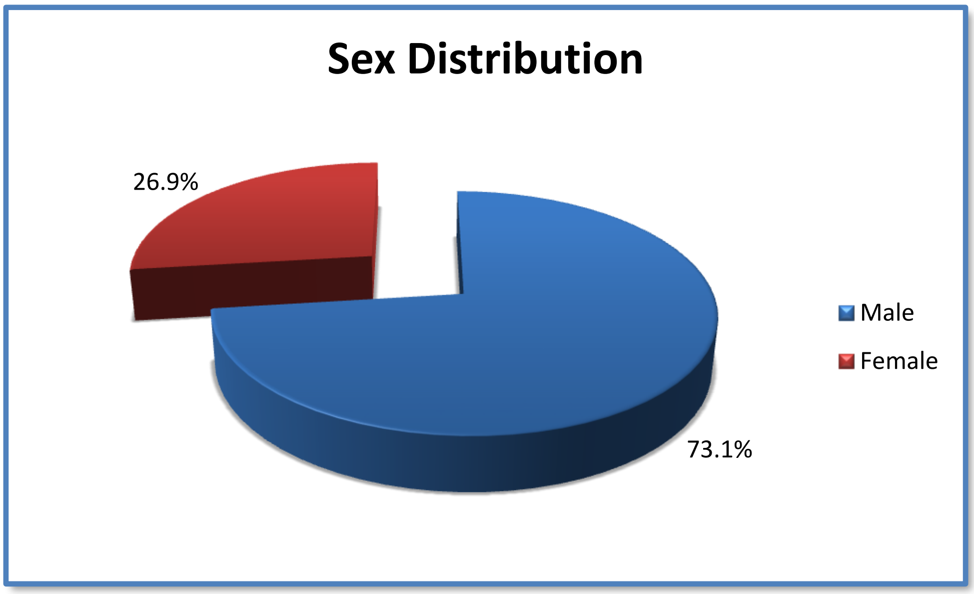
RESULTS

From November 2015- March 2017, 26 patients of fracture shaft Humerus treated with Dynamic compression plate and screws were followed up at BLDEU'S Shri B.M.Patil's Medical College, Hospital and Research Centre, Vijaypur. Observations of the study are as follows:

SEX	N	%
Male	19	73.1
Female	7	26.9
TOTAL	26	100

Table 1 : Distribution of cases by sex

In our study, A male preponderance of 73% was seen.

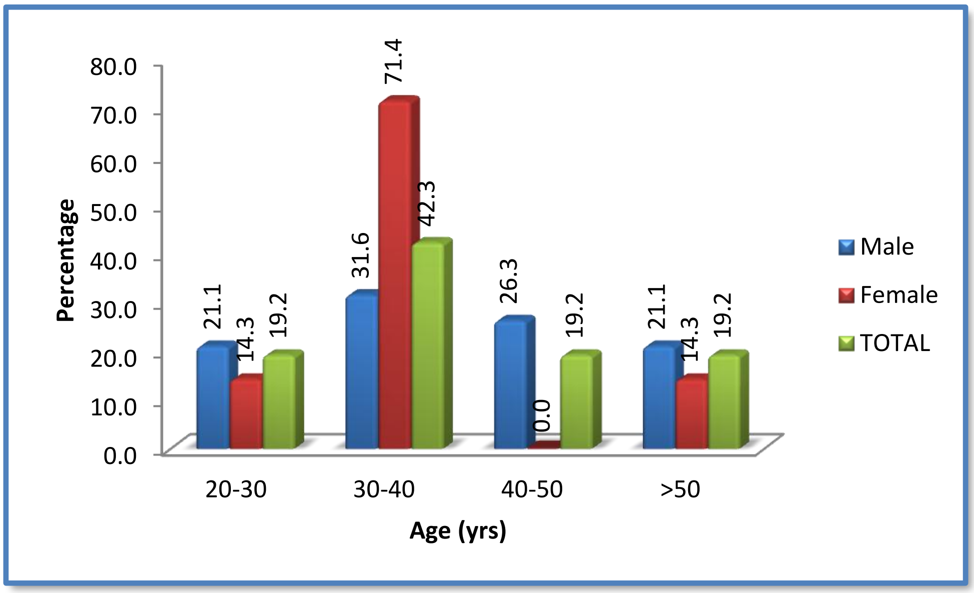


Graph1: Distribution of cases by sex

	Minimum	Maximum	Mean	SD
AGE(Yrs)	20	70	39.2	13.4

Table 2 : Mean Age among cases

The mean age of patients presenting with humerus fractures in SBMPH was 39.2 years. The youngest one was 20 year old and oldest was 70 years old. The modal age group was 30 - 40 years with 42.3% preponderance.

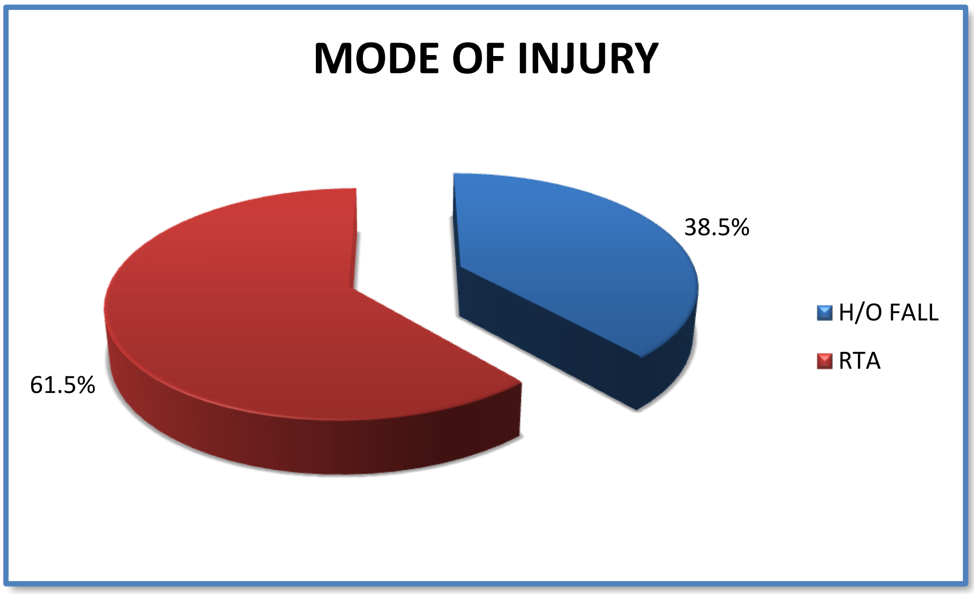


Graph2 : Association of Age and sex among case

MODE OF INJURY	N	%
H/O FALL	10	38.5
RTA	16	61.5
TOTAL	26	100

Table 3 : Distribution of cases by Mode of Injury

The majority of humerus fractures admitted in SBMPH were due to RTA (61.5%), followed by history of fall (38.5%).

