“STUDY OF SURGICAL MANAGEMENT OF FRACTURE SHAFT OF HUMERUS WITH LOCKING COMPRESSION PLATE”

By

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In partial fulfillment of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

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ABSTRACT

BACKGROUND:

Humeral shaft fracture make up approximately 3% to 5% of all fractures and have bimodal distribution. One group consists of mostly young males of 21 to 30 years age group and the other of older females of 60 to 80 years. The predominant causes of humeral shaft fractures in young age group are high energy trauma and in case of second group mainly simple fall or rotational injuries.[1]

Most fractures will heal with appropriate conservative care, although a small but consistent number, which is on a rise, will require surgery for optimal outcome. The emphasis has changed from splinting and prolonged immobilization to Open Reduction and Internal Fixation with early mobilization to minimize complications of prolonged immobilization such as joint stiffness.

The current study is to assess the efficacy of Locking Compression Plate.

.**AIM OF THE STUDY:**

1) To assess the duration of radiologically proved union in fracture shaft of humerus treated with Locking Compression Plate (LCP).
2) To assess the anatomical and functional outcome.

MATERIALS AND METHODS:

All cases admitted under Department of Orthopaedics of R L JALAPPA HOSPITAL AND RESEARCH CENTRE attached to SRI DEVRAJ URS MEDICAL COLLEGE, TAMAKA, KOLAR from NOVEMBER 2013 – APRIL 2015 will be included in this

study and meeting the inclusion criteria as mentioned below, during the study period, will be the subject of study.

RESULTS: Most (80%) of the patients showed fracture union by twenty weeks. By six months 90% of the patients had full or almost full range of movements. According to UCLA and Mayo Elbow Performance Index, 80% of the patients through UCLA and 75% through MEPI had excellent to good funtional outcome. There was one iatrogenic radial nerve injury which recovered and two patients had non-unions who were reoperated.

CONCLUSION: Locking compression plating is a superior method of surgical management of diaphyseal fractures of humerus due its rigid fixation which allows early mobilization.It can be used both in young and the elderly with excellent outcomes.

KEYWORDS: Humerus, Locking Compression Plate, diaphyseal fracture

LIST OF ABBREVIATIONS USED

LCP- Locking Compression Plate

DCP Dynamic Compression Plate

LCDCP- Limited Contact Dynamic Compression Plate

Cms centimeter

Mm millimeter

DoA Date of Admission

DoD Date of Discharge

IP In - patient

OP Out – patient

No. Number

POP Plaster of Paris

HOPI History of Presenting Illness

His History

GPE General Physical Examination

CVS Cardiovascular System

RS Respiratory System

PA Per Abdomen

P/I/C/C/L/E Pallor/ Icterus/ Clubbing/ Cyanosis/

Lymphadinopathy/ Oedema.

Flex. Flexion

Ext. Extension

Abd. Abduction

Add. Adduction

IR Internal Rotation

ER External Rotation

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INTRODUCTION

In this modern age, fractures of Humerus are on an increase & the management of these fractures also form an important part of orthopedic management. Fractures of Humerus accounts for nearly 3% of all fractures[1].

With ever increasing vehicular traffic, leads to considerable increasing number of road traffic accidents. Speedy vehicles have high velocity injuries associated with complicated fracture. Fracture pattern are often grossly comminuted and often open fractures resulting in greater morbidity among the working population. The other cause of fracture are being direct blow, fall from height, assault, gunshot injuries and blast victims of terrorist activities.

Although most of humeral shaft fractures can be managed conservatively with good to excellent results, the matter of consideration is of maintaining their alignment, length, rotations & early mobilization of the neighboring joints.

More and more, devices and implants are designed to cope up with various complex fracture patterns as the trend now being internal fixation and early mobilization which allows immediate to return to their work .

The AO group has devised many excellent implants for the fixation of fractures. Locking compression plate is a newer device in which the screws are locked into the threads provided in the screw hole of the plate making the plate and screw become a single assembly. The advantage is that there wont be any backing out of the screw resulting in loosening of the plate and failure of fixation especially in case of osteoporotic bone, poor quality bone, metaphyseal fixation etc. It offers numerous fixation possibilities and has proven its worth in complex fracture situations and in revision operations after the failure of other implants

This study is undertaken to understand better the use of locking compression plate system in the treatment of fresh fractures of humerus bone. Advantages of the technique over the prevailing technique if along with the attendant complication have been studied. The results obtained in the present study shall be compared with the other authors.

AIMS AND OBJECTIVES

1) To assess the duration of radiologically proved union in fracture shaft of humerus treated with Locking Compression Plate (LCP).

2) To assess the anatomical and functional outcome.

REVIEW OF LITERATURE

Internal fixation of fractures of long bones of the extremity with plate & screws as a mode of treatment has come a long way.

Egyptians are known to be skilled at the management of fractures. From the beginning, fracture treatment has sought to immobilize the bone fragment. Splints were used initially, and presumably those who applied the splints assumed that either contraction of the muscle adjacent to the fracture (or) the force of gravity during weight bearing would compress the fragments together.

Hippocrates and Celsius described in detail the splint age of fracture by using wooden appliances. But the fascinating account of external splint age was given by Al-Zaire an Arabic surgeon. He used both clay and gum mixtures, flour and egg white for casting materials.

In 1770, Malgaigne was the first to describe the earliest technique of internal fixation of fracture by ligation of wire suture.

Up to 18th century, simple splintage was used to treat fractures

In 1822 A.D. **Sir Astley Cooper** published his textbook on fractures &dislocations CURLING was the first to report basic sequences of fracture healing in 1836 A.D.

In 1840, **Cucuel and Rigaud** started the use of screw fixation in bone

In 1852 A.D. **Antonnine Methijsen** devised the method of using bandage impregnated with plaster of Paris for reduction maintenance.

In 1855 A.D. the functional cast brace was introduced which was the fore runner in the treatment of shaft fractures

Hugh Owen Thomas (1831-1891) stressed the importance of uninterrupted& prolonged immobilization in fracture treatment.

In 1886 **Hansmann**, apparently used the first bone plate during the American civil war.

In 1894 **Sir William Lane** introduced the idea of metallic internal fixation in fracture treatment.

After invention of X-rays by **Roentgen** in 1895 science of bone including fracture treatment has advanced tremendously.

Lambotte (1909), Lane (1914), Sherman (1912) and Townsend and Gilfillan (1943) played prominent roles in the development of the early bone plates (Fig. 1).The designs of the plates used by these surgeons and others improved progressively, providing greater strength and better conformity of the plates to the bone surface.

In 1912, Plate fixation for diaphyseal fracture was introduced by **Beckmann**.

In 1912, **Sherman** introduced Vanadium steel bone plates & self tapping Screws.

Hey Grooves in 1914 was the first to declare that some fractures do require open reduction while there are many fractures which do well with skillful closed treatment & should not be operated upon.

Caldwell introduced hanging cast method for the fracture of Humerus in 1933. The weight of the cast & extremity reduces & maintains the reduction of the fracture. But there was danger that it will distract the fracture & produce delayed union or non-union.

In 1937 **L.V.Rush & H.L.Rush** reported use of Steinman in the medullary canal of Humerus & other long bone.

The principles of gutter splint & plaster 'U' slabs were described by **McMurry in 1939 & Rowley** in 1942 respectively.

In 1943 **Townsend & Gilfillan** designed a plate with slots to allow the surgeon to coapt the fragments manually just before tightening the screws

None of the above authors made any reference to compression of bone. These plates were used to fix the fracture fragments, represented an extension of the old principle of splintage

In 1948 **Egger's** & associates studied the effect of compression on healing of experimental fractures in animals & concluded that compression forces applied to healing bone fragments could influence the rate of healing.

In 1949 **Robert Danis (1880-1962)** was the first surgeon to use a true compression plate in the treatment of acute diaphyseal fractures of long bones. DANIS plate was not popular because of the inherent difficulty in application of compression. The head of axially oriented compression screw was so close to the bone, that at operation it was difficult to apply a wrench & turn the screw.

In 1951 **Venable**, He modified Danis plate where the compression screw was oriented obliquely to make it more accessible, but this change made the junction between the compression screw and the threads of the anchoring screw insecure.

In 1952 - **Boreau and Hermann** - Used dual plates for compression Osteosynthesis.

Dr Whitson in 1954 demonstrated that, radial nerve does not pass in the spiral groove, instead it is separated by about 1-5 cm thick muscles, usually medial head of triceps & only near the inferior lip of the groove it is in direct contact with the humerus where it pierces lateral intramuscular septum[2].

In 1956 **G.W.Bagby** & associates devised a plate which had an oblong slot & used chamfered head screws which exerts translatory movement of the screw along the slot provides self compression.

P.G.Laing in 1956 studied the blood supply of adult humerus by injecting a radio opaque dye into the brachial artery of cadavers & according to his study the main nutrient artery arises in 2/3rd of cases from the brachial artery & in the remaining from the profunda brachii artery.[3]

In 1958 **M.E.Muller** assembled a group of friends, general & orthopaedic surgeons to discuss the poor results obtained with both non-operative methods of fracture treatment in the country. This nucleus in the same year developed into the group called A.S.I.F. (Association for the Study of Internal Fixation) or A.O. (Arbeints gemein schaft fur osteosynthese fragen).

In 1961 **M.E.Muller** devised a plate with basic design of Danis but with a more sophisticated compression mechanism applied temporarily at one end of the plate, but it was certain disadvantages.

1) Separate compression devices requires a wide exposure & may be difficult at some sites & more soft tissue injury.

2) It has conical hole, which can be counter sunk to make it to fit closely & needs the screws to be placed exactly at right angles to the plate to fit properly, there is no provision for angulation of screw if needed.

3) There is an unpredictable change in the forces exerted by the screws when the compression device is removed & hence the chances of implant failure.

4) Removal of stress from the bone beneath a rigid plate can lead to osteoporosis.

5) **Hinschhorn** modified Muller's plate with the compression device over the fracture site only & hence no additional exposure.

6) In 1969 **Perren.S.M , Bagby & Denham** devised a Dynamic compression plate was introduced using the Pauwel's tension band principle (1935). It has intrinsic compression mechanism

Dr Arthur Holstein & Gwilyn Lewis of California in 1963 described "Humeral fracture syndrome" in which they said, in case of fractures of distal third humerus, which are usually spiral, the distal bone fragment had always displaced proximally with its proximal end deviated radial wards, the radial nerve was caught in the fracture site & if there was a comminuted fragment, that damaged the nerve. If there was no displacement, the radial nerve was spared.[4]

In 1963, **L.Klenerman**, London received 98 patients with fractures of humerus, middle third being the commonest site. 87 were treated conservatively & in 11 patients internal fixation was carried out because of multiple injuries, distraction of fragments or inadequate alignment. Ten patients had radial nerve palsy, 4 nerve injuries were of the Holstein-Lewis type. Of 87 fractures treated conservatively delayed union was found in 10, middle third fractures being commonest level. Damage to the main nutrient artery is most likely in middle third fractures.[5]

In 1971,**Dr Franklin.h & Dr Patrick.J** reported their series of 68 radial nerve palsy with humeral shaft fractures. 47 patients had palsy at the time of fracture, of these 38 were complete & 9 partial.21 patients had palsy after the initial injury, of these 18 were complete & 3 were partial. They concluded that ultimately restoration of nerve function was better in the group with early operation.

In 1982, **P.V.A.Mohan Das** series of 30 cases of fresh humeral shaft fractures were treated by open reduction & internal fixation with compression plates. Patients varied in their ages from 15-60years. The fracture occurred in 3 of the upper third, in 20 the middle third & 6 at lower third of the humerus. All the cases united, 4 patients had radial nerve involvement postoperatively but recovered completely within 6 months.[6]

In 1984, **Muller & Witzel** devised a type of biological fixation called BRIDGE PLATE with a nonflexible plate where in only the intact bone is fixed with 3 or 4 screws proximally & distally. The plate is slightly elevated at the fracture site. Mainly used in complex fractures or comminuted fractures where axial or interfragmentary compression is not possible. It has the advantages of wave plate also.

In 1985, **Richard H.Lange & Robert.J.Foster** reviewed nine cases of ipsilateral humeral shaft & forearm fractures with the patient average age being 27.3 years (range 18-47years), in all but one case there were multiple associated injuries to other extremities, the axial skeleton; & or other organ systems. One patient was treated by a hanging arm cast & one other by olecranon skeletal traction followed by functional bracing. One case was managed by intramedullary rush rod& six cases by dynamic compression plating with interfragmentary screw fixation as indicated by fracture pattern. Follow-up time ranged from 6 to 58 months (average 28months). Hanging arm cast treatment in one patient went for border line malunion (30 degree varus angulation).patients treated by olecranon traction & rush rod fixation resulted in non-union & the six cases managed with DCP & the non-union rush rod case re-operated with DCP & bone grafting achieved union.

In 1986, **Robert Vander Griend, John Tomasin & e. Frazier Ward** treated 36 patients with an acute fracture of the humeral shaft by open reduction & internal fixation using A. O. plating techniques. Four patients were 19 treated after non-operative treatment failed. Follow up of 34 patients showed union in 33 & failure in1, necessitated two subsequent procedures of the 9 patients who had radial nerve palsy when they were first seen, one was found to have a partially lacerated nerve, which was repaired. Four had contusion of the nerve at the level of the fracture & in 4 the nerve appeared normal. 3 had permanent radial nerve palsy.[7]

In 1989 **Seidal** developed locking nail for the humerus. Closed nail techniques have reduced blood loss, infection rates & length of stay in the hospitals, with locking nails, the fixation is rigid, no rotational instability & external splintage is not required.

In 1989 **Limited Contact Dynamic Compression Plate** was devised by **Perren.S.M**. It stands for a new concept of biological plating which aims at:-

1) Reduced trauma to the bone.
2) Preservation of blood supply.
3) Avoidance of production of stress raisers after implant removal.
4) Excellent tissue tolerance.
5) It is made up of Titanium alloy but off late it is also available in stainless steel, at a lower price. Grooves on the under surface of the LC-DCP serves a few purposes.
6) They improve blood circulation by minimizing the damage due to contact between plate & bone.
7) They allow for a small bone bridge beneath the plate & reduces the chances of bone weakness due to stress concentration effect of the non healed fracture gap at the periosteal surface.
8) This causes more even distribution of the stiffness of the plate than the conventional DCP. Between the slots, the plate is markedly stiffer, which causes relative bone loading within the weakest spot i.e. at the screw hole.
9) It allows pre-bending (preloading) of the plate between slots which is difficult in conventional DCP.
10) Plate induced remodelling is small because of the limited contact on the bone.

In 1990, **William.W.Brien & Harris Gellman** reported 21 adults who had a fracture of the middle of the humeral shaft & an injury of the ipsilateral brachial plexus were followed for an average of 28 months.11 fractures were treated non-operatively with a brace or cast & there were 5 non-unions, 2 delayed unions & 2 mal-unions of the 10 fractures that were treated operatively, 3 that were treated by compression plating all united. 2 were treated by external fixation, 1 had a delayed union & 1 mal-union. In the remaining 5 patients, treated with an I.M.nail, there were 2 non-unions. 1 delayed union & 1 mal-union. 3 acute fractures & 6 of 7 non-unions treated by compression plating & fixation with screws units.

Guse.T.R& Ostrum.R.F in 1995 did a study on cadaveric arms to demonstrate the relation of radial nerve to the humerus. They found that radial nerve passed anterior to long head of triceps & was at an average of 124mm below the posterior tip of acromion. It was never closer than 97mm. The radial nerve leaves the posterior shaft of humerus at an average of 126mm above the lateral epicondyle & 131mm above the medial epicondyle. It was never within 100mm of either epicondyle. They concluded that if surgeons can use these landmarks during surgery, injury to radial nerve could be avoided.

G.T.Strong, N.Walls & M.M.McQueen in 1998 studied the epidemiology of humeral shaft fractures. In their study of 249 humeral shaft fractures majority of fractures were on left side & about 60% of fractures occurred in patients above 50 years of age. About 64.2% of fractures were in middle third & over 60% were of transverse type fractures. About 40% of cases were due to road traffic accidents.

R.G.McCormack, D.Brien et al., in 2000 compared the fixation of fracture of shaft of Humerus by Dynamic Compression Plate or Intramedullary nail &suggested that open reduction & internal fixation with DCP remains the best treatment for unstable fractures of the shaft of the humerus.

The products from the AO group were introduced as the Point contact fixator(PC-Fix) and Less Invasive Stabilization System (LISS plate) from early 2000 onward. The clinical successes of these plates led to the introduction of the Locked Compression Plate (Synthes)and a recent proliferation of locked-plate designs by several manufacturers.[8]

The results of the first general study of various Locking compression plate were published in 2003 by **Sommer C et al**.They concluded that the LCP was a technically mature and has proven its worth in complex fracture situations and in revision operations after the failure of other implants.[9]

In 2006, **Niemeyer P et al.,** described that locking compression plate (LCP) is represented by the combination of two completely different anchorage technologies and two opposed principles of osteosynthesis in one implant it combines the principles of conventional plate osteosynthesis for direct anatomical reduction with those of bridging plate osteosynthesis.[10]

A biomechanical study on LCP conducted in 2006 by **Ahmad M et al**., opined that if an LCP is being is used then it is desirable to place the plate at or less than 2mm from the bone as it maintains the periosteal blood supply to the bone beneath the plate and also allows a mechanically stable environment at the fracture site to allow fracture healing to continue undisturbed.[11]

In **2010,Heineman DJ, Poolman RW, Nork Sean SE, Bhandari M** in their study concluded that the difference between plates and nails in the treatment of fracture shaft of humerus appear to be insignificant.[12]

In a retrospective comparative study of 91 humerus fractures conducted **by Denis et al., in 2010** showed that a significant number of complications common in intramedullary nailing than in plating. Hence plating is still considered as the preferred management of humeral shaft fractures.[13]

Shantharam Shetty in **2011** studied a 2 year follow-up of humeral shaft fractures treated with LCP through MIPO technique which showed satisfactory union and functional outcome and concluded that MIPO should be considered as one of the treatment options in these fractures.[14]

In 2013, a study conducted by **Soumya Ghosh et al.,** they have compared locking plate with intramedullary nailing in 60 humeral shaft fractures through which they suggested that LCP shows early union and excellent to good functional outcome in 73% than intramedullary interlocking nail (60%).[15]

In a study in 2012 by **Yang Q et al**., of surgical treatment of adult extra-articular distal humeral diaphyseal fractures, an oblique metaphyseal Locking Compression Plate applied via a posterior approach achieved an adequate internal fixation and obtained an excellent functional outcome.Only 1 patient developed iatrogenic radial nerve palsy which recovered completely in 2.5 months.[16]

In another study by **Neuhaus V et al**., in 2012 they concluded that osteoporotic and often comminuted fractures are ideal settings/indications for LCP utilization in the upper extremity.There has been a clear and fashionable trend to choose operative treatment for these fractures, because the angular stability allows stable fixation and early functional mobilization.[17]

In an Indian study in 2013 by **Pal CP et al.,** which compared results of Locking Compression Plate and stack nailing for diaphyseal fractures of humerus showed that locking compression plating is the preferred method in the majority of fractures with better preservation of joint function and lesser need for secondary bone grafting for union.There were 2 post operative cases with neuropraxia of radial nerve who recovered completely on conservative treatment.[18]

In a study in 2013 by **Kumar MN et al.**, which conducted Locking Compression Plate osteosynthesis in 24 humeral shaft non-unions,of which 23 of them united successfully.Functional outcome using Constant and Murley score showed excellent results in 11 patients.2 patients had radial nerve palsy that recovered after 5 to 7 months.[19]

In 2014,**Singh A K et al**., after comparing limited contact dynamic compression plate and locking compression plate for humerus shaft fractures concluded that final outcome is determined by using proper principles of plating and it is the proper application of the principles of plating and not the type of plate which decides outcomes and complications.[20]

In 2015, in a study conducted by **Kim et al**., where they compared conventional open plating and minimally invasive plate osteosynthesis(MIPO) for humerus shaft fractures concluded that both techniques had comparable union rate and MIPO is suggested to be equally safe and effective as conventional plating if the surgeon is experienced.[21]

ANATOMY

Anatomy of Arm:[22]

The arm extends from the shoulder to the elbow joints. The bone of the arm is the humerus. The arm in an adult male is flattened from side to side because of grouping of the muscles of the arm into anterior & posterior to the humerus. The varying degree of fullness, anteriorly corresponds to the belly of biceps brachii, posteriorly corresponds to the belly of the triceps. The deep fascia forms a complete investment for the arm & continues with that of the forearm. From the inner surface of this fascia, lateral & medial intermuscular septae are derived. These are strong fibrous partitions extending from the deep fascia to the shaft & epicondyles of humerus. Thus dividing the arm into anterior & posterior osseo-aponeurotic compartments. The medial intermuscular septum extends from the medial epicondyle to the level of deltoid insertion along the medial supracondylar ridge & is pierced by the ulnar nerve, the superior ulnar collateral artery & the posterior branch of the inferior ulnar collateral artery.