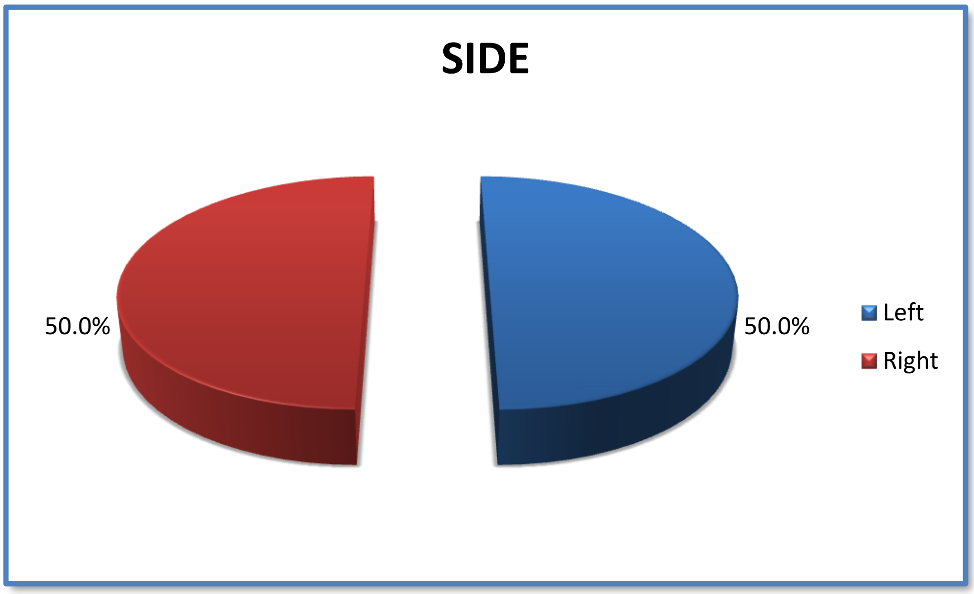


Graph3 : Distribution of cases by Mode of Injury

SIDE	N	%
Left	13	50
Right	13	50
TOTAL	26	100

Table 4 : Distribution of cases by Side

Out of 26 patients with humerus fractures there was equal incidence of both sides of the arm.

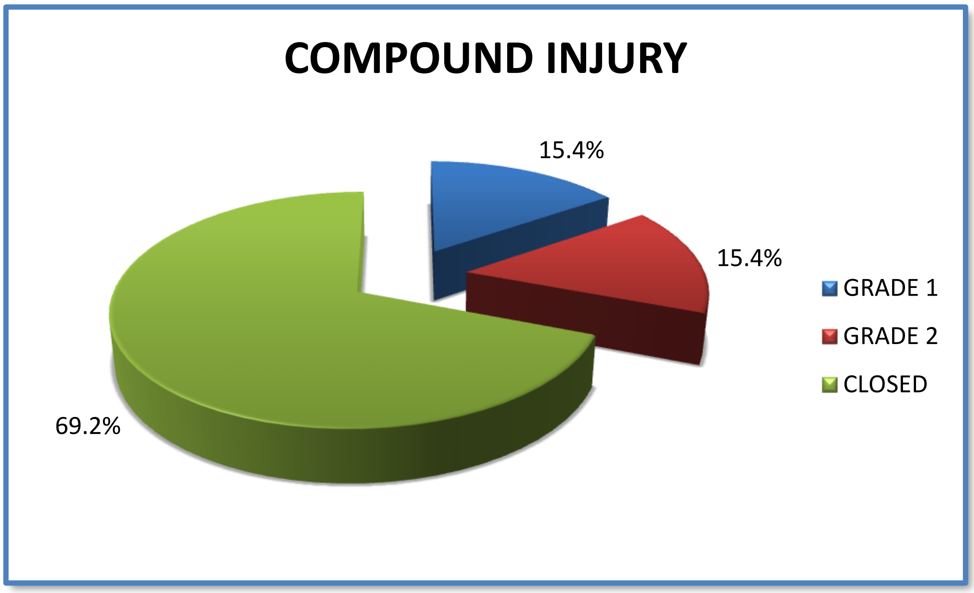


Graph4 : Distribution of cases by Side

COMPOUND INJURY	N	%
GRADE 1	4	15.4
GRADE 2	4	15.4
CLOSED	18	69.2
TOTAL	26	100

Table 5 : Distribution of cases by Compound Injury

Majority of humerus fractures were closed (69.2%), followed with grade 1 and grade 2 Gustilo and Anderson compound injuries. Grade 3 injuries were not included in the study.

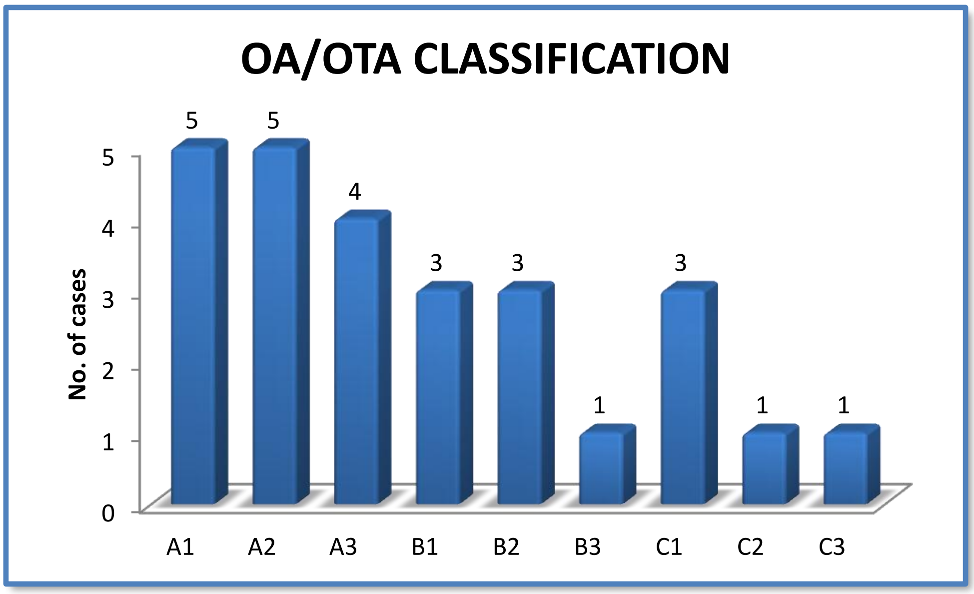


Graph5 : Distribution of cases by Compound Injury

OA/OTA CLASSIFICATION	N	%
A1	5	19.2
A2	5	19.2
A3	4	15.4
B1	3	11.5
B2	3	11.5
B3	1	3.8
C1	3	11.5
C2	1	3.8
C3	1	3.8
TOTAL	26	100

Table 6 : Distribution of cases by OA/OTA classification

There were 14(53.8%) AO type A fractures, 7(26.8%) AO type B fractures and 5(19.1%) AO type C fractures.

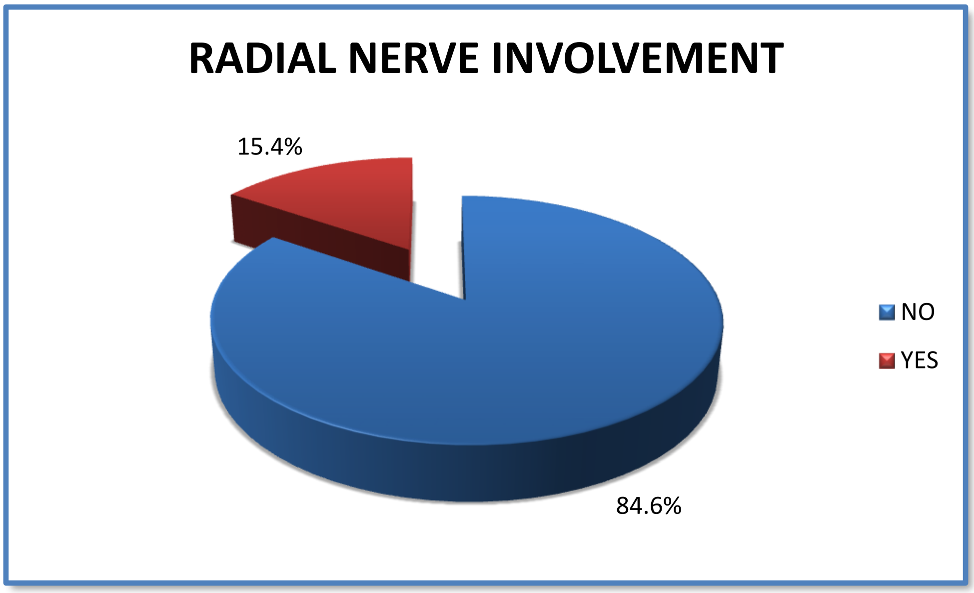


Graph6 : Distribution of cases by OA/OTA classification

RADIAL NERVE INVOLVEMENT	N	%
NO	22	84.6
YES	4	15.4
TOTAL	26	100

Table 7 : Distribution of cases by Radial Nerve Involvement

Preoperative radial nerve palsy was seen in 4(15. 4%) patients. Among them, 3 patients recovered completely and one had persistent nerve palsy.