The lateral intermuscular septum extends from the lateral epicondyle along the lateral supracondylar ridge to the deltoid insertion & is pierced by the radial nerve & the profunda brachii artery. There are transverse as well as anteroposterior septae in the flexor compartment of the arm. The transverse septum separates biceps from brachialis, while the anteroposterior septum separates brachialis from the musclesarising from the lateral supracondylar ridge & encloses the radial nerve with the anterior descending branch of the profunda brachii artery

The anterior compartment contains:-

1) Coracobrachialis.

2) Biceps Brachii.

3) Brachialis.

4) Brachial artery.

5) Basilac vein.

6) Median nerve.

7) Musculocutaneous nerve

8) Medial cutaneous nerve of the forea

The posterior compartment contains:-

1) Triceps muscle.

2) Radial nerve.

3) Profunda brachii artery.

4) Ulnar nerve.

5) Superior collateral artery.

6) Inferior collateral artery.

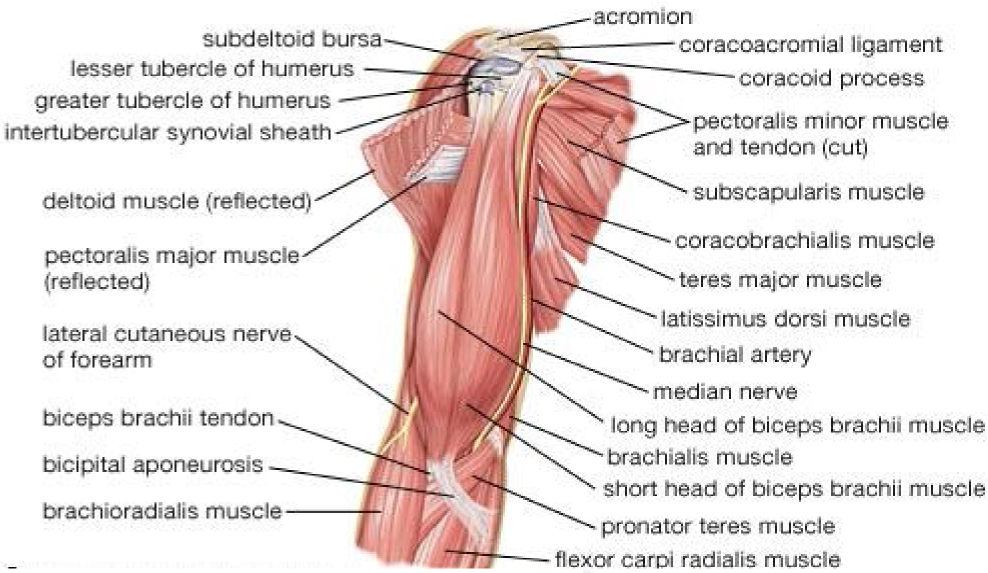
Flexor compartment:

Muscles:- The muscles of the flexor compartment are Coracobrachialis, biceps brachii & brachialis. Coracobrachialis is innervated by Musculocutaneous nerve (C5, 6, 7) & it flexes the arm at shoulder. Biceps brachii has 2 heads & is innervated by musculocutaneous nerve (C5, 6). It functions as supinator of the forearm, flexor at the shoulder & the long head prevents upward displacement of the head of the humerus. Brachialis as dual nerve supply i.e. lateral 1/3 is supplied by the radial nerve & the medial 2/3 is supplied by musculocutaneous nerve. It is the flexor of the elbow.

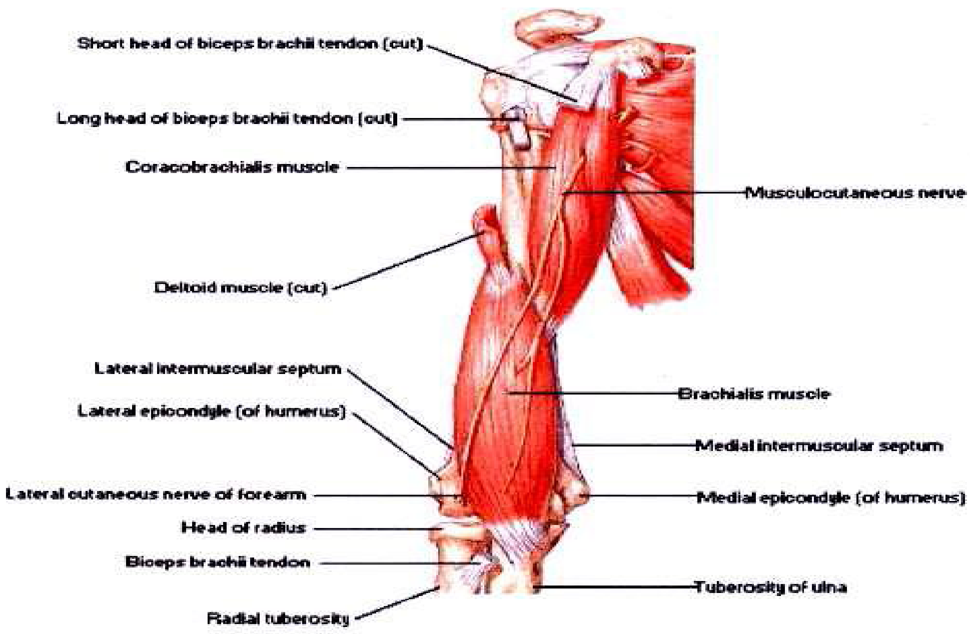
Muscles of the Arm

Anterior View-Superficial layer

FIGURE NO 1



Muscles of Arm
Anterior View - Deep Layer



Arteries of the Arm:-

Brachial artery:- It is the continuation of axillary artery. It extends from the lower border of teres major muscle to the neck of the radius where it divides into ulnar & radial arteries. It is superficial throughout, Anteriorly, it is related to medial cutaneous nerve of the arm & the median nerve in the upper & lower halves respectively.

Coracobrachialis & brachialis. Medially, it is related to ulnar & median nerve in the upper & lower parts respectively. Laterally, it is related to biceps, coracobrachialis & median nerve.

Branches:-

1) Profunda brachii artery leaves through the lower triangular space, runs in the spiral groove with the radial nerve. Apart from the muscular branches it supplies the following arteries, nutrient artery, deltoid branch, middle collateral & radial collateral vessels. The deltoid branch ascends between the lateral & long head of triceps & anastamoses with the descending branch of posterior circumflex humeral artery. The middle collateral branch ascends in the substance of the medial head of triceps to the elbow where it anastamoses with the interosseous recurrent artery behind the lateral epicondyle. The radial collateral artery accompanies the radial nerve through the lateral intermuscular septum & then descends between the brachialis & the brachioradialis to the front of the lateral epicondyle where it anastamoses with the radial recurrent artery.

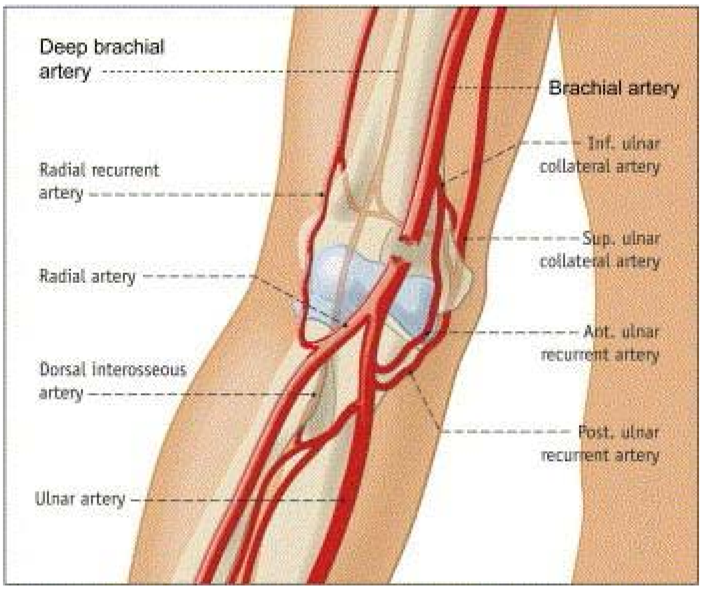
2) Superior ulnar collateral artery arises little below the middle of the arm & accompanies the ulnar nerve & ends deep to flexor carpi ulnaris by anastamoizing with posterior ulnar recurrent artery.

3) Inferior ulnar collateral arteries (supra trochlear) starts about 5 cms above the

elbow & ends by anastamoizing with anterior ulnar recurrent artery.

4) Nutrient artery to humerus sometimes arises from the profunda brachii artery in the radial sulcus.

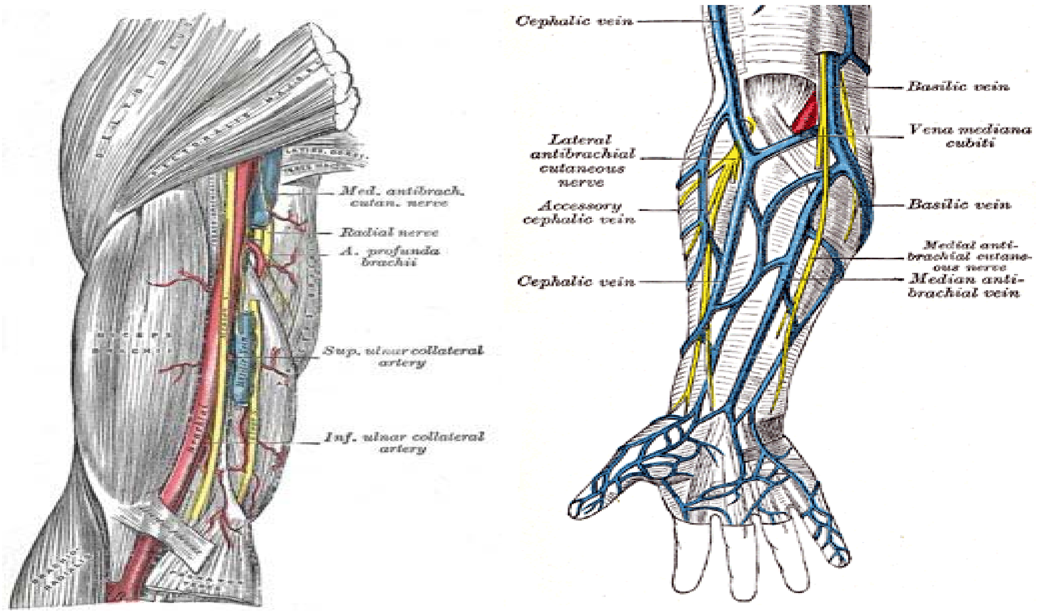
FIGURE NO 2



Veins of the Arm:-

Venae commitantss accompany brachial artery & all its branches. In addition the basilic vein & cephalic vein course upwards through the subcutaneous tissue. The basilic vein perforates the deep fascia in the middle of the arm, the cephalic vein lies in the groove between the deltoid & pectoralis major muscle. Ends by piercing the clavipectoral fascia to enter the axillary vein.

<u>**FIGURE NO 3**</u>



Nerves of the Arm:-

1) ***Musculocutaneous nerve:-*** is the nerve of the flexor compartment of the arm & is the terminal branch of the lateral cord. It pierces & supplies the coracobrachialis & comes to lie between the brachialis & the biceps & supplies both muscles. It continues as the lateral cutaneous nerve of the arm.

2) ***Median nerve:-*** is formed by the union of its medial & lateral branches from the corresponding cords of the brachial plexus in front of the axillary artery. In the upper arm it is lateral to the brachial artery & crosses over it in the middle of the arm & then lies on the medial side of the brachial artery. The nerve has no branches in the arm.

3) ***Ulnar nerve:-*** is the continuation of the medial cord & lies posterior to the brachial artery & then medially. At the level of insertion of coracobrachialis it pierces the medial intermuscular septum accompanied by the ulnar collateral artery. It gives no branches in the arm.

4) ***Intercostobrachial nerve:-*** The skin of the axilla is supplied by the lateral cutaneous branch of the second intercostobrachial nerve & extends for a variable

distance into the skin on the medial side of the arm.

5) ***Medial cutaneous nerve of the arm:-*** This lies anterior to the brachial artery, this nerve pierces the deep fascia in the upper part of the arm & supplies the skin on the front & medial side of the upper part of the arm.

Extensor compartment:-

Muscles:- Triceps muscle has 3 heads i.e. lateral head, medial head & long head. All three heads are supplied by the radial nerve. It is the extensor of the elbow & the long head stabilizes the abducted shoulder joint & aids in extending the shoulder joint.

Radial nerve in the arm:- (2,4,22)

The radial nerve arises from the posterior cord of the brachial plexus that is C5, C6, C7, C8, T1. It is the largest branch of the brachial plexus & descends behind the third part of the axillary artery & upper part of the brachial artery & in front of subscapularis & the tendon of the latissimus dorsi & teres major. Accompanied by profunda brachii artery & later its radial collateral branch, it inclines dorsally between the long & medial head of the triceps & then in a shallow groove deep to the lateral head of triceps muscle. On the lateral side of the humerus, it pierces the lateral intermuscular septum & enters the anterior compartment of the arm. It then descends lying deeply in the intermuscular groove, which is bounded on the medial side by the brachialis & on the lateral side by brachioradialis above extensor carpi radialis longus below. On reaching the front of the lateral epicondyle it divides into terminal branches i.e. superficial & deep branches.

Muscular branches of the radial nerve supplies the triceps, anconeous, brachioradialis, extensor carpi radialis longus & brachialis which are grouped into:-

1) Medial.

2) Posterior.

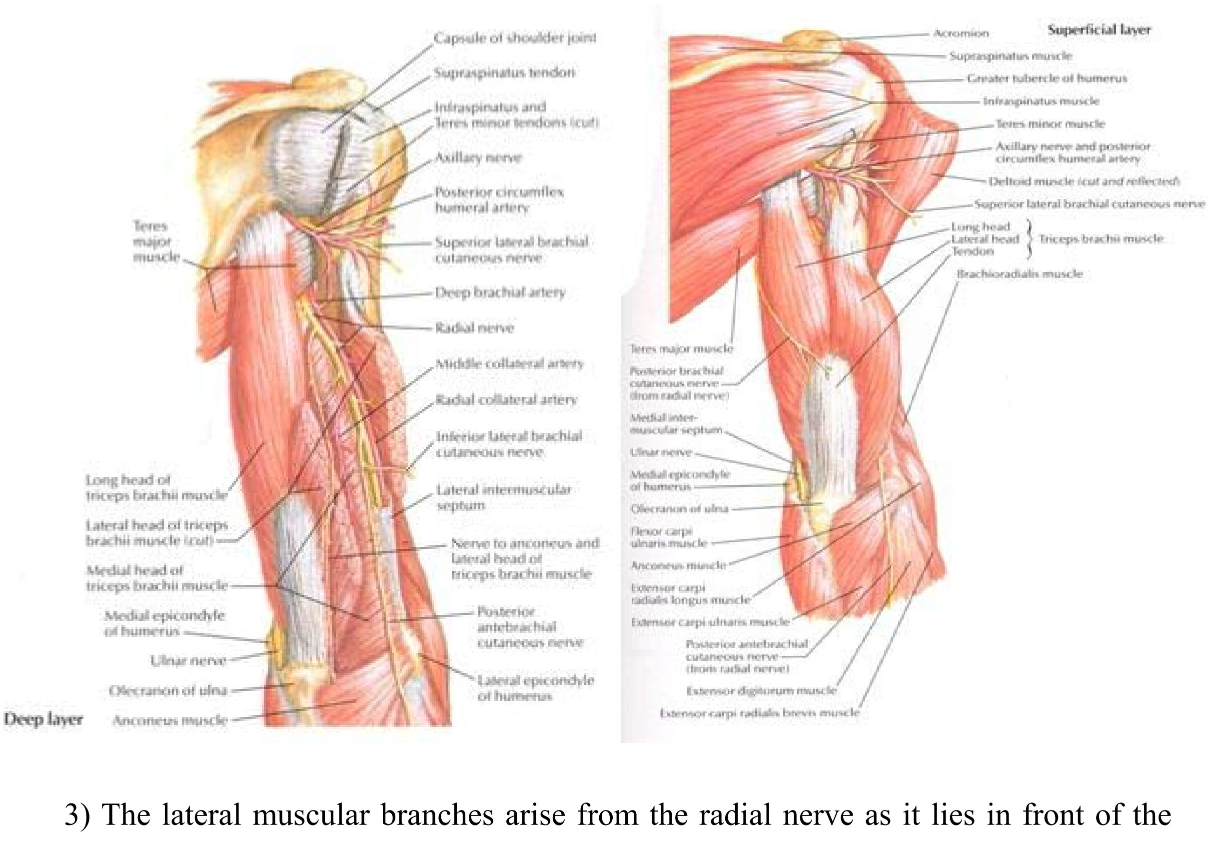
3) Lateral.

1) The medial muscular branches rise from the radial nerve on the medial side of the arm & supplies the medial & long head of triceps; the branch of the medial head is long which lies close to the ulnar nerve as far as the distal third of the arm & is frequently named as the ulnar collateral nerve.