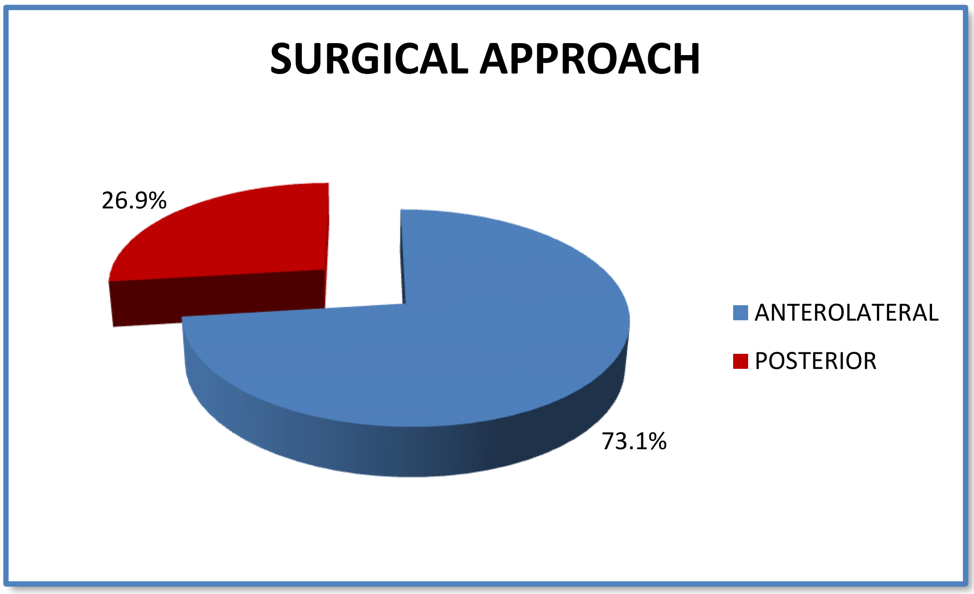


Graph7 : Distribution of cases by Radial Nerve Involvement

SURGICAL APPROACH	N	%
ANTEROLATERAL	19	73.1
POSTERIOR	7	26.9
TOTAL	26	100

Table 8 : Distribution of cases by Surgical Approach

Most common surgical approach used for plating was anterolateral approach (73.1%), followed by posterior approach (26.9%). All patients with radial nerve palsy, posterior approach was used.

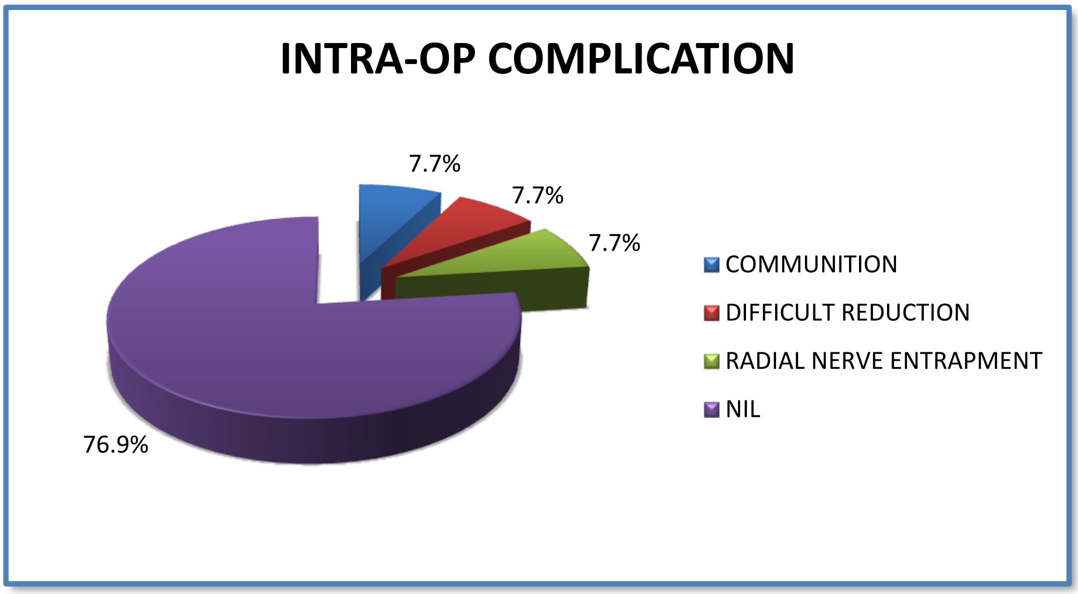


Graph8 : Distribution of cases by Surgical Approach

INTRA-OP COMPLICATION	N	%
COMMUNITION	2	7.7
DIFFICULT REDUCTION	2	7.7
RADIAL NERVE ENTRAPMENT	2	7.7
NIL	20	76.9
TOTAL	26	100

Table 9 : Distribution of cases by INTRA-OP complication

20 patients (76.9%) had no intra operative complications. Rest patients had either communition (7.7%), difficult reduction (7.7%), or radial nerve entrapment (7.7%).



Graph9 : Distribution of cases by INTRA-OP complication

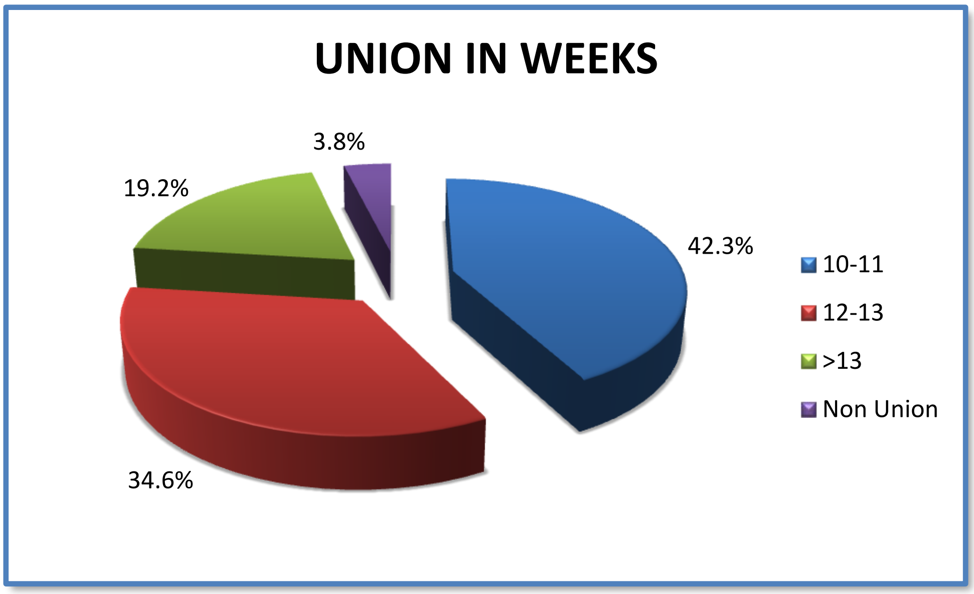
UNION IN WEEKS	N	%
10-11	11	42.3
12-13	9	34.6
>13	5	19.2
Non Union	1	3.8
TOTAL	26	100.0