2) The posterior muscular branches arise from the radial nerve as it lies in the groove. It divides into filaments which supplies the medial & lateral head of triceps & anconeus

Muscles of Arm posterior view

<u>FIGURE NO 4</u>



3) The lateral muscular branches arise from the radial nerve as it lies in front of the lateral intermuscular septum & supplies the lateral part of the brachialis, Brachioradialis & extensor carpi radialis longus. Cutaneous branches of the radial nerve are the posterior cutaneous, lower lateral cutaneous nerve of the arm &

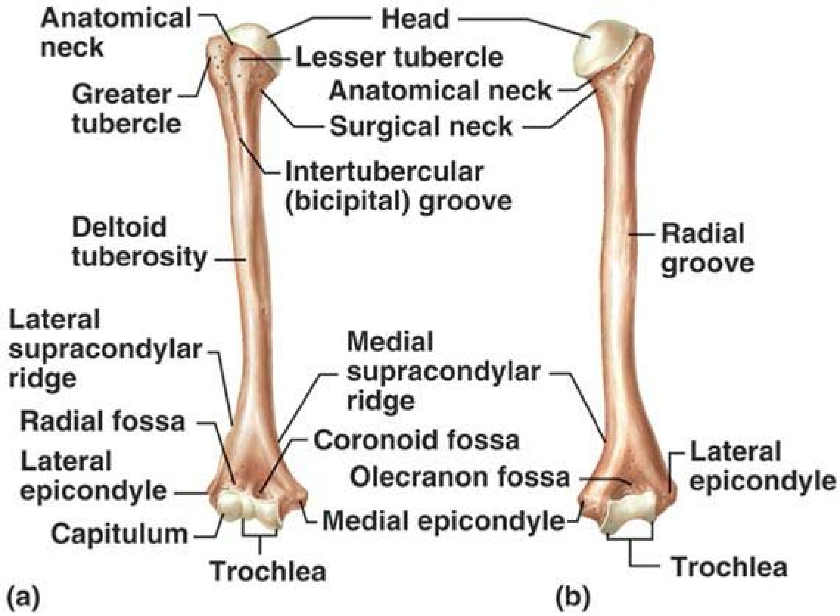
posterior cutaneous nerve of the forearm. Articular branches of the radial nerve are distributed to the elbow joint. Whitson in 1954[2] demonstrated that the radial nerve does not travel along the spiral groove of the humerus. Instead, along most of the course it is separated from the humerus by 1 to 5 cms i.e. The thickness of the muscle (medial head of triceps & brachialis). It demonstrates that the nerve lies close to the inferior lip of the groove. Only for the short distance is the nerve is in direct contact with the humerus & it is at this area that the nerve pierces the lateral intermuscular septum before passing on to the surface of the brachialis muscle.

Arthur Holstein & Gwilyn Lewis of California in 1962[4], are of the opinion that the nerve has least mobility at this point & it is this lack of mobility which contributes to nerve injury in fractures of the humerus at this distal third of the arm. Hence they described a syndrome "Holstein Lewis syndrome", in which the nerve becomes trapped between the fragments of a closed fracture at the distal third of the humerus. These distal third fractures are often spiral & typically angulated laterally with the distal fragment displaced proximally. As the radial nerve is fixed to the fragments here by the lateral intermuscular septum may be trapped between the fragments when closed reduction is carried out. This is an indication for the exploration of the radial nerve.

Anatomy of the Humerus:-

Humerus is the longest & the largest bone of the upper limb. It comprises of a rounded head at the upper end, the shaft & the expanded lower end. The Head of the humerus forms less than half a sphere & its smooth surface is covered by hyaline cartilage which articulates with the glenoid cavity of the scapula forming a ball & socket joint. The anatomical neck is a slight constriction separating the head from rest of the upper end of the humerus.

FIGURE NO 5



The lesser tuberosity is on the anterior aspect of the upper end immediately beyond the anatomical neck. The greater tuberosity occupies the lateral part of the upper end of the humerus & is the most lateral bony point in the shoulder region. The two tuberosities are separated by intertubercular sulcus, where the upper extremity joins the shaft is a tapering region called the Surgical neck.

The shaft of the humerus is almost cylindrical in its upper half but is triangular on section below this as it is compressed in an anteroposterior direction. It presents 3 surfaces & 3 borders which are not everywhere equally obvious. Anatomically, the shaft may be considered to expand from the upper border of the insertion of the pectoralis major muscle above to the supracondylar ridge below.

The anterior border commences above the front of the greater tubercle & runs downwards almost to the lower end of the bone. Its upper third forms the lateral lip of the intertubercular sulcus & is roughened from the muscular attachments. The succeeding portion is also roughened & forms the anterior limit of the deltoid tuberosity, but the lower half of the border is smooth & rounded. The lateral border is conspicuous inferiorly where its sharp edge is roughened along its anterior aspect. In its middle & upper third the border is barely visible, but in a well marked bone it can be traced upwards to the posterior surface of the greater tuberosity. About its middle third the border is interrupted by a shallow groove, which crosses the bone obliquely, passing downwards & forwards from its posterior to anterior surface. It is the sulcus for the radial nerve.

The medial border although rounded is clear in the lower half of the shaft. A little below the middle of the bone it presents a roughened strip & superiorly it becomes indistinct until it reappears as the medial lip of the intertubercular sulcus. The anterolateral surface of the humerus lies between the anterior & lateral borders. A little above to middle, it is marked by a roughened area tapering to a point below, which is termed the deltoid tuberosity. Behind this, the groove for the radial nerve runs downwards and fades away on the lower part of the surface.

The anteromedial surface is bounded by the anterior & medial borders of the bone. Rather less than its upper third forms the rough floor of the intertubercular sulcus, but the rest of the surface is smooth. A little below its middle the nutrient foramen which is downwards opens close to the medial border.

The posterior surface lies between the medial & lateral borders & is the most extensive surface of the three. Its upper third is crossed by the faint ridge sometimes roughened, which runs obliquely downwards & laterally.

The middle third is crossed by the commencement of the groove for the radial nerve. Rather more than the lower third forms an extensive, flattened surface which widens considerably below. The lower end of humerus forms the condyle which is expanded from side to side & has articular & non-articular parts. The articular part includes the capitellum, which articulates with the head of the radius & the trochlea which articulates with the trochlear notch of the ulna. The non-articular part includes medial & lateral epicondyle which re bony prominences on the medial & lateral aspects respectively. Medial & Lateral supra-condylar ridges are sharp margins just above the medial & lateral epicondyles respectively. The coracoid & the olecranon fossa lie just above the anterior aspect & posterior aspect of lower end of humerus respectively. The radial fossa lies just above the anterior aspect of the capitulum.

Arterial supply of the Adult Humerus:-

Healing of the fracture like any other wound, depends upon blood supply (Johnson- 1927). P.G.Laing(3)from the surgical & pathological services, department of veterans service hospital, Lancaster, studied the blood supply of adult humerus by injecting radio opaque contrast medium into the brachial artery of cadavers & taking 40 radiographs. The largest artery supplying the humerus is termed as the main nutrient artery.According to his study, the main nutrient artery arises in 2/3 cases from the brachial artery & in the remaining cases from the profunda brachii artery. The point of entry of the main nutrient artery to the humerus is a restricted area, beginning on the medial side of the distal third & spiraling upwards & medially to the dorsal surface of the middle third of the shaft. This was proved by dissection in cadavers undertaken by S.E.Carroll in the University of Ontario, Canada.

CARROL's[23] study also revealed that 2/3 of the humerus had single nutrient foramen & the mean position is distal to the midpoint of the humerus & distal to the insertion of the deltoid. ¾ of the foramen are found in the medial border or the anteromedial border or the anteromedial surface.

The main nutrient artery on or before entering the bone divides into ascending & descending branches. The ascending branch travels up the medullary canal & anastamoses with accessory nutrient arteries & with periosteal vessels through transcortical vessels. In most cases, a peculiar coiled arrangement of the beginning of the ascending branch was noted in the study of P.G.Laing. Descending branches are usually smaller, divides immediately into branches to reach supra-condylar region. Accessory nutrient arteries vary from 1-4 in number & may arise from anterior circumflex humeral artery or profunda brachii artery. These arteries enter the bone either in the spiral groove or in the anterolateral surface, mostly in the upper third of the shaft. No accessory nutrient artery was found between the site of the main nutrient artery & the epicondylar region.

Practical importance of blood supply:-

Healing of fracture depends upon the blood supply (Johnson 1927). Injury to nutrient artery at the time of trauma or during manipulation or during surgery, may be a significant predisposing factor for non-union (Steward 1955, Watson Jones 1955, Kennedy 1957, Mercer 1959, Turek 1959). If surgeons could avoid the area of cortex of the humerus containing the nutrient artery foramen during open reduction an improvement in the result might be expected (S.E.Carroll).The danger of damaging the blood supply during operation is maximum in open reduction of fractures at the junction of middle & lower third. In such cases upper end of lower fragment will depend on epicondylar vessels & periosteal stripping of the lower fragment should be avoided. Because of the intremedullary course of the nutrient artery, it may get damaged during intramedullary nailing & at the same time periosteum is stripped extensively, blood supply will be jeopardized unduly.

Surgical Anatomy of Humerus:-

Humerus is not a weight bearing bone & therefore compression forces are not a factor & shortening does not significantly worsen the end results. Humerus is the mobile of the long bones. The freely movable scapulohumeral articulation minimizes tortional stresses. Rigid immobilization is not always necessary nor practicable except rigid internal fixation because of respiratory movements. Realignment of the fracture fragments is facilitated by the physiology dependent position & by relaxation of the musculature under the influence of gravity. Humerus is the most easily reducible of all the long bones which can easily be accomplished under sedation. Malunion up to 20^{o} of anterior angulation & 30^{o} of varus is tolerated without compromising function of appearance(5).

Transverse fractures of the middle third of humerus heals slowly because of small fracture surface area. Distraction & angulations may occur due to long lever arm which is difficult to immobilize. Proper rotation is also a problem during healing as the forearm is usually is brought in front of the chest causing the distal fragment to rotate internally while the proximal fragment is in neutral rotation.

The critical zone is at the junction of the middle third & lower third of the shaft. Here the radial nerve is fixed & is close to the bone as it penetrates the lateral intermuscular septum. Here too main nutrient artery enters the shaft medially near the insertion of the coracobrachialis tendon. The blood supply to the shaft is limited compared to metaphysis. Middle third shaft fracture may damage the nutrient artery, thus contributing to delayed & non-unions.

MECHANISM OF INJURY

Humeral shaft fractures result from direct and indirect trauma. Common mechanism for humeral shaft fracture include fall on the outstretched hand, motor vehicle accidents and direct loads to the arm. The commonest cause of injury leading to fracture of humerus shaft is a motor-vehicle accident especially in young adults.[24,25,26,7]

Elderly patients who suffer a humeral shaft fracture as a result of a fall often have less comminuted fracture patterns.[27] Greater amounts of comminution and soft tissue injury results from higher energy injuries. The other modes of injury include fall on outstretched hand, direct blows, automobile injuries, and crush injuries from machineries.

Pure compressive forces results in proximal or distal humerus fractures. Bending forces result in transverse fractures of the humeral shaft. Torsional forces result in spiral fracture patterns. The combination of bending and torsion usually results in an oblique fracture, often associated with a butterfly fragment.

The muscle forces that act on the humeral shaft produce characteristic fracture deformities. A fracture proximal to the pectoralis major insertion results in abduction and internal rotation of the proximal fragment secondary to the pull of the rotator cuff, while the distal fragment is displaced medially by the pectorals major. If the fracture is distal to the pectoralis major insertion and proximal to the deltoid insertion, the distal fragment is laterally displaced by the deltoid, while the pectoralis major, latissimus dorsi and teres major displace the proximal fragment medially, when the fracture is distal to the deltoid insertion, the proximal fragment is abducted and flexed.

Classification

There is no universally accepted classification system for humeral shaft fractures, but the following are the classification systems used by various authors.

Klenerman[28] has classified the humeral shaft fractures based on the level of fracture as follows:

1) Fractures of upper third of shaft

2) Fractures at junction of middle and upper third

3) Fractures at middle third of shaft

4) Fractures at junction of middle and lower third

5) Fractures of lowest third of shaft

The humerus shaft fractures have further been classified depending on:

I. Location of fracture[29] :

a) Proximal to the pectorails major insertion

b) Distal to pectorails major insertion but proximal to the deltoid insertion

c) Distal to the deltoid insertion

II. Associated soft tissue injury:

a) Open fractures

b) Closed fractures

III. Direction and character of fracture line:

a) Longitudinal

b) Transverse

c) Oblique

d) Spiral

e) Segmental

f) Comminuted

IV. Degree of fracture

a) Complete

b) Incomplete

V. Associated injury

a) Nerve

i) Radial

ii) Median

iii) Ulnar

b) Blood Vessel

i) Brachial artery

ii) Brachial vein

VI. Intrinsic condition of the bone

A) Normal

B) Pathological

Muller et al of AO/ASIF group[30] have classified humeral shaft fractures, based on fracture comminution as follows.

A: Simple fractures

A1 Spiral

A2 Oblique

A3 Transverse

B: Wedge fracture

B1 Spiral wedge

B2 Segmental wedge

B3 Fragmented wedge

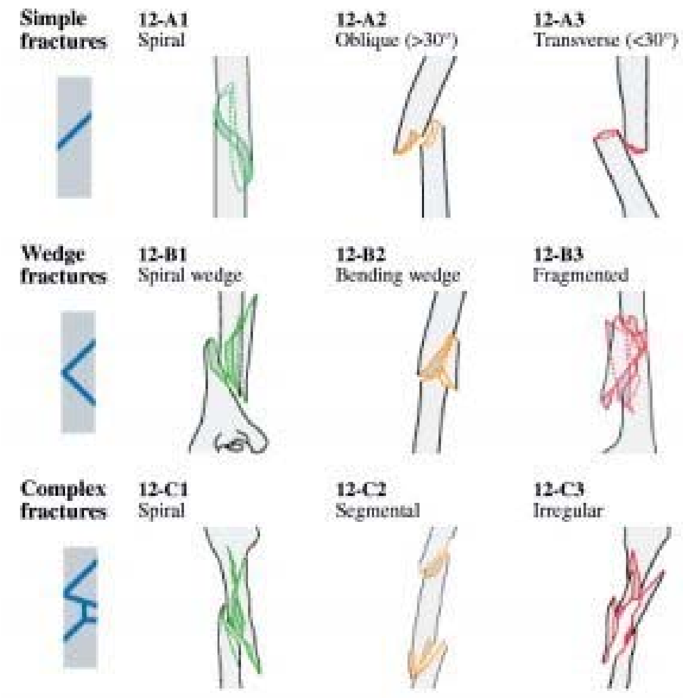
C: Complex Fractures

C1 Spiral

C2 Segmental

C3 Irregular

<u>FIGURE NO 6</u>



Further according to AO alphanumerical classification, the humerus has been allotted the number 1 and the diaphysis, the number 2. Thus all the fractures of the humeral shaft with the numbers 12 according to AO classification.

MANAGEMENT

The goals of humeral shaft fracture management are to:

1) Establish union.

2) Restore the patient to their prior level of function.

Many methods have been described for the treatment of humeral shaft fractures. Good to excellent results have been reported in most series of humeral shaft fractures treated by non-operative or by open reduction & internal fixation. But non-operative methods are associated with a significant risk of non-union, malunion, fracture disease & difficulty in nursing & rehabilitation in polytrauma cases. There are however certain instances in which open reduction & internal fixation is required even though it is associated with relatively high incidence of delayed union, non-union, risk of infection & the risk of radial nerve injury.

The problems inherited in the management of humeral shaft fractures are primarily technical problems encountered in the selection & application of appropriate method. The numerous methods available today allow considerable individuality in the selection of the technique. The type & level of fractures, the patients age & cooperation of the patient, the degree of fracture displacement & presence of associated injuries are factors that influence the choice of treatment.

NON-OPERATIVE TREATMENT:-

HANGING ARM CAST:

It is a traction method introduced by Caldwell in 1933, which uses dependency traction provided by the weight of the cast to effect fracture reduction. This dependency traction may cause fracture distraction resulting in delayed union or non-union. The indications include displaced mid-shaft fractures with shortening, particularly those fractures with an oblique or spiral pattern. It is useful when certain principles are followed.

i. The arm must always be in dependent position and it is considered to cause fracture distraction.

ii. It should be of light weight and extend from at least 2 cm proximal to the fracture site to the wrist joint distally, with the elbow in 90 degree flexion and forearm in neutral rotation.

iii. The sling must be securely fixed at the wrist by a loop of POP to correct lateral angulation place the loop on the dorsum of the wrist, and to correct the medial angulation placed on the volar side. Lengthening the sling corrects posterior angulation while shortening corrects anterior angulation.

iv. Check X-ray has to be done weekly.

v. Shoulder and hand range of motion exercises are instituted as pain subsides.

COAPTATION SPLINT:

A molded plaster slab (U shaped brachial splint) is placed around the medial and lateral aspects of the arm, extending around the elbow and over the deltoid and acromion with a cuff and collar introduced by Rowly in 1942. It does not cause hinging effect at the fracture site as in the hanging cast. It has distinct advantage of allowing exercises of elbow, wrist, hand & to some extent the shoulder during the entire period of immobilization.

ABDUCTION HUMERAL SPLINT:

Stewart has advocated the use of humeral abductional splint in humeral shaft fractures. Closed and continued observation is required. Increased comfort is cited as an advantage and also the effect of gravity is eliminated.

SHOULDER SPICA CAST (THORACO HUMERAL SPICA CAST):

It is recommended in the early healing stage of the unstable fractures where delayed or non-union appears imminent. It usually replaced by a simpler form of treatment following reduction for maintenance. Patient non compliance is the main disadvantage, more so in hot and humid climates, old, obese patients and in patients with significant pulmonary problems.

OPEN VELPEAU METHOD:

Gilchrist has described the open velpeau type cast for un-displaced or minimally displaced fractures in active and unmanageable children or for some elderly patients unable to tolerate hanging cast. The desired degree of abduction and forward flexion at shoulder is maintained by axillary & forearm pads. In these cases patient comfort, not fracture reduction is the critical consideration. Early humeral fracture brace application is considered as well.

SKELETAL TRACTION:

It is rarely indicated for the treatment of closed or open humeral shaft fractures, these fractures with associated skeletal injuries requiring prolonged recumbency are now considered for operative intervention. When indicated, skeletal traction is applied through a transcondylar kirschner wire or steinmann pin. The pin should be inserted from medial to lateral to minimizes the risk of ulnar nerve injury.

FUNCTIONAL BRACING: [32,33,34]

The humeral functional brace was first described by Sarmiento in 1977. A functional brace is an orthosis that effects fracture reduction through soft tissue compression. Use of this device maximizes shoulder and elbow motion. This brace initially was custom-made and designed as a wrap around sleeve. However, currently prefabricated and consist of an anterior shell (contoured for the biceps tendon distally) and a posterior shell. These shells are circularized with velcro straps, which can be tightened as swelling decreases. The proximal aspect of the brace approaches the acromion laterally and encircles the arm underneath the axilla medially. Distally, the sleeve fashioned to avoid the medial and lateral epicondyles permitting free elbow motion.