Table 10.1 : Distribution of cases by duration of union in weeks

	Minimum	Maximum	Mean	SD
UNION IN WEEKS	10	20	12.1	2.5

Table 10.2 : Mean duration of union in weeks

Majority (77%) of fractures united within 13 weeks. 42.3% of for fractures united within 10 to 11 weeks. Mean duration of union was 12.1 weeks. 19.2% of fractures took more than 13 weeks for union with one patient taking 20 weeks. There was one non-union.

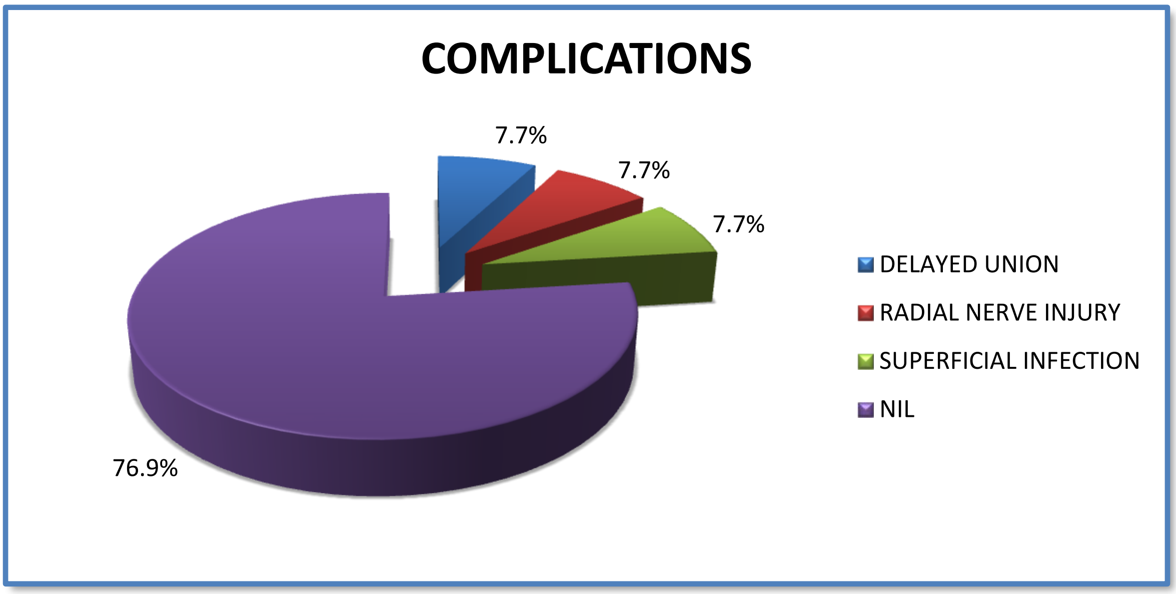


Graph10 : Distribution of cases by duration of union in weeks

COMPLICATIONS	N	%
DELAYED UNION	2	7.7
RADIAL NERVE INJURY	2	7.7
SUPERFICIAL INFECTION	2	7.7
NIL	20	76.9
TOTAL	26	100

Table 11 : Distribution of cases by Complications

77% patients had an uneventful outcome while few had delayed union (7.7%), radial nerve injury (7.7%) and superficial infection (7.7%).



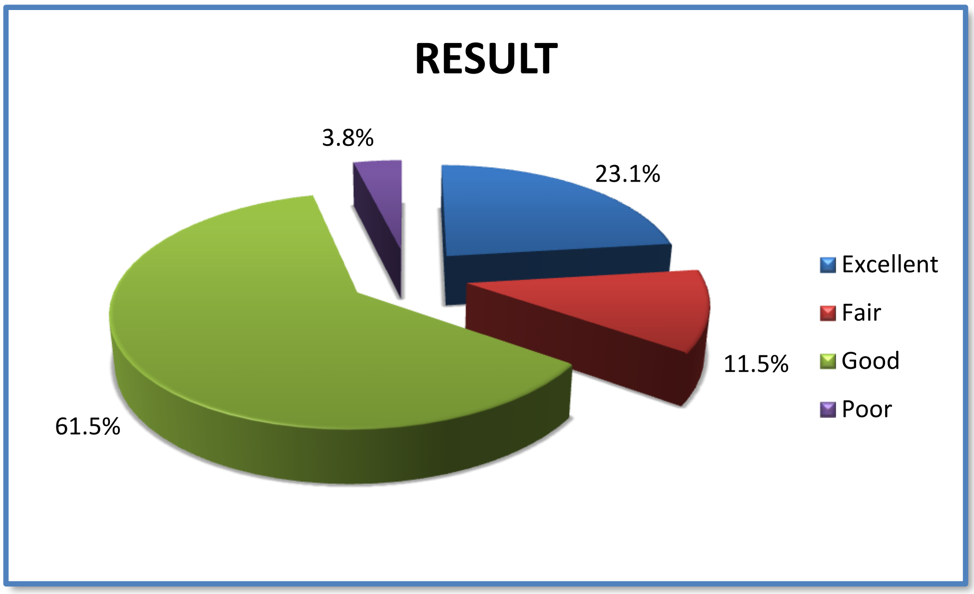
Graph11 : Distribution of cases by Complications

RESULT	N	%
Excellent	6	23.1
Good	**16**	**61.5**
Fair	3	11.5
Poor	1	3.8
TOTAL	26	100

Table 12 : Distribution of cases by Result using ASES score

ASES score of more than 85 was taken as excellent, 75 to 85 as good, 60 to 75 as fair and less than 60 as poor. ASES scores were assessed at the end of six months or full recovery whichever was earlier.

Among 26 patients, 23.1% had excellent outcome, 61.5% had a good outcome and 11.5% had fair outcome.