Contraindications include:-

i) Massive soft tissue injury or bone loss

ii) Unreliable or uncooperative patient

iii) Inability to obtain or maintain acceptable fracture alignment.

The fracture brace can be applied acutely or 1-2 weeks after application of a hanging arm cast or coaptation splint. If the brace is applied acutely, the patient should be re-evaluated the following day to assess the extremity`s neurovascular status and amount of arm or forearm edema. The patient instructed to keep the arm hanging free of the body, use of a sling may result in varus angulation. The patient is followed at weekly intervals for the first 3-4 weeks to assess fracture alignment & is instructed to do pendulum exercises and range of motion of the shoulder, elbow, wrist and hand. The patient is encouraged to remain upright to allow gravity assisting fracture reduction. When patient comfort permits, the brace be removed for hygiene. The brace is worn for a minimum of 8 weeks poster education.

OPERATIVE TREATMENT:

Operative management may be indicated in

Absolute Indications

1) Failed conservative methods

2) Holstein-Lewis type with radial nerve palsy

3) Bilateral humerus fractures

4) Associated with polytrauma

5) Associated injuries in ipsilateral forearm

6) Associated with vascular injury in the arm

7) Progressive /secondary radial nerve palsy

8) Non-union and delayed union

Relative Indications

9) Intra articular fracture extension

10) Segmental fractures

11) Pathological fractures

12) Associated chest injury

13) Compound fractures Type I & II

14) Severe neurologic disorders such as uncontrolled Parkinsonism

15) Associated brachial plexus injury.

INTRAMEDULLARY NAILS:

There are Two types

1) Flexible intramedullary nails- include Ender nails, Hackenthal nails and Rush nails. They can be used retrograde from the distal humerus or antegrade near the rotator cuff. These nails do not provide rigid fixation or prevent shortening or rotational control. Use of a functional brace should be considered for additional stability.

2) Interlocking nails like Seidal nails, Russel Taylor nails. These nails usually rely on proximal screw or distal screw or fin fixation to provide stability. They maintain alignment of unstable fracture preventing fracture shortening and rotation. They can be used to stabilize fractures from 2 cms distal to the surgical neck to 3 cms proximal to the olecranon fossa. These nails can be inserted antegrade through the rotator cuff/ greater tuberosity or retrograde proximal to the olecranon fossa with or without prior reaming.

ADVANTAGES:

i. They are subjected to smaller bending loads than plates because it is closer to the mechanical axis than the usual plate position on external surface.

ii. Nails can act as load sharing devices in fractures with cortical contact if the nail is not locked at both proximal and distal ends, it will act as a gliding splint and allow fracture compression as the extremity is loaded.

iii. In mid shaft fractures, nails that fill the medullary canal automatically reestablish osseous alignment.

iv. Stress shielding with resultant cortical osteopenia, commonly seen with plates and screws, is minimized with intra medullary nails.

v. Refracture after implant removal is rare with the use of intramedullary nails,secondary to lack of cortical osteopenia, and the fewer stress risers created.

vi. Nailing does not need extensive exposure required for plate application. With image intensification these can be inserted in a closed manner, without exposing the fracture site, thus decreasing the infection rate and soft tissue scarring with higher union rate.

vii. Less chances of iatrogenic radial nerve palsy.

DISADVANTAGES:

i. Nail migration

ii. External immobilization is required.

iii. Non-union rate is high

iv. Mal-union (specially rotatory) are quite common. The above disadvantages are not seen in interlocked nails.

v. Subacromial impingement causing shoulder pain and decreased shoulder motion.

vi. In case of distal entry of nail there can be limitation of elbow movements, myositis and iatrogenic fracture.

vii. Nailing interferes with endosteal blood supply

viii. Technical problems of interlocking nails are encountered

ix. The axillary nerve is at risk during proximal locking screw insertion.

PLATES & SCREWS: [24]

Plates and screws are devices which are fastened to bone for the purpose of fixation. They are principally differentiated by their function as

i. Neutralization plate

ii. Buttress plate

iii. Compression plate

iv. Tension band plate

Plates and screws fixation undergone continual design modification and improvements.

Some of them are

a. Regular ASIF with ordinary round holes

b. Semi-tubular plate

c. Round holes with key holes at the end of the plate for facilitating the Muller`s compression device.

d. Dynamic compression plate (DCP)

e. Limited contact-DCP (LC-DCP)

Plates offer the benefits of anatomical reduction, stable fixation without violation of the rotator cuff and early function of the muscle-tendon units and joints. Disadvantages of plate fixation include opening up of the fracture site causing soft tissue trauma, evacuation of the fracture haematoma, risk of bone refracture after plate removal, plate irritation and rarely an immunologic reaction.

Basic designs of plating are:

a. Careful handling of implant

b. Correct plate contouring before application

c. Drill diameter slightly smaller than screw diameter

d. Measurement of screw holes with depth gauge

e. Proper orientation of screw heads in the plate

f. Final tightening of all screws and assessing the fracture stability before closure.

Plates must be sufficient length and adequate screw fixation in bone is required.Over torquing of the screws should be avoided during insertion. Minimal soft tissue stripping must be performed; butterfly fragments must not be devitalized. Severe comminuted fragments require cancellous bone grafts.

PRINCIPLES OF AO PLATE OSTEOSYNTHEISIS

The AO group of surgeon (ASIF), Association for the study of internal fixation propounded the idea of early surgery and early movement in fracture fixation. The AO group coined the term, the so called fracture diseases. (LUCAS – CHAMPIONNIERE -1907).

Fracture diseases is caused by pain and lack of physiological challenge to the bone muscle complex. By movement and changing mechanical load, in the lower limb the lack of weight bearing, and in the upper limb the lack of normal muscle work load to various complicating situations like chronic edema, osteoporosis of bone diffuse atrophy of the muscles and stiffness of the joints. This is exactly what happens when the patients are immobilized for a long time.

Life is movements and movement is life:

AO group advocated adequate fixation for the fracture and early movements to prevent fracture disease. Prolonged immobilization leads to stiffness and degeneration of the articular cartilage of the joints. Active movements at the joint is required for proper circulation of the synovial fluid due to pumping action and nutrition of the articular cartilage.

Partial weight bearing, effective mobilization of the joints greatly decreases post traumatic osteoporosis and also maintains the functional bone and musculature of the limb. All these are possible, only when the fracture, is fixed so that pain free mobilization and partial weight bearing is possible.

Yet again, inadequate fixation of the fracture will lead to painful motion at the joints and also leads to implant failure (or) loss of fracture fixation. Hence the AO group formulated some of the essential basic principle of no fixation and also devised various equipment and implant to deal with any kind of fixation.

CONVENTIONAL PLATING:

In 1979, Danis stated that there were three requirements for satisfactory internal fixation,

- The ability to undertake immediate active motion
- The complete restoration of original shape of bone
- Direct union without formation of visible callus.[34]

This was achieved with interfragmentary compression using screws, plates or tension wires. Callus formation was seen as a sign of instability, leading to loosening of the fixation. Fractures were reduced and fixed using open techniques, which required extensive surgical approaches and considerable soft tissue dissection. The stability of conventional plate osteosynthesis relies on friction, which is achieved by compression between the bone and the plate, the lag effect of the screw is the determining factor for the stability. Compression between bone and plates leads to cortical porosis as result of impaired periosteal blood supply.[35]

Hence the part of cortex underlying the plate undergoes necrosis, followed by process of remodeling. These increases the chances of infection, and non union.[35,36] This is also the reason for increased incidence of refractures following plate removal.[37]

THE AO PRINCIPLE OF FIXATIONS:

1) Anatomical reduction of particular joint fractures.

2) Stable internal fixation designed to fulfill the local biomechanical demands.

3) Preservation of blood supply to the bone of fragments and soft tissue by appropriate technique.

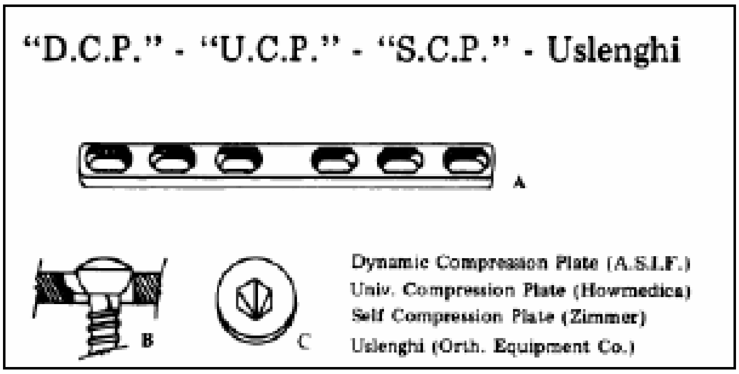
4) Early active pain free mobilization of the muscle and joints adjacent to the fracture, preventing the development of fracture disease.

5) The AO group further stress the importance of compression at the fracture site and devised various plates for achieving the same.

DYNAMIC COMPRESSION PLATE:

Dynamic compression plate represents a significant improvement on the round hole plates. It is self compressing plate due to special geometry of the screw hole which makes it possible to achieve axial compression without the use of a tension device, and the screw can be angled in any direction. This can be used as a static compression plate, a dynamic compression plate, a neutralization plate and buttress plate. The screw hole is a combination of inclined and horizontal cylinder which permits the downward and horizontal movement of the screw head. The screw head has spherical contact in the screw hole which results in maximum stability.

FIGURE NO 7



LIMITED CONTACT DYNAMIC COMPRESSION PLATE

The limited contact dynamic compression plate is technically a further development of DCP (Perren et al), based mainly on the experimental work of Klaue 1982 and Perren 1982 who developed dynamic compression unit. The advantages are minimal surgical damage to blood supply, improved healing in cortical zone covered by plate, reduced risk of refracture following plate removal. Grooves on the undersurface minimizing the damage between plate and bone without disturbing the blood supply.

FIGURE NO 8

LC-DCP

BRIDGE PLATING:

Bridge plating was originally recommended by the AO/ASIF for comminuted fractures, where anatomic restoration was not possible.The plate was fixed to main proximal and distal fragments, leaving the fracture untouched. This method of osteosynthesis does not produce rigid fixation, and hence fracture healing is with callus formation.

FIGURE NO 9

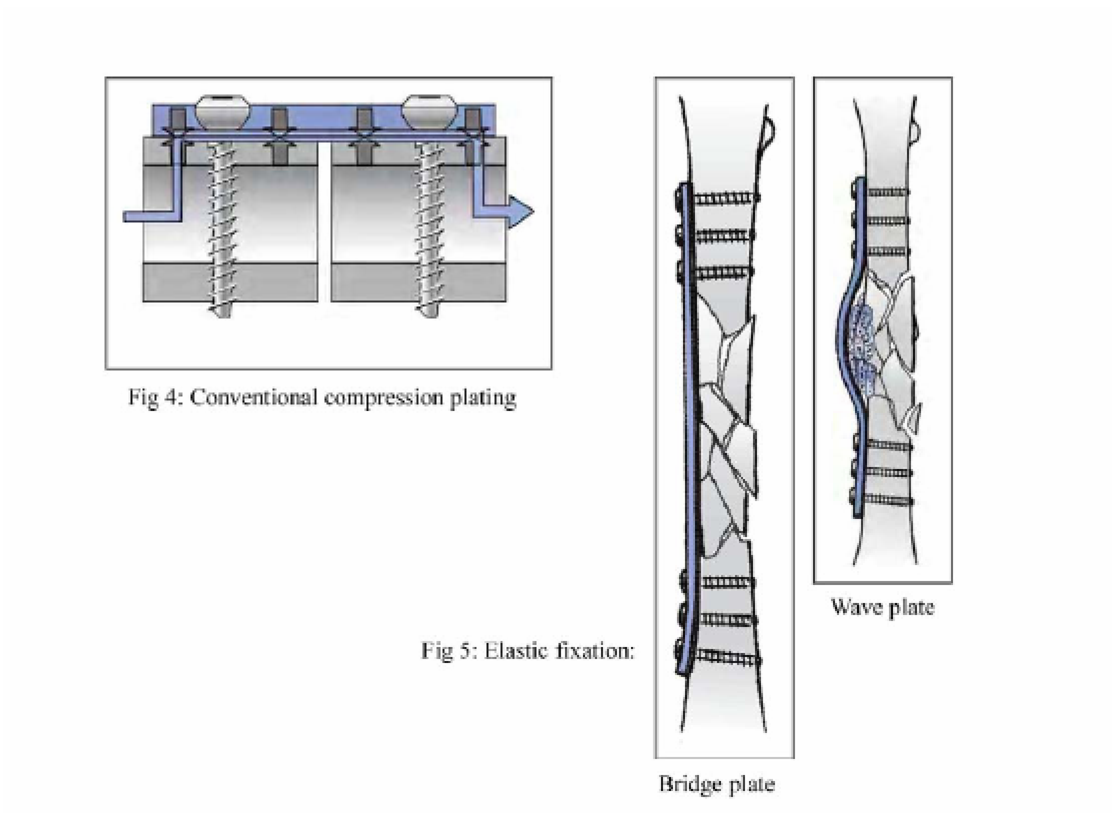
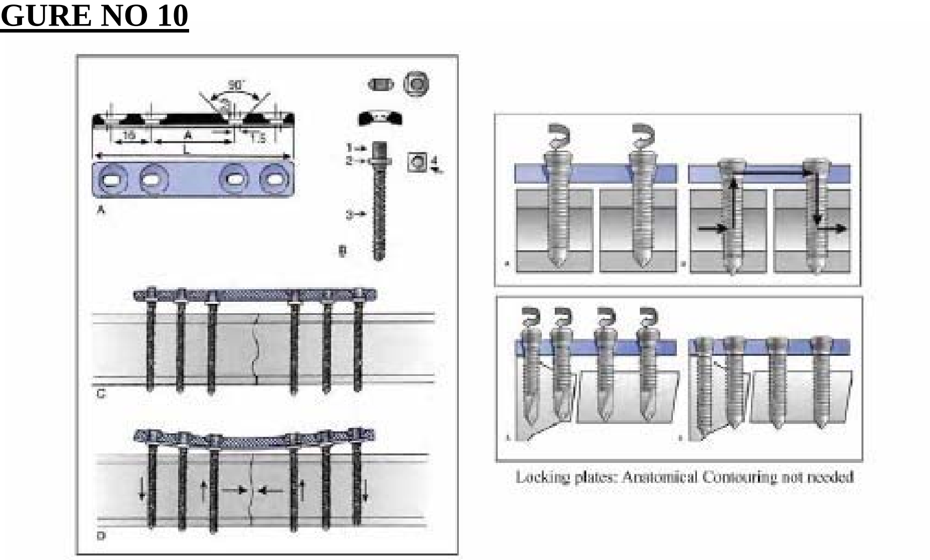


FIGURE NO 10



A modification of this was bending the plate in bridging zone to produce a wave plate, where in the shape allowed to put bone grafts and hence was used for non-union also. To enhance callus formation, plate osteosynthesis must permit micromovement as occurs with IM nailing. This occurs in bridge plating, where the stiffness of plates-bone construct is reduced as a result of large length of plate without screws. This results in motion within the fracture gap while the fracture is in axial or cyclical loading. However, even small gaps can be treated with bridge plating as long as the stiffness of the construct allows micromotion, which is achieved by using long plate and leaving at least 2-4 plate holes over the fracture empty. This results in 'elastic' osteosynthesis, which might be considered to be the precursor of minimally invasive plate osteosynthesis.[35]

MINIMALLY INVASIVE PLATE OSTEOSYNTEHSIS (MIPO):

The clinical experience gained from the use of the wave plate and the bridge plate passed the way for the era of biologic plating.

The aim is to protect the soft tissues. These techniques use indirect fracture reduction techniques and maintain fracture alignment by plating the fracture without compression.

With the MIPO technique, the incision should be at a safe distance from the fracture site, ideally in an area where the soft tissues or not compromised. A sub muscular approach allows for easy insertion of a plate between the periosteum and the surrounding muscles

FIGURE NO 11

Additional soft tissue trauma is minimized. The periosteal vasculature and medullary perfusion is increased compared to conventional plating techniques. This MIPO technique is applied to fractures that do not require anatomic reduction, but merely anatomic alignment. Intra-articular fractures require anatomic reduction.Hence MIPO technique usually applied for metaphyseal and diaphyseal fractures

INTERNAL FIXATOR : [35]

The concept of internal fixators was devised by a group of Polish surgeons in the 1980s.

Principles they used to design their implants are –

1. The screws should be fixed to the plate.
2. Compression between the plate and the bone should be eliminated.
3. The number of screws necessary for stable fixation should be reduced.
4. Plate stability and interfragmentary compression should be preserved.

The basic principle of the internal fixator is its angular stability, where as stability of conventional plate osteosynthesis relies on friction. This friction is caused by compression between the bone and the plate. In contrast the principle of fixation of angular stable devices is screw locking. It does not rely on the lag effect of the screws.

The function of screws in internal fixator is more akin to that of external fixator pins than to the screws in conventional plating. In internal fixators, the screws have to neutralize all the bending forces. As internal fixators do not need compression contact with the bone, precise contouring of the fixator is not necessary, where as screw tightening in poorly contoured conventional plates causes fracture malalignment, the internal fixator holds the fragments in position. This feature makes the internal fixator ideal for minimally invasive plate osteosynthesis. The benefits of angular stability over conventional fracture stability are best seen in osteoporotic bone.

Biomechanical tests have shown that lowest stability is seen in screws that are loaded in their long axis as in conventional plating and highest stability is seen when shear loading in the direction perpendicular to long axis of the screws.

BIOLOGICAL PLATING: [38]

The basic principles of an internal fixators procedure using a conventional plates and screw system (compression method) are direct, anatomical reduction and stable internal fixation of the fracture, wide exposure of bone is necessary to gain access to and provide good visibility of the fracture zone to allow reduction and platen fixation to be performed. This procedure requires pre-contouring of the plate to match the anatomy of the bone. Then screws are tightened to fix the plate to the bone.Stability results from the friction between the plate and the bone.[39]

These results in absolute stability achieved by interfragmentary compression and rigid fixation and resulted in primary fracture healing. Primary fracture healing is in general a slow process based on internal remodeling. To prevent any unacceptable rate of refracture, the consensus is that implants such as plates must remain in place, as a rule for about 1.5 to 2 years. During this period the fracture is protected by the implant.

But there is extreme difference in healing time between conservative treatment (3 months) and compression fixation (15 months) indicating that circumstances can be improved.

Hence a new method of treatment has emerged, the so-called biological internal fixation. This method takes advantage of whatever biological support from bone and soft tissues is still available after trauma.[40]

Biological internal fixation avoids the need to reduce anatomically, especially the intermediate fragments, and takes advance of indirect reduction techniques. This principle applies equally to loaded nailing, bridge plating and internal fixator like devices. Pure splinting without compression results in flexible fixation. Aim here is just to align the fragments, thus avoiding imperative surgical trauma for anatomical reduction of fracture.[36]

Biological internal fixation does not compromise the restoration of early and complete function of bone, limb and patients.

By avoiding the biological damage produced by overly precise reduction, the application of two many implants and too extensive implant to bone contact should reduce the risk of biological complications and help in improved and early healing.