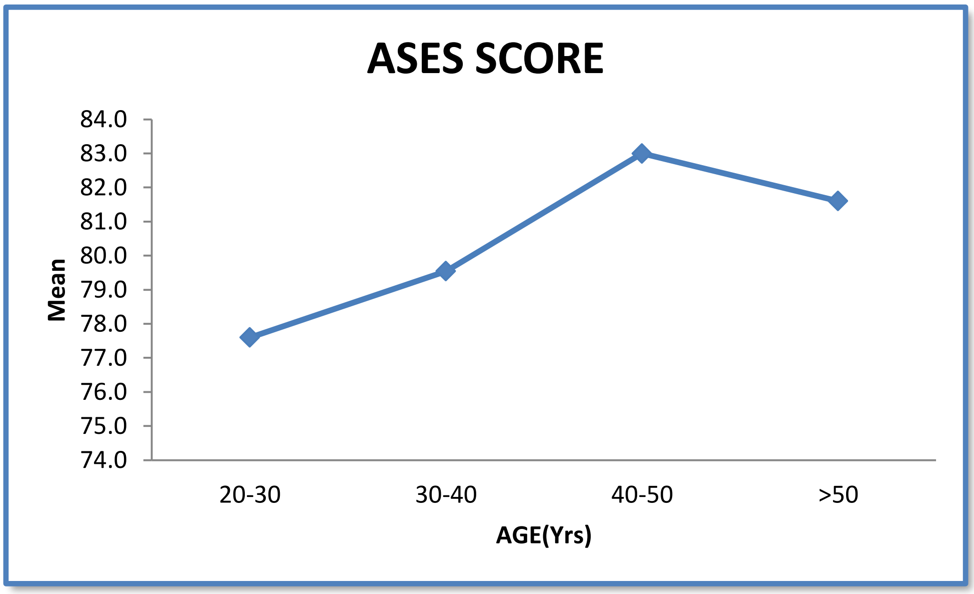


Graph12 : Distribution of cases by Result

AGE(Yrs)	ASES SCORE		p value
	Mean	**SD**	
20-30	77.6	7.5	0.664
30-40	79.5	8.5	
40-50	83.0	6.1	
>50	81.6	5.0	
Total	80.2	7.2	

Table 13.1 : Association of Age and mean ASES Score

The average ASES score was 80.2 with standard deviation of 7.2. Maximum Mean score (83) was seen in age group of 40–50 years, ‘p‘–value being 0.664, there was no statistical significance.



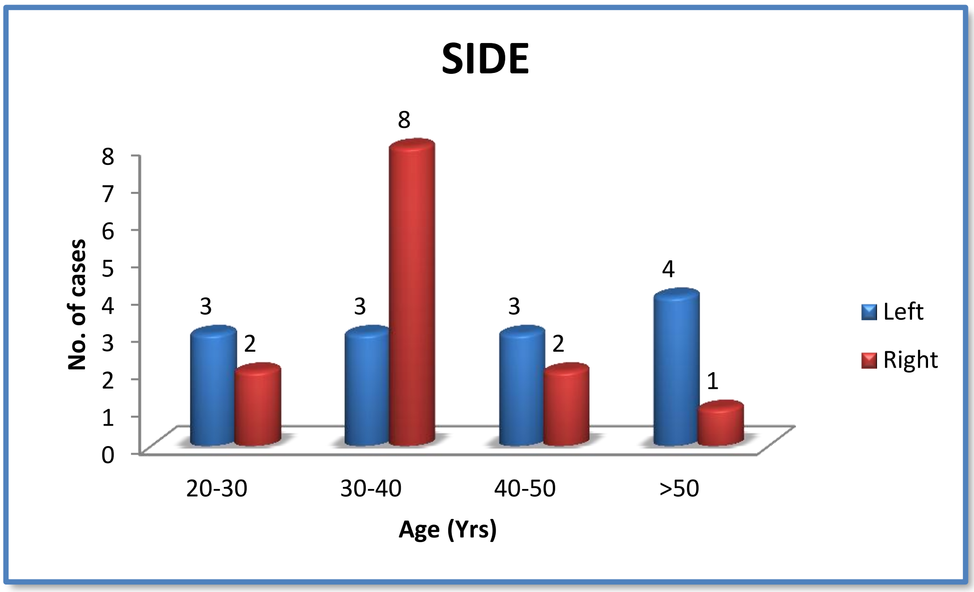
Graph13.1 : Association of Age and mean ASES Score

SIDE	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Left	3	60	3	27.3	3	60.0	4	80.0	13	50.0	0.213
Right	2	40	8	72.7	2	40.0	1	20.0	13	50.0	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.2 : Association of Age and Side

Left arm was involved most commonly in age group of 20–30 years (60%), 40–50 years (60%) and more than 50 years (80%), while right arm was involved most commonly in 30–40 years (72.7%) age group. Overall incidence was equal on both sites.

‘p‘–value being 0.213, there was no statistical significance.

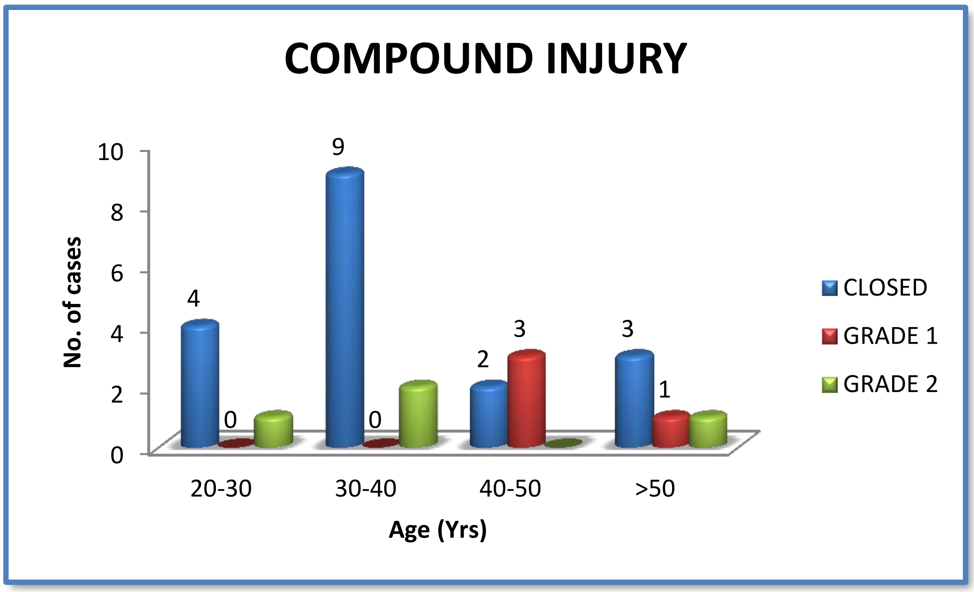


Graph13.2 : Association of Age and Side

COMPOUND INJURY	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
CLOSED	4	80	9	81.8	2	40.0	3	60.0	18	69.2	0.093
GRADE 1	0	0	0	0.0	3	60.0	1	20.0	4	15.4	
GRADE 2	1	20	2	18.2	0	0.0	1	20.0	4	15.4	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.3 : Association of Age and Compound Injury

‘p‘–value being 0.093, there was no statistical significance.

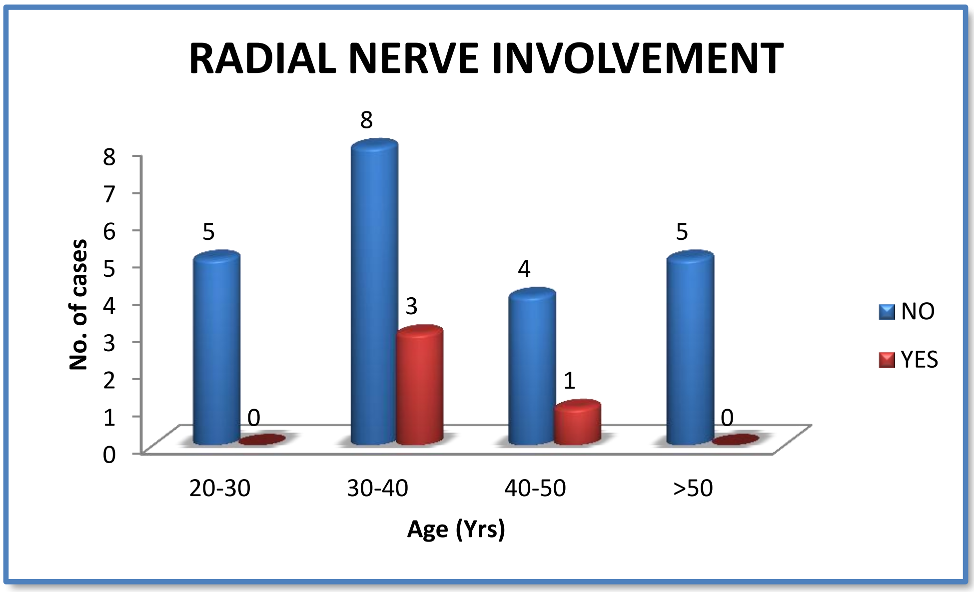


Graph13.3 : Association of Age and Compound Injury

RADIAL NERVE INVOLVEMENT	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
NO	5	100	8	72.7	4	80.0	5	100.0	22	84.6	0.632
YES	0	0	3	27.3	1	20.0	0	0.0	4	15.4	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.4 : Association of Age and Radial Nerve Involvement

‘p‘–value being 0.632, there was no statistical significant.

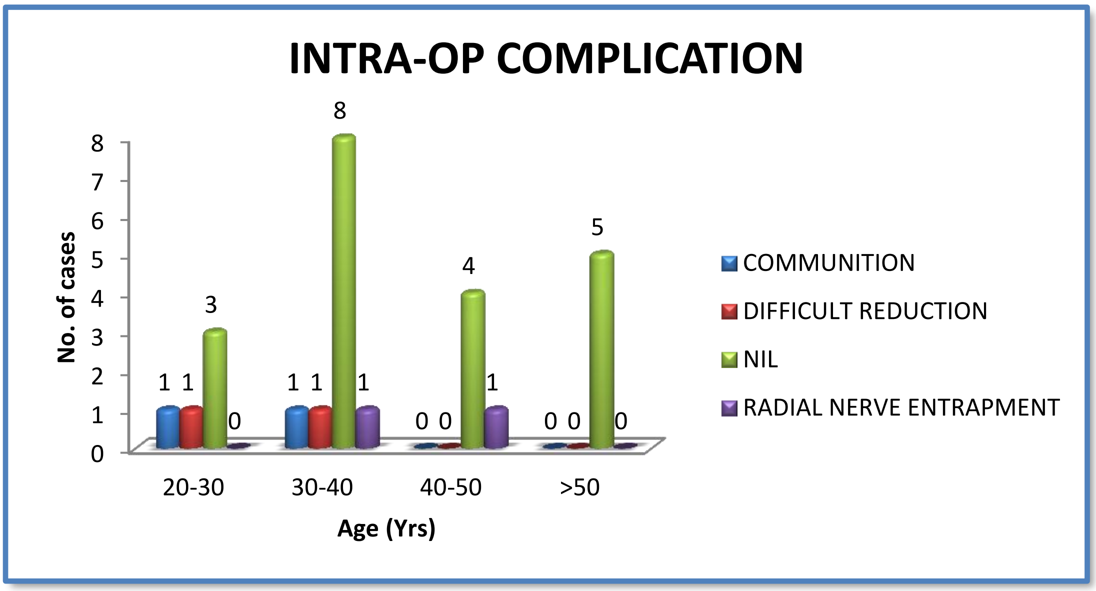


Graph13.4 : Association of Age and Radial Nerve Involvement

INTRA-OP COMPLICATION	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
COMMUNITION	1	20	1	9.1	0	0.0	0	0.0	2	7.7	0.964
DIFFICULT REDUCTION	1	20	1	9.1	0	0.0	0	0.0	2	7.7	
NIL	3	60	8	72.7	4	80.0	5	100.0	20	76.9	
RADIAL NERVE ENTRAPMENT	0	0	1	9.1	1	20.0	0	0.0	2	7.7	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.5 : Association of Age and INTRA-OP complication

‘p‘–value being 0.964, there was no statistical significance.

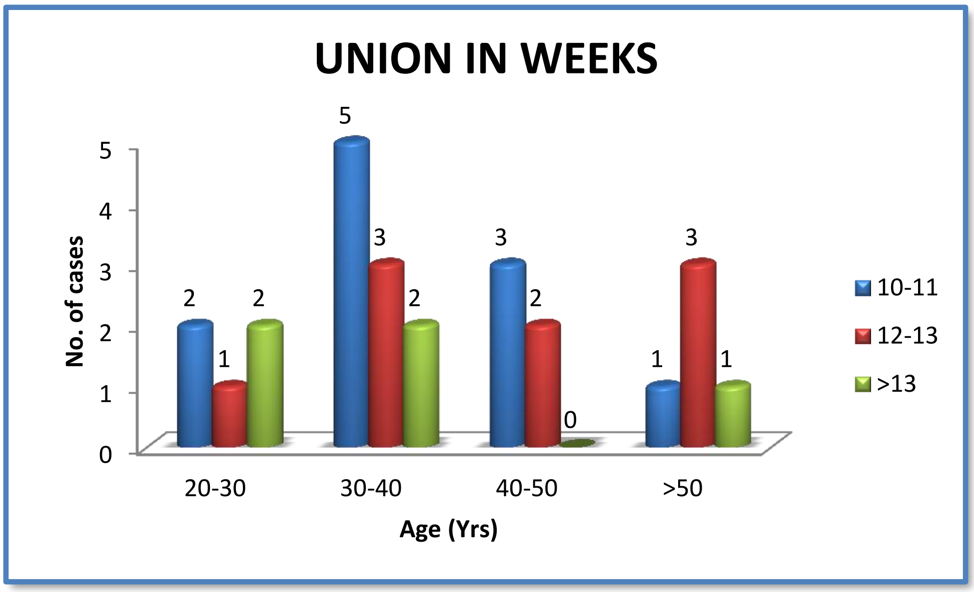


Graph13.5 : Association of Age and INTRA-OP complication

UNION IN WEEKS	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
10-11	2	40	5	45.5	3	60.0	1	20.0	11	42.3	0.685
12-13	1	20	3	27.3	2	40.0	3	60.0	9	34.6	
>13	2	40	2	18.2	0	0.0	1	20.0	5	19.2	
Total	5	100	10	90.9	5	100.0	5	100.0	25	96.2	

Table 13.6 : Association of Age and duration of union

'p'–value being 0.685, there was no statistical significance.