Biological fixation is not achieved by rigid fixation; here the fixation is flexible allowing for indirect healing of the fracture. Flexible fixation induces healing by callus formation, which is in accordance with strain theory, which states that 2% - 10% strain over the granulation tissues induces woven bone as thin one tolerates this by its three dimensional configuration.[36]

Flexible fixation can only be achieved by avoiding interframentory compression. It is also worth noting that effect of dimensions of the implant on its structural bending stiffness is much greater than are changes in young's modulus which depends on the material of the implant.[36]

Since locked nailing has demonstrated that flexible fixation without anatomical reduction results in reliable healing, biological fixation with plates in fractures which are not nailable, has shown a new ways in the surgical management of fracture.

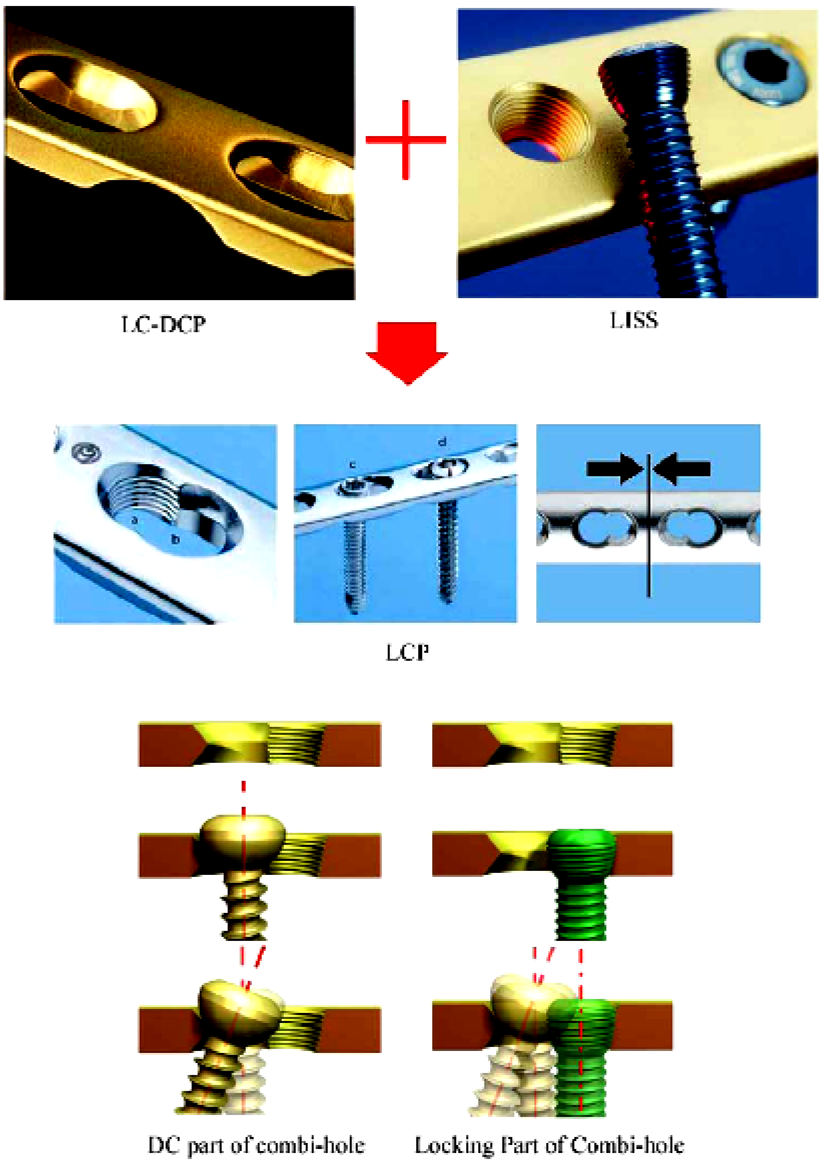
THE EVOLUTION OF LOCKING COMPRESSION PLATE: [38]

Internal fixation with plates and screws is oriented towards absolutel stable fixation by means of fracture compression. In conventional plating since the stability is achieved by creating friction between the plate and the bone, this requires precontouring of the plate to match the anatomy of the bone. The newly developed, so – called internal fixators (ex. PC fix, LISS) consist of plate and screw systems where the screws are locked in the plate. Hence minimizing the compressive forces exerted by the plate on the bone and also reducing the contact area between bone and plate.

The advantage of reduced contact area between bone and plate and of fixed angle anchorage of the screws in the plate was demonstrated for the PC-fix in laboratory testing and by clinical application. Not only the angular stability was guaranteed but also the axial stability was proven. This was achieved technically by matching a conical thread in both screws head and plate hole. This method of plate and screw fixation means that the plate need not touch the bone at all.

The most promising idea to compensate for this disadvantage was to merge a DCU (dynamic compression unit) hole geometry of the DCP and LC-DCP with the conical threaded hole of the PC-fix II and LISS, the result being the so called combihole.

FIGURE NO 12



The shape of the conical thread is identical to that of the second generation PC-fix and LISS. The locking head screw is captured in the threaded part of the combi hole through more than 200° circumference, which is sufficient to provide angular as well as axial stability of the screw in the plate.

Also the mechanical popularities of the conventional LC-DCP are comparable with that of the LCP. The smallest plate cross section is situated in the area of the DCU part of the comi-hole and not in the area of the conical threaded part of the hole. Therefore, the combi-hole could be implemented in all 3.5 mm and 4.5 mm AO plates without having to alter the outer width or thickness of the plates. Hence thin design allow for a one to one clinical comparison of the conventional plate with new locking compression plate.

With reference to the mechanical, biomechanical and clinical results, the new AO LCP with combination holes can be used, depending on the fracture situation, as an internal fixator, as a compression plate or as an internal fixation system combining both techniques.

The union of two stabilizing concepts within one treatment procedure brings with it the risk of incorrect handling, but correct application will offer optimal benefit from combined methods.

Thus, the locking compression which is and symbiosis of various techniques of plate osteosynthesis and a result of experience gained in research and in the clinic.

GENERAL PRINCIPLES FOR USING LCP: [39]

Conventional compression plating needs good bone quality and precise anatomical reduction. In multifragmentary shaft fractures, precise anatomical reduction is often not possible without a great risk of an iatrogenic soft tissue trauma. Few problems in internal fixation with conventional plates and screws remain unsolved. Two of which are implant related and therefore technical issues; viz., the primary and the secondary loss of reduction leading to mal alignment and instability. The third is that conventional plating leads to compression of the periosteum, which causes a disturbance of the bone blood supply.

In conventional plating, the total injury of the bone and the surrounding soft tissues is caused by trauma and by the operative injury. The operative injury includes damage caused by achieving reduction, the approach needed to reach the fracture site and the method and implant used in fixation of fracture.

Additional surgical damage can be reduced by adjusting the surgical technique, eg a change in soft tissue handling, reduction, and fixation techniques (insertion and choice of implants). New methods that bear a minimal risk for treating problematic fractures were developed to accelerate bone regeneration and bone healing.

Plate and screw system, where the screw can be locked in the plate, form one stable system and the stability of the fracture depends on the stiffness of the construct. No compression of the plate on the bone is required to suppress the risk of primary loss of reduction and preserve the bone blood supply. Locking the screw into the plate, ensures both angular as well as axial stability and eliminates the possibility for the screw to toggle, slide or be dislodged. This greatly reduces the risk of postoperative secondary loss of reduction.

The LCP with combination holes allows the surgeons to use it as a conventional plate as well as an internal fixator with locking head screws. There are different indications to use LCP for different techniques and biomechanical principles.

TECHNIQUE OF INSERTING LOCKING COMPRESSION SCREW :

The primary difference with the locking compression plate is the method of locking head screw insertion. Here since the locking head of the screw has to get locked in the locking part of the combi-hole, the direction of the drilling has to be perfect. Hence drilling for all locking head screw has to be after fixing the screw –in drilling sleeve (available with the locking compression plate set).

Also the tactile surgeon has when inserting the regular cortical screw is lost while inserting the locking head screw, as this gets locked regardless of the quality of bone and depth of insertion. Hence we actually determined the length of screw so as not to miss the far cortex. We also made sure that whenever using the non-locking regular cortical screws in the fixation, they were inserted prior to the insertion of the locking screws.

TABLE 1

Specifications for the different indications

	Compression	Bridging	Combi-nation	
Simple diaphyseal fractures	+	(+)*		
Simple metaphyseal fractures	+	(+)*		
Multifragmentary metaphyseal fractures		+		**No compression!**
Multifragmentary metaphyseal fractures		+		**No compression!**
Osteotomies	+	+		
Articular fractures	**+ No bridging!**			
Articular fractures with multifragmentary meta-or diaphyseal fractures			+	
Segmental fractures				
With two different fracture patterns			+	

* Newer clinical experience has shown an uneventful bone healing also after bridging of simple fractures with internal fixator principle.

1. LCP a conventional plating technique (compression method, principle of absolute stability).

a) Simple fractures in the diaphysis and metaphysis (if precise reduction is required for functional outcome).

b) Articular fractures.

c) Delayed or non-union.

d) Closed wedge osteotomies.

If LCP is used in a compression mode, two cortex screws (placed eccentrically in the Dynamic Compression part of the combination hole) are used to compress the fractures.

The operative technique is much same as conventional plating, where by conventional instruments and screws are used. In case of good bone quality, additional screws can be regular cortical screws, giving stability by increasing fixation between plate and the bone. Three bi-cortical conventional screws on each side of fracture are effective.

In osteoporotic bone, stability is increased by using locking head screws. The locking head screws are used as they increase the stability of bone implant interface by acting as one stable construct.

Three LHS (locking head screws) on each side of the fracture are advised, where by atleast one bi-cortical LHS is mandatory. (Minimum of 4 cortices on either side of fracture).

2. LCP in a MIPO technique bridging the fracture bone or regular technique with unicortical, biocortical LHS screws (internal fixator method, principle of relative stability)

a) Multifragmentary fractures in diaphysis and metaphysic.

b) Simple fractures in metaphysis and diaphysis (if non-precise reduction is enough for functional outcome. Strictly following the biomechanical principles of strain tolerance are important).

c) Open-wedge oteotomies.

d) Periprosthetic fractures.

e) Secondary fractures after intramedullary nailing.

f) Delayed change from external fixator to definitive internal fixation.

The plate and screws for one stable construct and stability of fracture depends on the stiffness of the construct. The biomechanical behaviour of LCP when used completely with locking screws can be compared to an external fixator. A long plate (more than what is required when used with open technique and conventional screws) and adequate spacing between locking screws must be used.

Sometimes temporary space holders can be screwed into few of the locking holes of the plate. These space holders maintain or minimal distance between the plate and the bone.[41]

These spare holders can be replaced by locking screws later in the surgery, or may be removed or can be kept in situ. This procedure offers the advantage that the plate will not touch the bone at any point, thus minimizing the damage to bone vascularity.[41]

3. LCP in a combination of both methods (compression method and internal fixator method) using one plate.

a) Articular fracture with a multifragmentary fracture extension into the diaphysis anatomical reduction and interfragmentary compression of the articular component, bridging of the reconstructed joint block to the diaphysis.

b) Segmental fracture with two different fracture patterns (one simple and one multifragmentary) conventional method and compression at simple fracture and bridging technique, internal fixator principle for multifragmentary fracture.

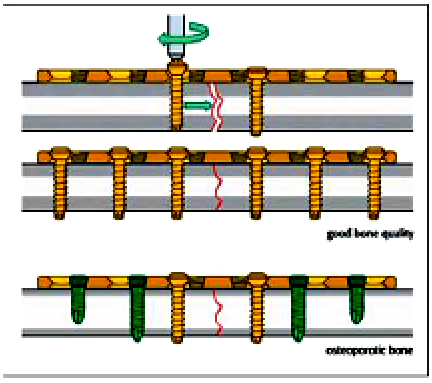
The term ‘combination’ describes the combination of two biomechanical principles :

use of combination of interfragmentary compression and the internal fixator method (bridging).

Note :

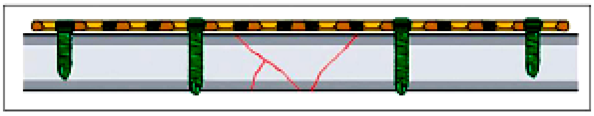
A combination technique does not mean combining different types of screws. This hybrid use of both type of screws are recommended sometimes for the reduction of a fragment onto the bone or to correct the mal-alignment of the plate on bone axis.

<u>FIGURE NO 13</u>



Compression Method

Combined Method
(Compression at articular level and bridging at metaphysis)



Internal Fixator Method (Bridging)

THE BENEFITS OF THE LOCKING COMPRESSION PLATE:

I. BIOMECHANICAL AND CLINICAL BENEFITS : [39]

1. The plate and screws from one stable system and the stability of the fracture depends on the stiffness of the construct. Locking the screw into the plate to ensure angular as well as axial stability, eliminates the possibility for the screw to toggle, slide or be dislodged and thus strongly reduces the risk of postoperative loss of reduction.

2. Multiple angle stable screw fixation in the epi and metaphyseal region, allows for fixation of many fractures that are not treatable with standard devices.

3. Improved stability in multifragmentary, complex fractures, which have loss of medial/lateral buttress or have bone loss double plating avoided.

4. The fixed angle stability avoids subsidence of fixation in metaphyseal areas. This allows for less precise contouring of the plate, as fixation depends of plate-screw construct rather than friction between plate bone interface.

5. Improved biology for healing. This is achieved by avoiding compressive forces on bone and also by elastic fixation in bridging techniques.

6. Improved biology and fixation lead to better clinical outcome and faster healing.

7. Better fixation in osteoporotic bone, especially in epi and metaphyseal areas. Divergent locked screws improve the pull out resistance of the entire construct. These locked screws have a higher core-diameter to exist cantilever and bending forces at the screw cortex junction and fixed angle devices are not subject to the toggling (weidsheild wiper effect) seen with unlocked screws which improves fixation in osteoporotic bone.

8. No or less need for primary bone graft as more fractures fixed with bridging technique with elastic fixation and also became of angle stable constructs avoiding post operative collapse.

These benefits of LCP are seen especially in the following situation :

1. Epi/metaphyseal fractures (short artiuclar block, little bone mass for purchase, angular stability).

2. In situations where the MIPO technique is indicated or possible, because accurate contouring of the plate is not mandatory.

3. Fractures with severe soft tissue injuries.
4. Fractures in osteoporotic bone.
5. Wider range indications.
6. Shaft fractures in children (questionable).

COMPLICATIONS OF PLATING AND ITS MANAGEMENT

The complications of fractures of the humeral shaft are:

1. Nerve injury

a. Radial nerve

b. Ulnar nerve

c. Median nerve

2. Vascular injury

3. Non-union

4. Mal union

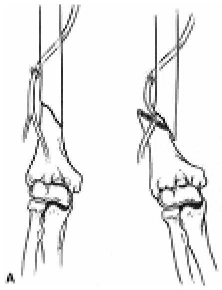
5. Compound fractures

Radial nerve injury: [42,43,44]

This is the most common complication. It could occur at the time of injury or following manipulative reduction or operative treatment or rarely due to callus. Up to 18% of humeral shaft fractures have an associated radial nerve injury. Although the Holstein-Lewis fracture (oblique, distal third) is the best known for its association with neurologic injury, radial nerve palsy is most commonly associated with middle third fractures. Most nerve injuries represent a neurapraxia or axonotmesis; 90% will resolve in 3-4 months. Electromyography and nerve conduction studies can aid in determining the degree of nerve injury and monitor the rate of nerve degeneration.

Early exploration is indicated for radial nerve palsies associated with open fracture, nerve caught between the fragments are penetrating injuries are one that develops after fracture manipulation. Radial nerve palsies that occur at the time of closed humeral fracture should be observed and radial nerve exploration is preferred a 6 to 12 months after injury if there is lack of neurologic improvement.

<u>FIGURE NO 14</u>



Other Nerves:

Ulnar nerve <1% cases.

Median nerve <2% cases usually associated with open fractures.

Vascular injury:

Although uncommon, injury or laceration of the brachial artery may occur due to gunshot wounds, stab wounds, vessel entrapment between the fracture fragments and occlusion secondary to haematoma or swelling in tight facial compartments. The brachial artery is at the greatest risk of injury in the proximal and distal third of the arm.

Fractures complicated by vascular injury constitute an orthopaedic emergency. Primary control of haemorrhage can usually be accomplished by direct pressure followed by vessel exploration, its repair and fracture stabilization. If limb viability is not in jeopardy, bony stabilization can be performed before vascular repair. If there is significant ischaemic time without distal limb perfusion, the vascular surgeon should place a temporary intraluminal vascular shunt before the fracture is stabilized.

Stabilization of the fracture is mandatory to protect the vascular repair and minimize additional soft tissue injury. The technique for definitive arterial repair is determined by the type and location of the vascular injury. Clean lacerations involving short segments of arterial wall can often be managed by direct repair. Jagged injuries and gunshot wounds may require excision of segments of artery followed by an end-to- end anastomosis or vein graft.

Non-union: [44,45,46,47,48,49,50]

The incidence of non-union of the humeral shaft has ranged from 0 to 13% in large series of patients. The proximal and the distal third of the humerus are at increased risk of non-union.

Factors associated with non-union are:

1. Mid shaft location
2. Transverse and short oblique fractures
3. Comminuted fractures
4. Open fractures
5. Infection
6. Distraction of the fracture fragments
7. Extensive soft tissue damage
8. Soft tissue interposition
9. Unstable surgical fixation.

Compression plating with bone grafting and reamed intramedullary nailing are probably the most effective methods for the treatment of established non-unions. Bridging a defect is less often necessary in the humerus than in other long bones because, when a defect occurs, the fragments can be opposed and grafted even when 4-5cms of shortening is necessary; such shortening causes little disability and the cosmetic result is of little consequence when compared with the difficulties of bridging a defect.

When preserving the length of the humerus is desirable, the defect may be bridged withna compression plate and the defect filled with cancellous and cortico-cancellous grafts.

A longer defect may be bridged with a fibular transplant. The illizarov method of internal bone transplant also can be used for humeral non-unions with bone loss.

Mal Union:

Conservative treatment usually results in mal union of the humerus. Malunions is adults should not be treated surgically unless angulation and overlapping are pronounced and disability is severe. When severe deformity is pronounced, surgical intervention i.e.osteotomy at the fracture site, accurate reduction and fixation with Dynamic Compression Plate is necessary.

Compound fractures:

Open fractures usually occur due to direct violence. Treatment consists of antibiotic coverage, debridement of the wound and fixation of the fracture fragments with plate and screws or medullary nailing or external fixators depending upon the type of wound.

TYPES OF FRACTURE UNION / REPAIR:

McKibbin (1978) suggested that fracture repair may be divided into 4 types with differing time courses of physical requirements.[51,52]

These divisions are arbitrary and in normal fracture healing is it not possible completely to separate them.

1. Primary callus response:

This commences within 2 weeks of injury, forming exuberant external callus, particularly beneath intact periosteum. The callus spreads from the fractured bone end, but if does not cause union of the bone, it will undergo involution. The primary callus response is relatively independent of environmental and hormonal influences, being an intrinsic property of the fracture.