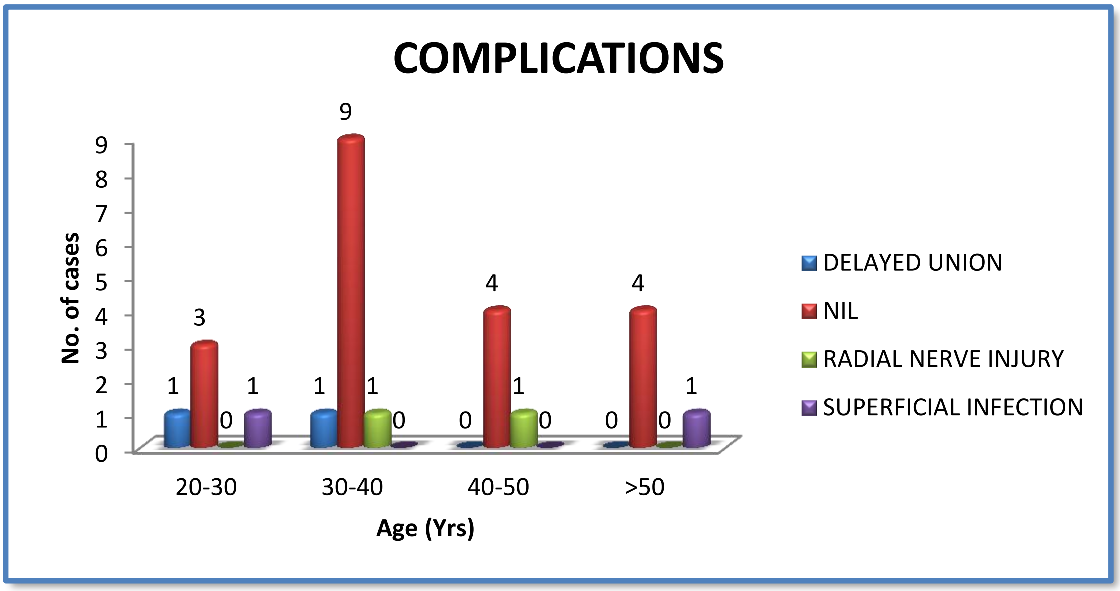


Graph13.6 : Association of Age and duration of union

COMPLICATIONS	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
DELAYED UNION	1	20	1	9.1	0	0.0	0	0.0	2	7.7	0.784
NIL	3	60	9	81.8	4	80.0	4	80.0	20	76.9	
RADIAL NERVE INJURY	0	0	1	9.1	1	20.0	0	0.0	2	7.7	
SUPERFICIAL INFECTION	1	20	0	0.0	0	0.0	1	20.0	2	7.7	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.7 : Association of Age and Complications

‘p‘–value being 0.784, there was no statistical significance.



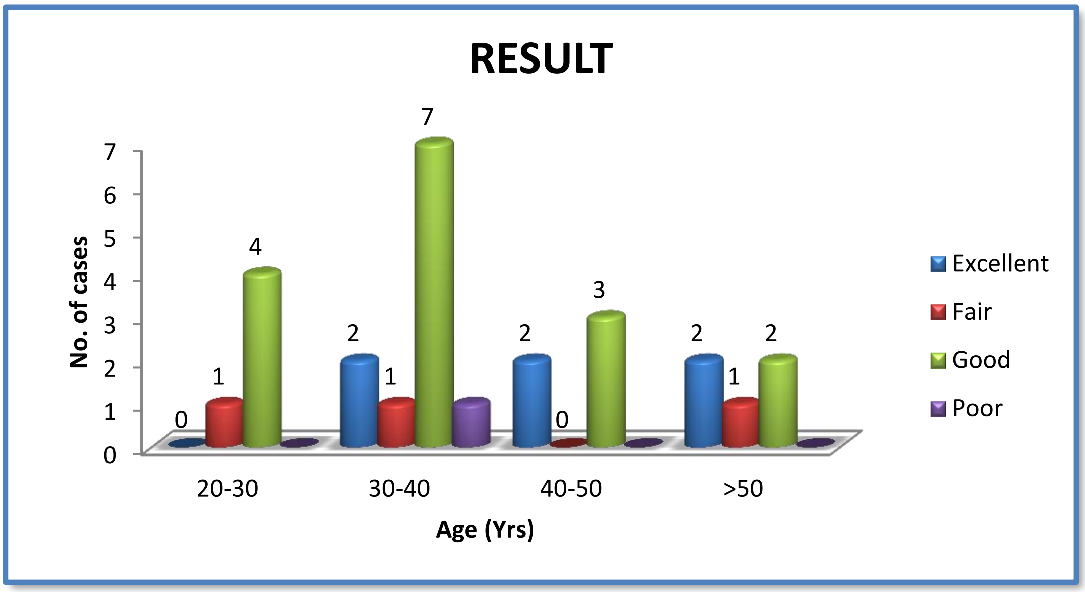
Graph13.7 : Association of Age and Complications

RESULT	20-30		30-40		40-50		>50		Total		p value
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Excellent	0	0	2	18.2	2	40.0	2	40.0	6	23.1	0.868
Fair	1	20	1	9.1	0	0.0	1	20.0	3	11.5	
Good	4	80	7	63.6	3	60.0	2	40.0	16	61.5	
Poor	0	0	1	9.1	0	0.0	0	0.0	1	3.8	
Total	5	100	11	100.0	5	100.0	5	100.0	26	100.0	

Table 13.8 : Association of Age and Result

80% good outcome was seen among 20–30 years age group, 63.6% good result among 30–40 years, 60% among 40–50 years. Among age group more than 50 years, 40% outcome was excellent and good.

‘p‘–value being 0.868, there was no statistical significance.



Graph 13.8 : Association of Age and Result

DISCUSSION

In our study period, 26 patients with midshaft humerus fractures were admitted at Shri B M Patil Medical College and Hospital. Surgical fixation when indicated has the option of plating and intramedullary fixation.[90,91,92] Intramedullary nails have the pitfalls related to shoulder stiffness, rotator cuff injury and elbow joint morbidity. Dynamic compression plate being gold standard for surgical treatment can be used depending on site of fracture and age of patient. Plates are associated with high union rate, low complication rate and rapid return of function.

The indications for open reduction and internal fixation of acute fractures of the humeral shaft have been described as: fractures in patients with multiple injuries, open fractures, fractures associated with vascular or neural injuries or with lesions of the shoulder, elbow or forearm in the same limb; bilateral upper extremity injuries, fractures for which closed methods of treatment have failed and pathological fractures.[93] In several reported series, the presence of associated multiple injuries was the most frequent indication for internal fixation of the humeral shaft. In my study, failed closed reduction and associated injuries were the most common indications.

The mean age of patients presenting with humeral fractures in SBMPH was 39.2 years with range between 20–70 years. The modal age group was 30–40 years. Studies by Ekholm R and Adami J[94], found that incidence increased from 50th decade onwards owing to osteoporosis especially in woman after fifth decade.[95,96]

Most of these fractures occurred more commonly in males. This is in keeping with previous publications[97,95]. In our study, 73% were males.

Of 26 patients operated, half of the patients sustained right humerus shaft fractures and half sustain left humerus shaft of fractures. This is in contrast with the previous studies which show humerus shaft fracture affecting the left arm.[95,96]

In a study carried out by Amit patti,[98] he reported meantime of union of 16 weeks in patient treated with DCP and 18 weeks in patients treated with nailing. In our study, we achieved mean healing time of 12.1 weeks in patients treated with DCP.

The incidence of non-union after plating according to previous reports range from 2% – 4%.[99] In our study, there was one case of non-union.

In previous studies, chances of post-operative radial nerve palsy with Humerus fractures ranged from 6–15%.[100] Dabezies EJ *et al*, in his study incidence of post-operative radial nerve palsy treated with DCP is 2–5%.[101] In our study, considering less sample size, only two patients persisted with post-operative palsy at a later date.

Functional outcome was assessed using ASES Score for shoulder function derived from patient self-reported visual analogue score (50%) rating of pain and cumulative activities of daily living scores (50%), yielding a maximum score of hundred. According to Kingori and Sitati f,[102] their mean ASES score was 46. In our study mean ASES score was 80.2 with the standard deviation of 7.2.

There was no problem with infection in our patients with only two superficial infection (7.7%) among 26 patients. They responded well to debridement and intravenous antibiotics for three weeks.

There were no cases of failure of fixation. In our study, there were two patients with intraoperative communition (7.7%), two with difficult reduction (7.7%) and two with radial nerve entrapment (7.7%).

We also studied, association of age with ASES score, side of fracture, radial nerve involvement, time for union, and result. None had any statistical significance.

SUMMARY

- 26 patients with fracture shaft of humerus were operated in our hospital from November 2015 to January 2017.
- The average age of patients was 39.2 with 19 males and 7 females.
- 16 fractures were due to road traffic accident and 10 were due to fall.
- There was equal distribution of sides of arm in our study.
- Most of the fractures were closed followed by grade I and grade II compound injuries. There were 14 type A (AO classification) fractures, 7 type B fractures and 5 types C fractures. Most common surgical approach used was anterolateral followed by posterior approach.
- Out of 26 patients majority had no intraoperative complications. Intraoperative communition was seen in two patients.
- Majority of fractures united within 13 weeks. There were six excellent results, 16 good results three fair results.
- Dynamic compression plate offers good union, the rate of secondary complications are less which makes it a more favourable modality.

CONCLUSION

Fractures of the shaft humerus are one of the common fractures affecting present generation and treatment modality has to be decided carefully. I am of the opinion that the operative treatment of the humerus fractures should be done in patients with poly trauma and in patients with failed conservative treatment.

The results of this study indicate operative management of humeral shaft fractures results in good functional outcomes with few complications.

Operative management by plating was the only method used for internal fixation. All patients in this study were fixed by this method.

Studies should be done in future comparing functional outcomes of different operative modalities.

For patients with indications for operative management of humeral shaft fractures, plating can be done because of good functional outcomes and healing potential. The limitations of the study are that the sample size is small and no patients were managed operatively by nailing.

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ANNEXURE-I

ETHICAL CLEARANCE CERTIFICATE

B.L.D.E.UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR – 586103

INSTITUTIONAL ETHICAL COMMITTEE

No/58/2015
20/11/15

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 17-11-2015 *at* 03pm *scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has accorded Ethical Clearance.*

Title "Study of Surgical Management of diaphyseal fractures of humerus by open reduction & internal fixation with dynamic compression plate & screws"

Name of P.G. Student : Dr. Sharad Shirol
Dept of Orthopaedics

Name of Guide/Co-investigator : Dr Ashok. R. Nayak
Professor of Orthopaedics

DR.TEJASWINI VALLABHA
CHAIRMAN

CHAIRMAN
Institutional Ethical Committee
BLDEU's Shri B.M. Patil
Medical College,BIJAPUR-586103.

Following documents were placed before E.C. for Scrutinization
1)Copy of Synopsis/Research Project
2)Copy of informed consent form.
3)Any other relevant documents.

SCORING SYSTEM

American Shoulder and Elbow Surgeon's Self-report Form

Patient Self-Evaluation

Pain:

1. How bad is your pain today (mark line)?

0|____|10

No pain at all   Pain as bad as it can be

Function:

Circle the number in the box that indicates your ability to do the following activities:

0 = Unable to do; 1 = Very difficult to do; 2 = somewhat difficult; 3 = Not difficult

Activity	Right arm	Left Arm
1. Put on a coat	0 1 2 3	0 1 2 3
2. Sleep on your painful or affected side	0 1 2 3	0 1 2 3
3. Wash back / do up bra in back	0 1 2 3	0 1 2 3
4. Manage toileting	0 1 2 3	0 1 2 3
5. Comb hair	0 1 2 3	0 1 2 3
6. Reach a high shelf	0 1 2 3	0 1 2 3
7. Lift 10 lbs above shoulder	0 1 2 3	0 1 2 3
8. Throw a ball overhand	0 1 2 3	0 1 2 3
9. Do usual work – List:	0 1 2 3	0 1 2 3
10. Do usual sport – List:	0 1 2 3	0 1 2 3

General Description

Purpose: Assessment of patient-rated shoulder pain and function/disability.

Content: Pain (1 item) visual analog scale (VAS); function/disability (10 items) 4-point Likert scale of level of difficulty.

Number of items in scale: 1 pain item and 10 function/disability items, for a total of 11 items.

Subscales: There are 2 subscales: pain (1 item) and function/disability (10 items)

Administration

Method: Questionnaire.

Training: None.

Time to administer/complete:4 minutes.

Equipment needed: Only the instrument itself.

Scoring

Responses: Scale. Pain: 10 cm VAS; function/disability: 10 items, each rated on 4-point Likert scale for level of difficulty

Score range: Pain subscale 0–50 ASES points, function/disability subscale 0–50 ASES points. Total score 0–100 ASES points, 0 -worse pain and functional loss/disability.

Interpretation of scores: Lower score means greater pain and disability.

Method of scoring: Pain subscale = (10-pain raw score) × 5; function/disability subscale = 10 item total × 5 divided by 3. Total score = pain subscale (50% of total score) + function divided by disability subscale (50% of total score).

Time to score: 2 minutes.

Training to score: None.

Training to interpret: None.

Norms available: None.

The results was then graded as Excellent, Good, Fair and Poor as follows

Excellent- > 85 points

Good – 75- 85 points

Fair – 60-75 points

Poor - < 60 points.

B.L.D.E.U.'s SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, VIJAYPUR-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned,________________ , S/O D/O W/O _________________, aged ____years, ordinarily resident of _____________ do hereby state/declare that Dr. Sharad Shirol of Shri. B. M. Patil Mdical College Hospital and Research Centre has examined me thoroughly on _______________ at _______________ (place) and it has been explained to me in my own language that I am suffering from _________________ disease (condition) and this disease/condition mimic following diseases. Further Dr. Sharad Shirol informed me that he/she is conducting dissertation/research titled "STUDY OF SURGICAL MANAGEMENT OF DIAPHYSEAL FRACTURES OF HUMERUS BY OPEN REDUCTION AND INTERNAL FIXATION WITH DYNAMIC COMPRESSION PLATE AND SCREWS

" under the guidance of Dr. Ashok. R. Nayak requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have been informed that I can withdraw from my participation in this study at any time if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt ____________________________ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

ignature of doctor:

Witness: 1.

2.

Date:

Place

PROFORMA

SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYPUR - 586103

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR:	RR:
BP:	TEMP:

Other Systemic Examination:

Local examination:

Right/ Left Leg

Gait:

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

c) Shortening

d) Skin

e) Compound injury if any

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Swelling

Movements:		Active	Passive
Shoulder:	Forward flexion		
	Abduction		
	External rotation		
	Internal rotation		
Elbow:	Flexion		
	Extension		

Measurements:

arm length

arm circumference

Neurological examination:

radial nerve involvement

<u>INVESTIGATIONS</u>

- X-ray of Arm AP & Lateral views.
- Complete blood count.
- Bleeding time, Clotting time.
- Urine- Albumin, sugar and Microscopy.
- Random blood sugar, Blood urea and Serum creatinine.
- HIV and HbsAg.
- Blood grouping and Rh- typing.
- ECG.
- Chest X-ray- Postero-anterior view.
- Computed-tomography scan if necessary.
- Other specific investigations whichever needed.

<u>TREATMENT</u>:

- Preliminary treatment on admission- U slab, analgesics
- Anesthesia used – Brachial block / General Anesthesia
  - Final inspection of the plate, screws and fracture reduction under 'C'-ARM.
  - Functional outcome assessed by American Shoulder & Elbow Surgeons Score.

FOLLOW-UP:

- Duration after surgery: 1st month, 3rd month, and 6th months.
- Radiological evaluation – Check X-RAY Arm AP & Lateral views.
- Post-operative complaints:

➢ Pain

➢ Infection

➢ Radial nerve palsy

➢ Iatrogenic fracture

➢ Shoulder and elbow functional restriction

➢ Compartment syndrome

➢ Hardware failure

KEY TO MASTER CHART

E- Excellent

G- Good

F- Fair

P- Poor