This kind of repair probably involves determined osteoprogenitor cells (DOPC) which are found in the cambium layer of the periosteum

2. External bridging callus:

If the primary callus response is unable to unite the fractured ends, then external bridging callus forms.

This stage involves the inducible osteoprogenitor cells (IOPC) found within the surrounding soft tissues and is under the control of humeral and mechanical influences. The external bridging callus appears rapidly and bridges gaps readily. Its formation depends on the presence of viable external soft tissues which provide the blood vessels for the repair tissue and its appearance is inhibited by rigid fixation as seen in conventional compression plating. This is therefore predominant form of healing in fractures treated conservatively by casting, or by internal fixation with intramedullary devices and bridging plates (elastic fixation).

3. Late medullary callus:

This often occurs in combination but not exclusively with external binding callus. But this is slower in appearance and is relatively independent of intact external soft tissues.

This is more dependent on the intramedullary vascularity. It can bridge small gaps between bone ends and will tolerate a small amount of inter fragmentary movement. It is not inhibited by rigid fixation of fractures, and is an important stage in fractures fixed with compression plating.[53]

Bone formed under these circumstances frequently does not show an intermediate stage of fibrocartilage.

4. Primary bone union:

This is term given to fracture repair where the fracture ends have been rigidly immobilized by a plate. In the original concept of Lane and Davis, primary bone healing referred to fractures that healed with radiographically visible callus formation. This type of healing depends on the width of the gap, where it was less than 200 μm, the gap was filled by true lamellar bone, where as larger gaps showed a more irregular pattern. Where the gap exceeded a millimeter, it was not bridged in a single jump by woven bone and complete filling in was considerably delayed.

The bone filling the interfragmentary gap appears denovo without intermediate formation of connective tissue or fibrocartilage.

Even after rigid fixation there is a continuous breakdown of necrotic bone in the cortex near to the fracture. In the absence of stability, breakdown alone is usual until stability has been produced by the calcification in callus. It is at this stage that a widening fracture gap is seen radiologically. In a stabilised fracture new bone is formed almost immediately to replace resorbed bone tissue. Thus a widening of the fracture gap does not occur. These characteristics distinguishes primary bone repair from other types of fracture repair.

MATERIAL AND METHODS

The clinical material for the prospective study of surgical management of fracture shaft of humerus with locking compression plate consists of fresh humerus shaft fractures of traumatic etiology meeting the inclusion and exclusion criteria, admitted under Department of Orthopaedics of R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar between November 2013 to April 2015.

Inclusion Criteria:

1. Patients of age group > 16 years.
2. All patients with closed displaced fracture shaft of humerus.
3. Open fractures type I, type II , type III Gustilo-Anderson classification.
4. Polytrauma patients

Exclusion Criteria:

1. Gustilo Anderson open type IIIB, IIIC fractures.
2. Pathological factures.
3. Non-union.

As soon as the patient is stabilized in the emergency, a detailed history was taken & a meticulous examination of the patient was done. The required information was recorded in the proforma. The patient's arm radiographs were taken in the Antero-Posterior & Lateral views. The diagnosis was established by clinical & radiological examination and is then admitted .

In the present study, **Muller** et al of AO/ASIF group[31] classification of humeral shaft fractures was used

A: Simple fractures

A1 Spiral

A2 Oblique

A3 Transverse

B: Wedge fracture

B1 Spiral wedge

B2 Segmental wedge

B3 Fragmented wedge

C: Complex Fractures

C1 Spiral

C2 Segmental

C3 Irregular

Initially the patient’s injured arm was immobilized in a plaster of paris U-slab, drugs were given to alleviate pain. All the patients were taken for elective surgery as soon as possible after necessary blood, urine & radiographic pre-operative work-up.

The patient’s attenders were explained about the nature of injury & its possible complications. Patient’s attenders were also explained about the need for the surgery & complications of surgery.

Written & informed consent was obtained from the patient for surgery. Medical evaluation of the patient was done after consulting the Physician. Hygiene of the skin was maintained with regular scrub with betadine. Tetanus vaccine injection was given. The affected arm with the axilla was shaved, scrubbed with savlon & betadine. The anesthetist was informed, Per-operative parenteral antibiotic (preferably Cephalosporins) are administered one hour before surgery (Post-operatively continued for 5days & then converted into oral antibiotics till the sutures are removed). The patient is shifted to the operation theatre.

LOCKING COMPRESSION PLATE :

The Locking Compression Plate (LCP) is a new screwplate system that offers the possibility of inserting conventional and locking head screws which achieve fixed-angle stability into the specially designed combination holes. It represents a further development of the PC-Fix and the LISS.

Inserting a locking screw :

The primary difference with the locking compression plate is the method of locking head screw insertion. Here since the locking head of the screw has to get locked in the locking part of the combi-hole, the direction of the drilling has to be perfect. Hence drilling for all locking head screws has to be after fixing the screw-in drill sleeve (available with the locking compression plate set).

Also the tactile surgeon has when inserting the regular cortical screw is lost while inserting the locking head screw, as this gets locked regardless of the quality of bone and the depth of insertion. Hence we actually determined the length of the screw so as not to miss the far cortex. We also made sure that whenever using the non locking regular cortical screws in the fixation, they were inserted prior to the insertion of the locking screws.

FIGURE NO 15

1)Periosteum elevator.

2) Bone Lever.

3) Bone holding clamp.

4)Plate holding clamp.

5)Bone Hook.

6)Bone curette.

7)Check-key.

8)Power drill

10)Screw driver

11)Drill bit.

12) Locking drill sleeve

13) Broad Locking compression plate.

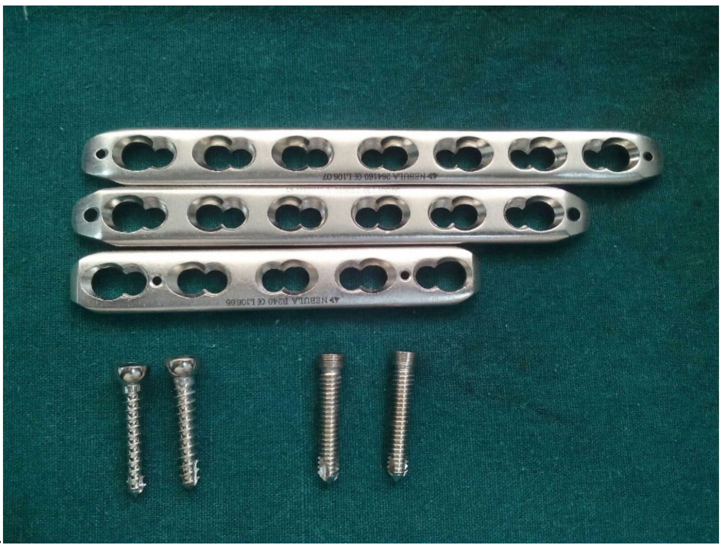
14)Tap.

15)Metal scale.

16)Depth gauge.

17)Narrow Locking compression plate.

<u>FIGURE NO 16</u>



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Pre-Operative Planning:-

Depending on the level of fracture, Nature of fracture, Line of fracture, Number of fragments, Approach, Type of plate (Broad or Narrow), Length of plate, Number of screws & Interfragmentory screws all are assessed.

Operative Technique:-

Anesthesia:- The patient taken up for surgery under General Anesthesia/brachial block.

Patients Positioning:- The patient is placed in lateral position for Posterior approach & Supine position for Antero-Lateral approach with arm on side board.

Draping:- The arm with the axilla is Scrubbed with Betadine scrub for 10 minutes, Painted with betadine solution & spirit, Draped with linen over the proposed incision site.

Exposure:-

1. Antero-Lateral Approach: Incise the skin in line with the anterior border of the deltoid muscle from a point midway between its origin and insertion, distally to the level of insertion, and then proceed in line with the lateral border of the biceps muscle to within 7.5 cms of the elbow joint. Divide the superficial and the deep fasciae and ligate the cephalic vein. In the proximal part, retract the deltoid laterally and the biceps medially to expose the shaft of the humerus. Distal to the insertion of the deltoid, expose the brachialis muscle, split it longitudinally to the bone and retract it subperiosteally, the lateral half to the lateral side and the medial half to the medial side. Retraction is easier when the tendon of brachialis is relaxed by flexing the elbow to a right angle. The radial nerve as it winds about the humeral shaft is protected by the lateral half of the brachialis muscle.

The distal end of this approach may be carried to within 5 cm of the humeral condyles and the proximal end further proximally. The anterior aspect of the humeral shaft at the junction of its middle and distal thirds can also be approached between the biceps and brachialis muscles medially and the brachioradialis laterally.

The advantages of this approach are that the brachialis muscle is usually innervated by both the musculocutaneous and the radial nerve and can thus be split longitudinally without paralysis and that the lateral half of the brachialis muscle protects the radial nerve.

2. Posterior Approach :- An incision is made in the midline on the back of the arm from the tip of the olecranon upwards and deepened through subcutaneous tissue to expose the muscle belly of the triceps. To identify the gap between the lateral and long heads of the triceps, begin proximally above where the two heads fuse to form a common tendon.

Develop the interval between the heads by blunt dissection, retracting the lateral head laterally and the long head of the triceps medially and split by sharp dissection the common tendon along the line of the skin incision. Identify and isolate the medial head of the triceps which lies below the other two heads, the radial nerve runs just proximal to it in the spiral groove (middle third). The Radial nerve is identified & retracted. Care should be taken not to bruise the ulnar nerve which lies close to the bone on the medial side. The incision can then be extended to expose the whole bone. The lateral cutaneous nerve of the arm may be seen as it escapes from under the posterior border of deltoid insertion which is reflected laterally. The lateral head of the triceps is split longitudinally.

The bone is exposed. The fracture identified, freshened by curetting, cleaned & approximated. The fracture fragments are Reduced & Plate is placed as assessed pre-operatively, held with clamps. Then the plate is fixed with screws. Inter-fragmentory screws are placed if necessary. The wound is closed in layers, wound is dressed. The shoulder arm pouch is applied.

FIGURE NO 17

PATIENT POSITION

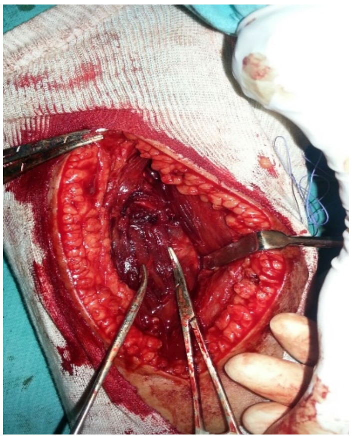
(SUPINE)

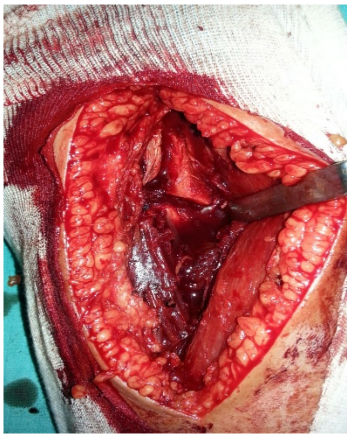
ARM ON SIDE BOARD

INCISION AND

SUPERFICIAL DISSECTION

BICEPS EXPOSED





BICEPS RETRACTED AND BRACHIORADIALIS SPLIT EXPOSING FRACTURE

RADIAL NERVE EXPOSED IN POSTERIOR APPROACH

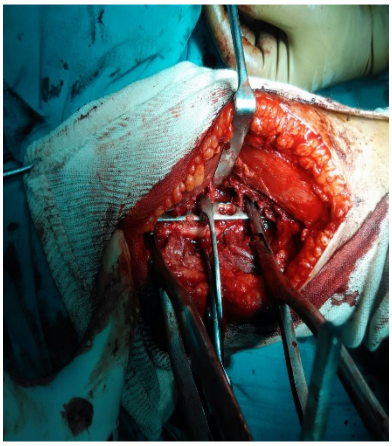
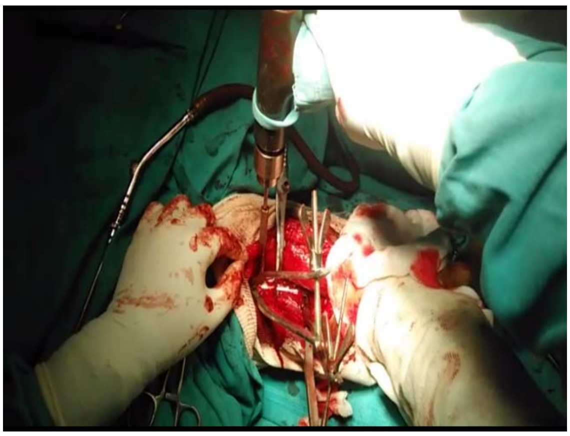
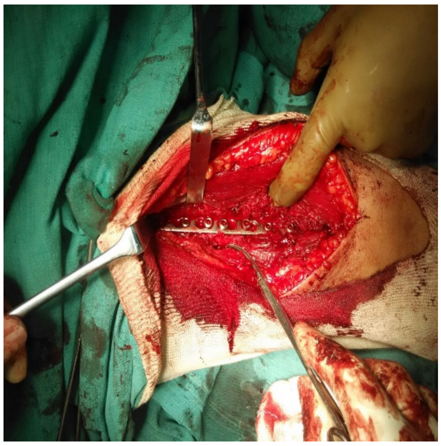


PLATE HELD WITH PLATE HOLDING FORCEPS



DRILLING WITH LOCKING SLEEVE



LOCKING AND CORTICAL SCREWS APPLIED

WOUND SUTURED

Post-operative Management:-

- ✓ The limb is elevated over a pillow.
- ✓ The patient is encouraged to move his fingers.
- ✓ The Blood pressure, Pulse, Temperature, Soakage of dressings are observed.
- ✓ Once patient recovers from anesthesia the wrist & finger were examined for iatrogenic radial nerve injury.
- ✓ Parenteral antibiotics continued.
- ✓ On the 2nd Post-operative day, check dressing was done, the condition of the wound are noted.
- ✓ Check X-ray is taken both in Antero-Posterior & Lateral views.
- ✓ From the 6th Post-operative day oral antibiotics administered till the suture removal.
- ✓ Sutures are removed on the 12th – 14th day.
- ✓ The patient is discharged with shoulder arm pouch & reviewed after 4 weeks.
- ✓ On follow-up active shoulder (Pendulum exercises), elbow, forearm & wrist exercises are taught.
- ✓ Regular O.P.D follow-ups were done on the 4^{th} week, 8^{th} week 12^{th} week,16^{th} week and 6thmonth.
- ✓ At each visit clinical & radiological evaluation done for pain, range of movement, fracture union & complications.

- ✓ The Results were assessed based on:

    1) Pain.

    2) Deformity.

    3) Range of Movements both of shoulder & elbow.

    4) Fracture Union clinically & radiologically.

    5) Functional outcome depending on the ULCA and MEPI.

    6) Complications like Non-union, Infection & Radial nerve injury.

PROFORMA OF THE CASE SHEET

Name: For identification of the patient.

Age: To record the age incidence in fracture shaft of Humerus.

Sex: To record the sex incidence of fracture shaft of Humerus in different sexes.

Occupation: Is noted to assess, how best the patient can be rehabilitated to go back to his routine occupation.

Address: Is recorded to communicate with the patient for the follow up.

Date of Admission: Is noted to record the total duration of hospital stay.

Date of Discharge: Is noted to record the total duration of hospital stay.

Hospital number: Is noted in the proforma for the hospital records.

Complaints:-

Pain: Pain is the chief complaint in Fracture shaft of humerus. Pain in the involved arm is recorded and the severity of pain is graded as severe(+++), moderate(++), mild(+) & nil(0) .

Swelling: Swelling of the arm is recorded as present or absent. In fresh fractures swelling will always be present.

Loss of function: Of the involved limb is noted. Whether the patient is able to use his limb for his routine daily activities is recorded.

Simple/compound: Compound fractures are excluded in the study.

Duration: To know the time that has lapsed from the time of injury and to plan the future course of management.

History of Present illness:-

Mode of Injury: To know the type and severity of trauma, To assess the state of bone. The trauma causing the injury may be trivial or forceful. More the severity of trauma, there will be gross comminution of the fracture which inturn hinders the anatomical reduction & affects healing. Comminution also depends on the quality of bone.

Site of Trauma: Is noted to know the amount and nature of contamination of the wound in case of a compound fracture. It is also useful to know the severity of trauma,

as in the case of an road traffic accident.

Systemic illness: Is recorded to know whether the patient can withstand surgery & affect bone healing.

Past History: Is noted to know whether the patient was suffering from any systemic illness like Diabetes mellitus, Hypertension, Tuberculosis, Epilepsy, Etc. Which may have caused the fracture or that may influence giving anesthesia to the patient and also fracture healing.

Personal History: Is recorded to know the diet of the patient, the bowel and bladder habits, the appetite, whether the patient is an alcoholic or smoker, whether there is any sleep disturbances, which may affect the general condition of the patient and thus the fracture healing. Personal history is also useful to assess the pre-injury status of the patient, his ability to attend to his daily activities with assistance or without assistance.

This is helpful in the rehabilitation of the patient.

Family History: Is recorded to rule out hereditary causes of diseases like Diabetes mellitus, Hypertension, Tuberculosis, Epilepsy, Etc. which may influence giving anesthesia and the fracture healing.

General Physical Examination:-

The general examination of the patient is done with regard to the

Built of the patient: whether the patient is obese/ well built/ moderate built/ poorly built.

Nourishment: Of the patient is noted as Good/ moderate/ poor.

Pallor: is noted as present / absent, which indicates whether the patient is anemic or not.

Icterus: is noted as present/ absent, which indicates whether the patient has Jaundice or not.

Cyanosis & Edema: is noted as present/ absent, which indicates whether the patient has Respiratory or cardiac problems.

Lymphadenopathy: is noted as present/ absent, which indicates infection

SYSTEMIC EXAMINATION

Cardiovascular system

Respiratory system

Per Abdomen examination

Local Examination:-

Signs of Fracture :

Deformity: The deformity will always be there. It is an Angular deformity depending on the level of the fracture & depending on the insertion of the Deltoid muscle, the angulation occurs. Often it is lateral angulation.

Swelling: It is a constant sign because of internal bleeding & inflammation. Swelling is graded as severe [+++], moderate [++], mild[+] & nil [0].

Skin: The condition of skin is noted for ecchymosis or abrasions. Only Simple fractures are included.

Muscle Wasting: is noted in old ununited fractures.

Tenderness, Irregularity, Crepitus & Abnormal Mobility: In the arm is appreciated & recorded.

Shortening: Is a constant sign & is noted.

All the signs of fractures are documented in the proforma as Present [P] or Absent [A].

Peripheral Pulsations: are recorded after examining the Brachial artery, Radial artery Ulnar artery.

Nerve examination: In a fracture shaft of Humerus it is mandatory to record the involvement of Radial nerve. It is the commonest complication in fracture shaft of Humerus.

Associated Injuries:- Associated Musculo-skeletal injury of the same limb & the other limb, Visceral injury, Head injury & Spinal injury are recorded as these are the days of high velocity injuries causing multi system poly trauma conditions. This always affects the selection of the patient , treatment, prognosis & rehabilitation of the injured.

Movements: In the injured limb movement are painful, restrained in shoulder & elbow.

Measurements: Of the arm is recorded from the angle of the acromion to the lateral Epicondyle & arm is always shortened.

Provisional Diagnosis:-

The provisional diagnosis of fracture shaft of Humerus is made.

Management:-

X-ray of the Arm: The Antero-Posterior & Lateral view radiographs of the involved arm is taken. The fracture was classified according to AO classification & noted in the proforma pathological fractures are excluded.

Investigations: Routine Blood investigations (Hb%, TC, DC, ESR.), Blood Sugars, Blood Urea, Serum Creatinine, Blood Grouping & typing, HIV, HbsAg, VDRL, ECG, Chest x-ray, Urine routine examination were carried out & were noted in the proforma.

Treatment Procedure: Under General anesthesia/brachial block, the fractures were reduced by open reduction & internally fixed with Locking Compression Plate using combination technique of compression of fragments and locking of the screws to the plate. The per-operative findings were recorded in the proforma.

Post-Operative Period: Post-Operatively all the cases were managed as mentioned in the material & methods. Any complications were recorded.

Follow up:- All the cases were regularly followed up at 4weeks,8weeks, 12 weeks, 16 weeks & 6 months. During the follow-up the patients were assessed with respect to the following parameters & the findings were recorded in the proforma:

1) Pain: Presence of pain in the arm is noted & the severity of pain is mentioned as severe [+++]/ moderate [++]/ mild[+]/ nil [0] (based on visual analog scale.)

2) Deformity: Presence of deformity in the arm is assessed & noted as absent [A]/ Present[D]. If there is a deformity the type of deformity is mentioned as angulatory [Ag] or rotatory [RO].

3) Movements: Range of movements of the shoulder & elbow is noted. Association of the movements with pain is mentioned.

4) Fracture Union: Based on the Clinical & Radiographic findings. It is mentioned as United [U] or Not United [Nt.U.].

5) **Functional Outcome:** of the shoulder & elbow is assessed as per UCLA and Mayo Elbow Performance Index

6) Complications: Non-union[N.U],Delayed union[D.U] Infection [I.N.F.] & Radial nerve injury [R.N.I.] are documented.

Results:- To evaluate the results of the study Sam. G. Hunter's Criteria[56], Kiviluoto

& Santovirta's Criteria[58], R. G.McCormack's Criteria[24], UCLA shoulder scoring[58,59] and Mayo Elbow Performance Index[60] were studied. An Evaluation Criterion for the Present Study was formulated based on the criteria.

OUR CRITERIA

	Excellent	**Good**	**Fair**	**Poor**
Pain(as per V A S)	Nil/Mild		Nil/Mild	Mild/Moderate
Moderate/Severe				
Deformity(of both Rotatory or angulatory)	Nil	Nil	<10	>10
R.O.M				
Shoulder	M I	M II	M III	M IV
	Full Range			
	Flex-0 to 170/180	0 to 140/170	0 to 120/140	0 to 70/120
	Ext- 0 to 40/45	0 to 30/40	0 to 20/30	0 to 10/20
	Abd-0 to 170/180	0 to 140/170	0 to 120/140	0 to 70/120
	I R- 0 to 80/90	0 to 70/80	0 to 60/70	0 to 50/60
	E R- 0 to 80/90	0 to 70/80	0 to 50/80	0 to 30/50
Elbow:	M I	M II	M III	M IV
Full range				
	Flex-0/10 to 140/150	10/20 to 130/140	20/30 to100/130	30/40 to 90/100
	Ext- 30/40 to 170/180	40/50 to 160/170	50/80 to 150/160	80/90 to 140/150
Fracture Union:	13-16weeks	17-20weeks	21-24weeks	>24weeks
Functional outcome				
UCLA	34-35	28-33	21-27	0-20points
MEPI	>90	75-89	60-74	<60points

Complications:

A) Non union

B) Delayed union

C) Infection

D) Radial nerve injury

The individual cases are evaluated based on these evaluation criteria.

RESULTS

In the present study, thirty cases of fracture shaft of Humerus treated with Locking compression plate between November 2013 to April 2015 at R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar between November 2013 to April 2015 were included.

The following observations were made in the present study

Age Incidence:

The age of the patients in the study ranged from twenty years to fifty seven years, average being 37.8 years

GRAPH NO 1

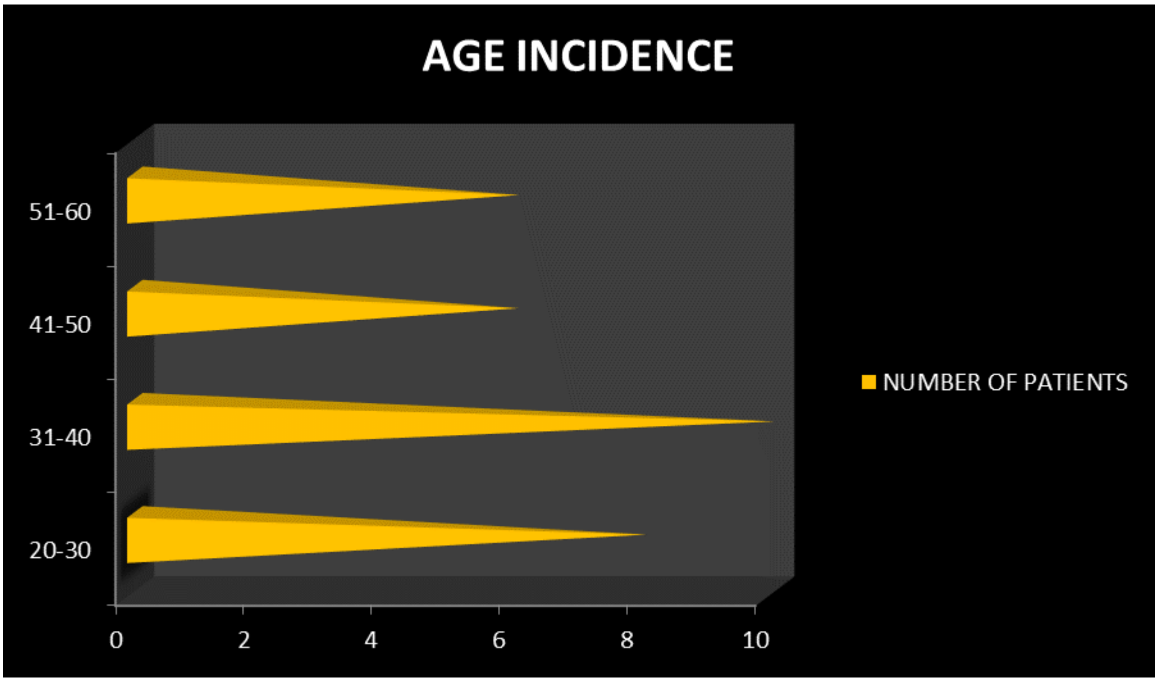


TABLE NO 2

SL.NO	***AGE***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	20-30	8	26.7%
2)	31-40	10	33.3%
3)	41-50	6	20%
4)	51-60	6	20%
	TOTAL	**30**	**100**

Sex incidence:

In the study, out of thirty patients, twenty seven were Male & three were Female

GRAPH NO 2

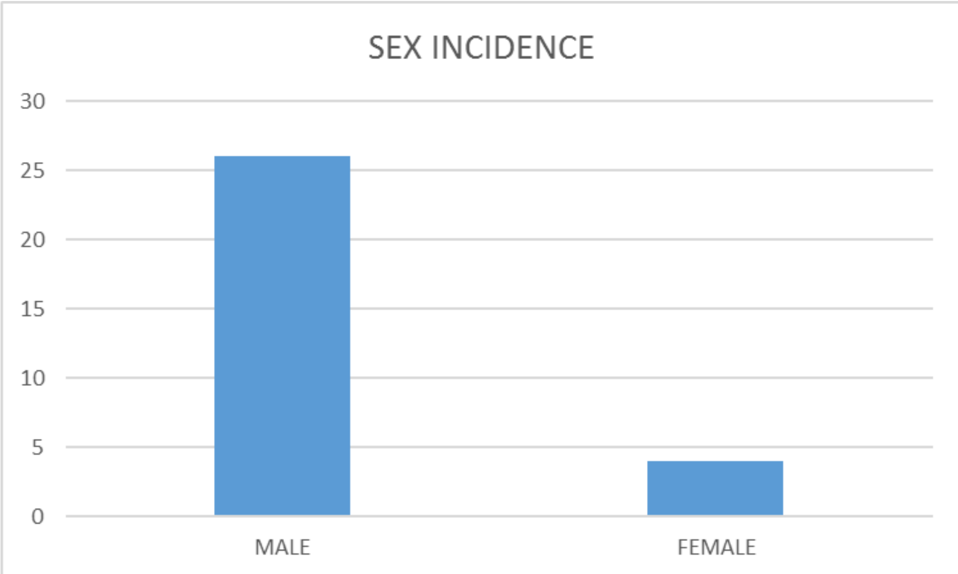


TABLE NO 3

SL NO	***SEX***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	MALE	26	86.7%
2)	FEMALE	4	13.3%
	TOTAL	30	100

Side Affected :

GRAPH NO 3

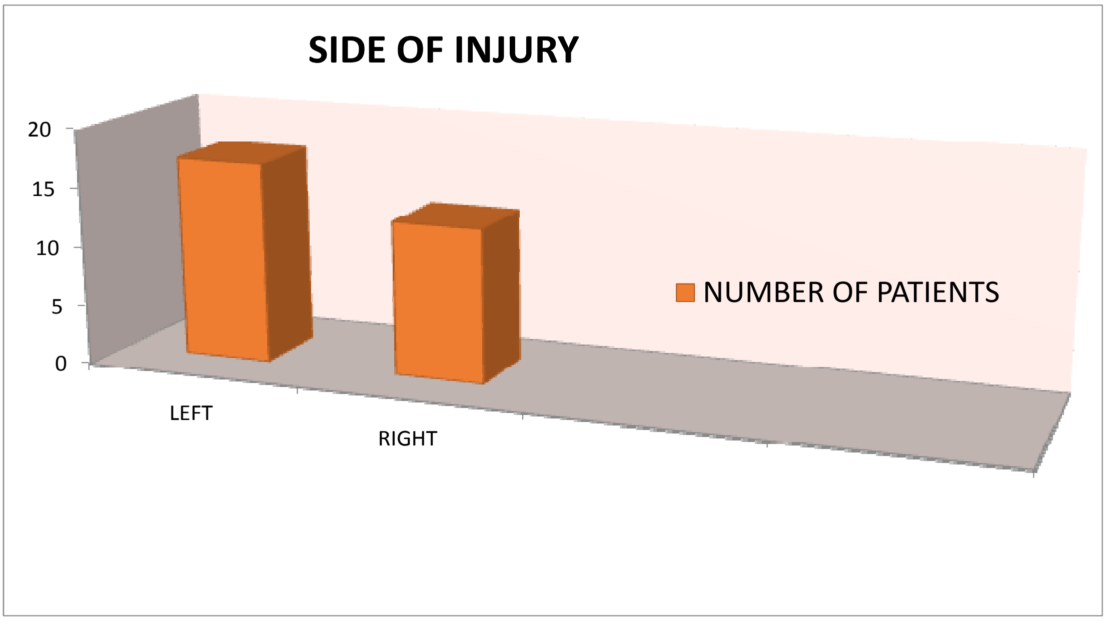


TABLE NO 4

SL.NO	***SIDE OF INJURY***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	LEFT	17	56.7%
2)	RIGHT	13	43.3%
	TOTAL	30	100

Mode of Injury:

Out of thirty patients the maximum i.e. twenty-five patients sustained road traffic accident, two self fall, two assault & one domestic injury.

GRAPH NO 4

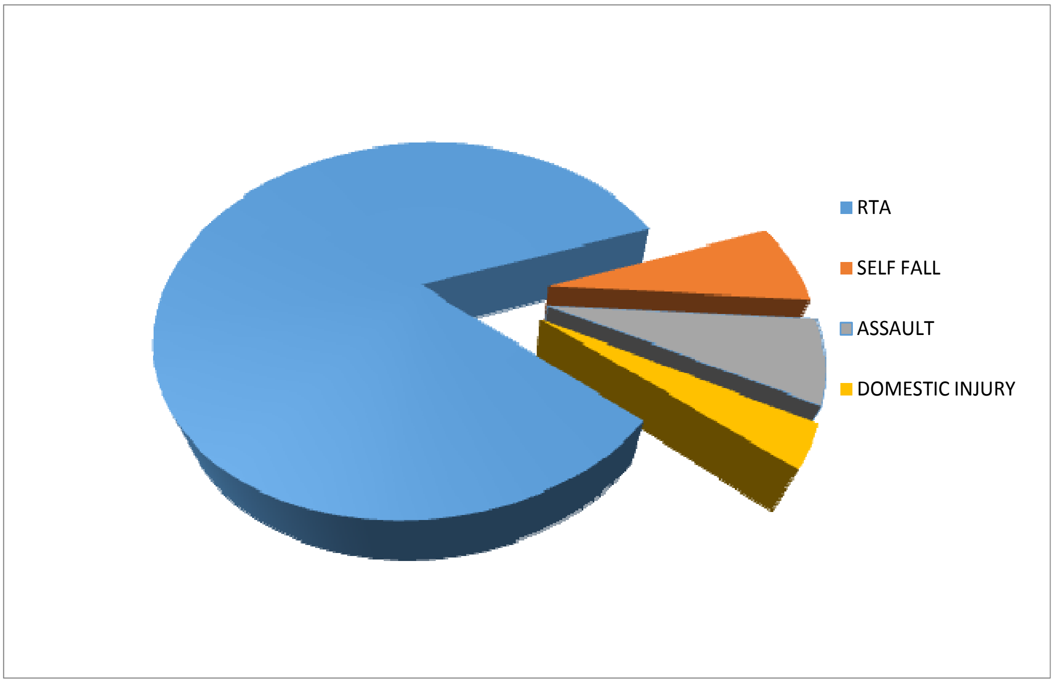


TABLE NO 5

SL.NO	MODE OF INJURY	NUMBER OF PATIENTS	PERCENTAGE
1)	RTA	25	83.4%
2)	SELF FALL	2	6.6%
3)	ASSUALT	2	6.6%
4)	DOMESTIC INJURY	1	3.4%
	TOTAL	30	100

Mechanism of injury:

In the present study out of thirty cases, twenty seven had direct injuries & only three had indirect injuries.

GRAPH NO 5

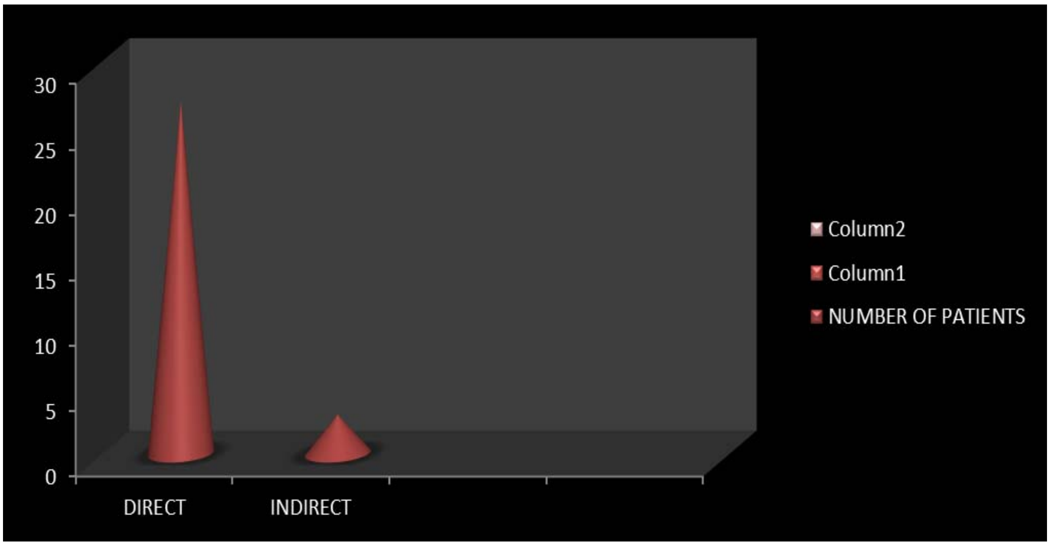


TABLE NO 6

SL.NO	*MECHANISM OF INJURY*	*NUMBER OF PATIENTS*	*PERCENTAGE*
1)	DIRECT	27	90%
2)	INDIRECT	3	10%
	TOTAL	30	100

Type of fracture:

In the study twenty six were closed frsctures with 3 open type I and 1 open type II fractures of Gustilo-Anderson classification.

GRAPH NO 6

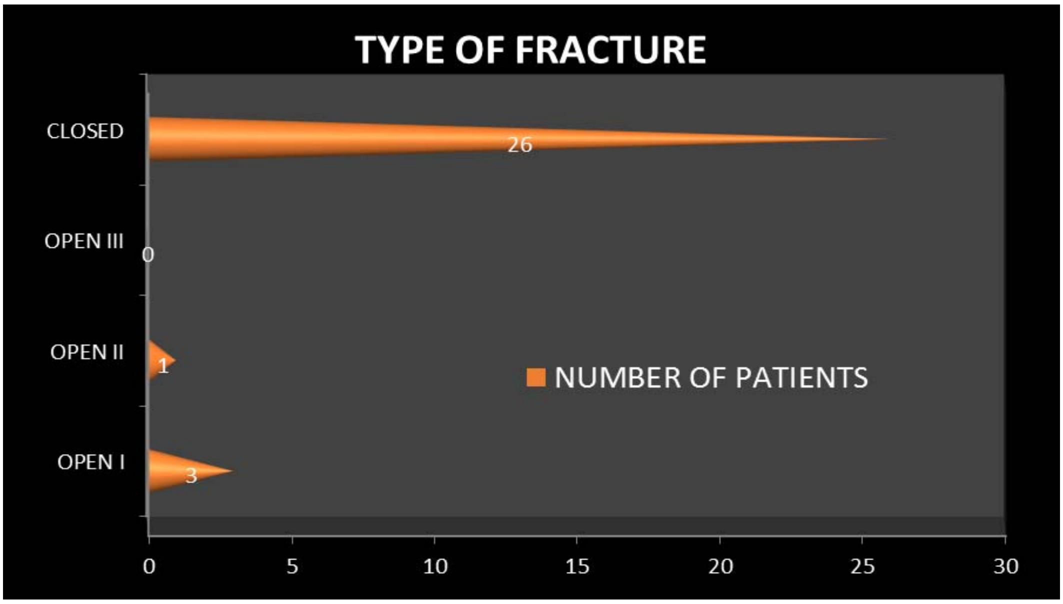


TABLE NO 7

SL.NO	***TYPE OF FRACTURE***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	OPEN I	3	10%
2)	OPEN II	1	3.3%
3)	OPEN III	0	0%
4)	CLOSED	26	86.7%
	TOTAL	**30**	**100**

Classification type of fracture:

There are 12 patients with A3(simple transverse) fractres along with 5 patients each of A2(simple oblique), B1(spiral wedge) and B2(bending wedge) fractures. There are 2 patients with A1(simple spiral) and 1 patient with C2(segmental) fracture.

GRAPH NO 7

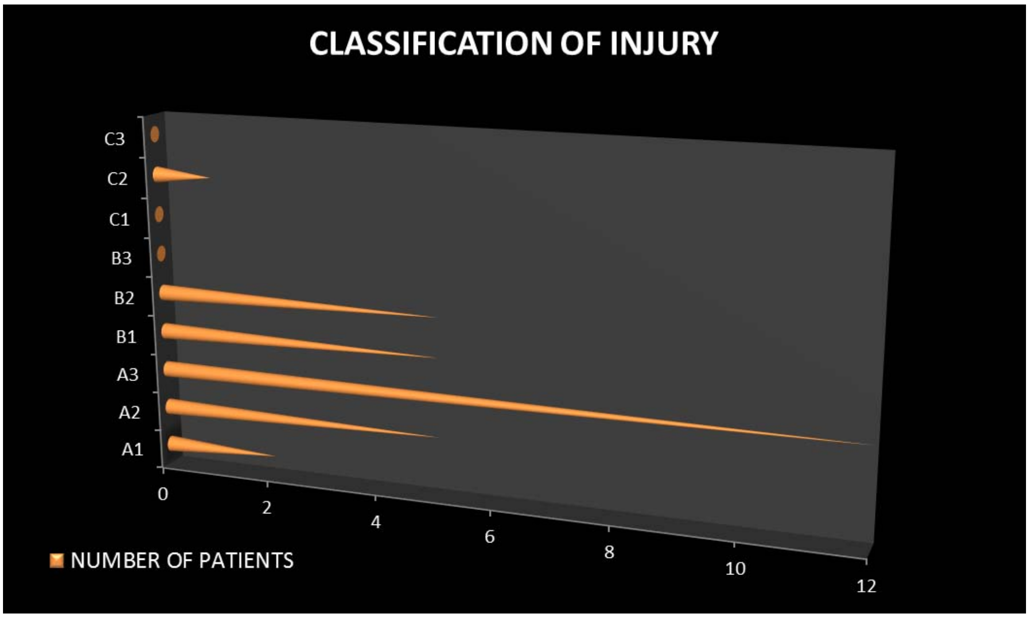


TABLE NO 8

SL.NO	*CLASSIFICATION OF THE INJURY*	*NUMBER OF PATIENTS*	*PERCENTAGE*
1)	A1(Simple spiral)	2	6.7%
2)	A2(Oblique)	5	16.7%
3)	A3(Transverse)	12	40%
4)	B1(Spiral wedge)	5	16.7%
5)	B2(Bending wedge)	5	16.6%
6)	B3(Fragmented)	0	0
7)	C1(Complex spiral)	0	0
8)	C2(segmental)	1	3.3%
9)	C3(Irregular)	0	0
	TOTAL	30	100

Associated Injuries:

In this study of thirty patients, one patient had contralateral fracture shaft of femur, one patient had ipsilateral both bone forearm fracture,one patient had ipsilateral elbow dislocation with scaphoid fracture and one patient had ipsilateral radial nerve injury with contralateral shaft of tibia fracture. Totally three patients had preoperative radial nerve palsy.

GRAPH NO 8

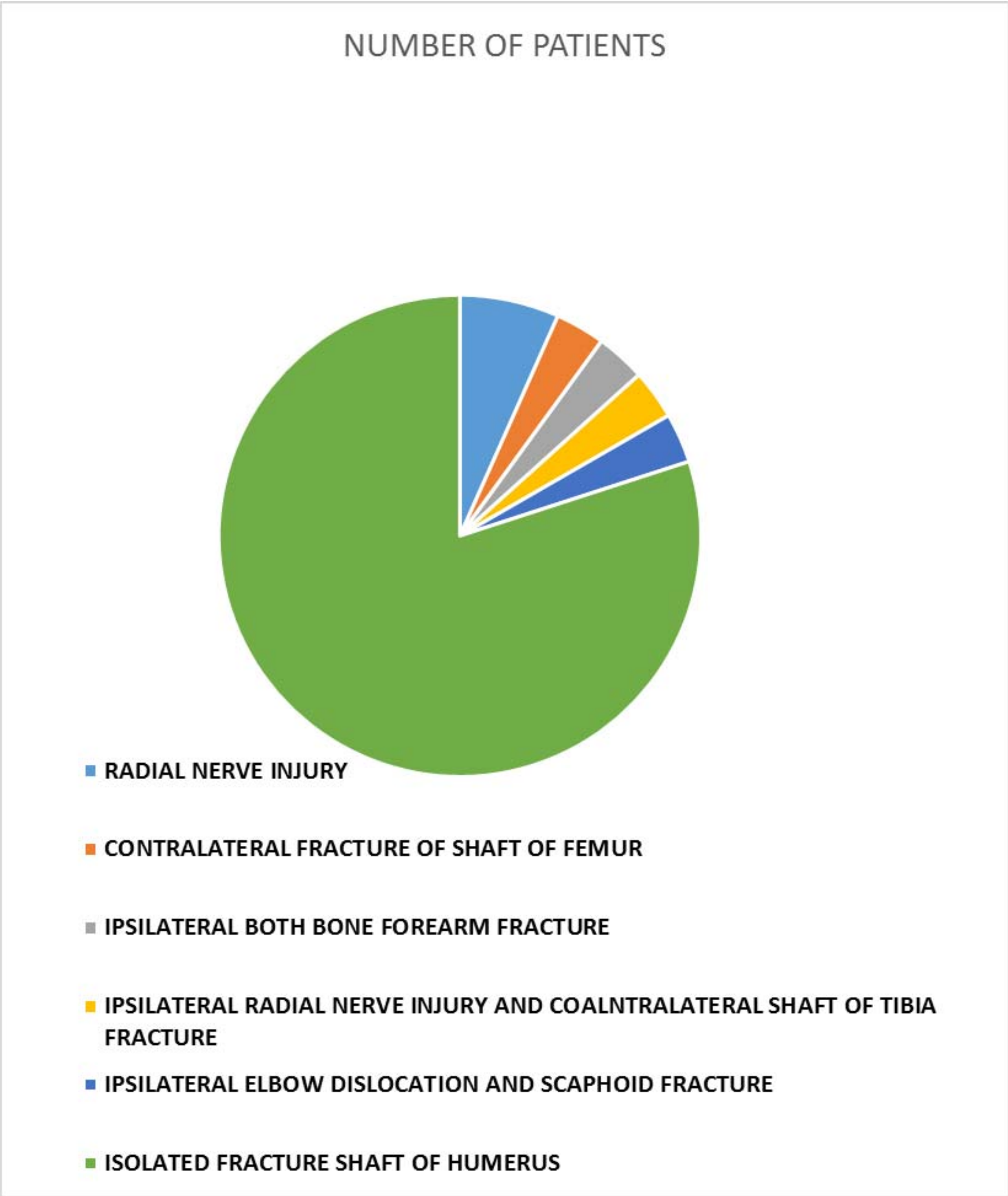


TABLE NO 9

SL.NO	***ASSOCIATED INJURIES***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	RADIAL NERVE INJURY	2	6.7%
2)	CONTRALATERAL FRACTURE OF SHAFT OF FEMUR	1	3.3%
3)	IPSILATERAL BOTH BONE FOREARM FRACTURE	1	3.3%
4)	IPSILATERAL RADIAL NERVE INJURY AND COALNTRALATERAL SHAFT OF TIBIA FRACTURE	1	3.3%
5)	IPSILATERAL ELBOW DISLOCATION AND SCAPHOID FRACTURE	1	3.4%
6)	ISOLATED FRACTURE SHAFT OF HUMERUS	24	80%
	TOTAL	**30**	**100**

Approach:

Majority of the patients were operated through anterolateral approach as most of the fractures are of mid-shaft fractures. Eight patients were operated through posterior approach where the fracture is extending distally.

GRAPH NO 9

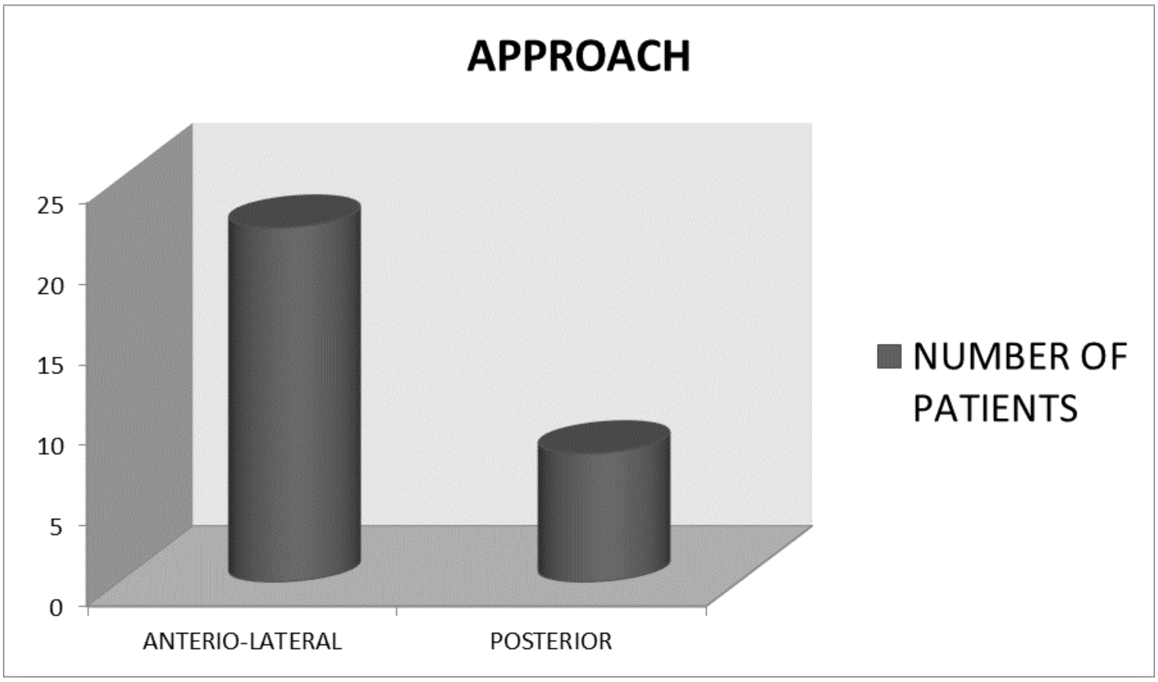


TABLE NO 10

SL.NO	***APPROACH***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	ANTERIO-LATERAL	22	73.3%
2)	POSTERIOR	8	26.7%
	TOTAL	30	100

Time Duration for Fracture Union:

In the study, the total time taken for fracture union ranged between 13weeks to 31weeks averaging 17.4 weeks. In fifteen patients fracture united between 13 to 16weeks, in nine patients fracture united between 17 to 20 weeks, in two patients fracture united between 21 to 24 weeks & one patient fracture united in 25weeks. One patient there was delayed union which healed in 31weeks without any intervention. There were two patients with non-union which required revision plating with bone grafting.

GRAPH NO 10

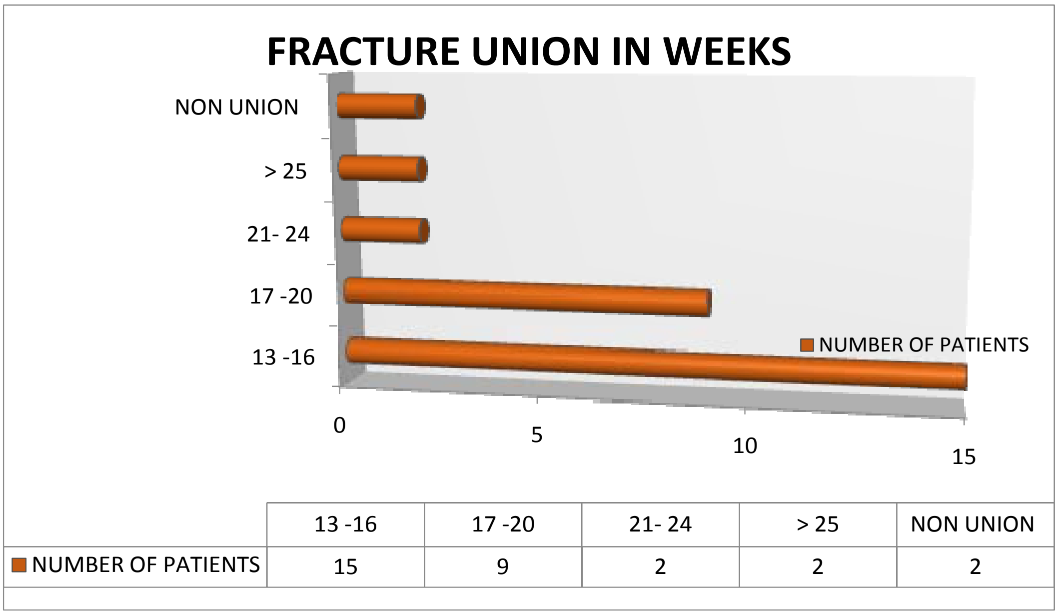


TABLE NO 11

SL NO	***FRACTURE UNION IN WEEKS***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	13 to 16	15	50%
2)	17 to 20	9	30%
3)	21 to 24	2	6.6%
4)	>/= to 25	2	6.7%
5)	NON UNION	2	6.7%
	TOTAL	**30**	**100**

Total Duration of Hospital Stay:

Fifteen patients were discharged at two weeks after suture removal and another eight patients by two and half to three weeks. There were seven patients who were discharged by one to one and half week.

GRAPH NO 11

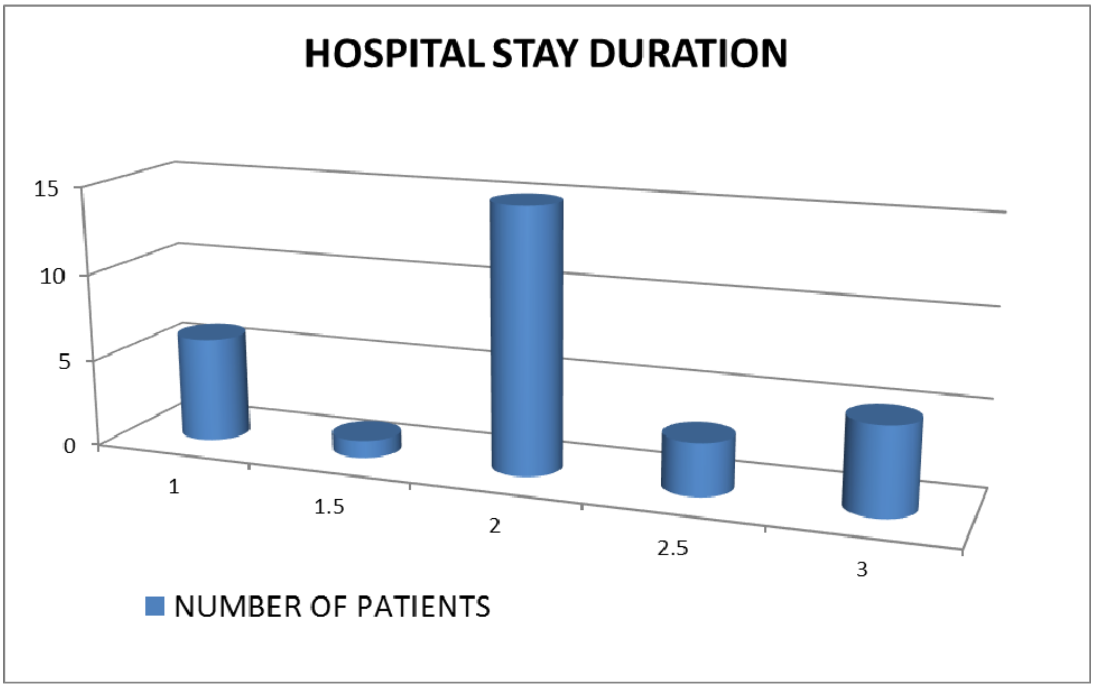


TABLE NO 12

SL.NO	HOSPITAL STAY(wks)	NUMBER OF PATIENTS	PERCENTAGE
1)	1	6	20%
2)	1.5	1	3.3%
3)	2	15	50%
4)	2.5	3	10%
5)	3	5	16.7%
	TOTAL	30	100

Functional Evaluation:

Most(twenty two) of the patients had no pain while six patients had mild pain and two patients had moderate pain.

GRAPH NO 12

Pain

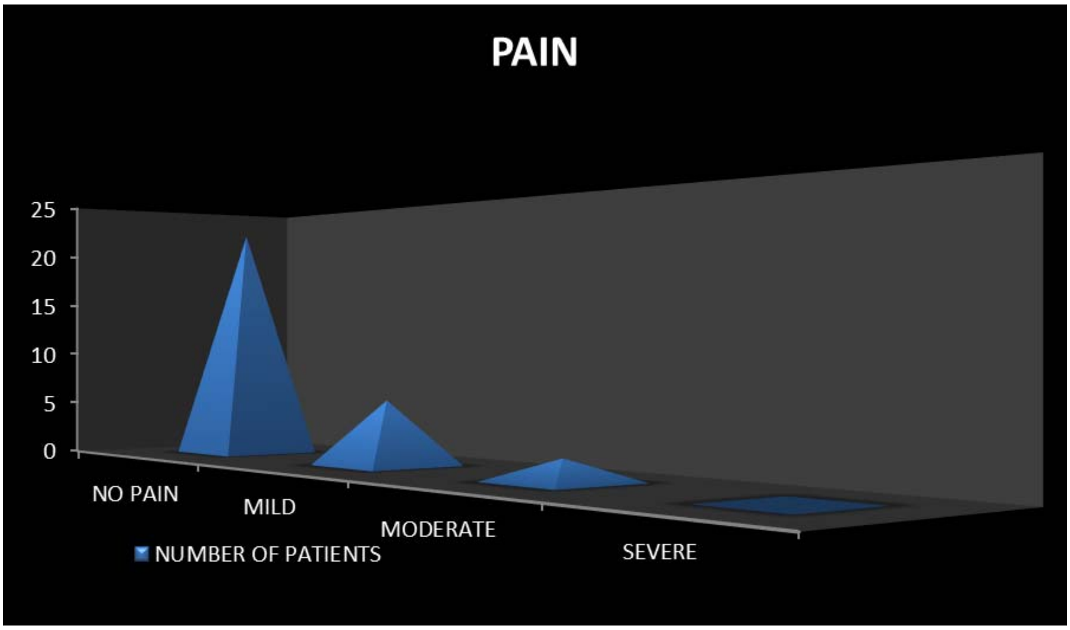


TABLE NO 13

SL. NO	***PAIN***	***NUMBER OF PATIENTS***	***PERCENTAGE***
1)	NO PAIN	22	73.4%
2)	MILD	7	23.3%
3)	MODERATE	1	3.3%
4)	SEVERE	0	0
	TOTAL	**30**	**100**

Deformity:-

There were no patients with deformity.

GRAPH NO 13

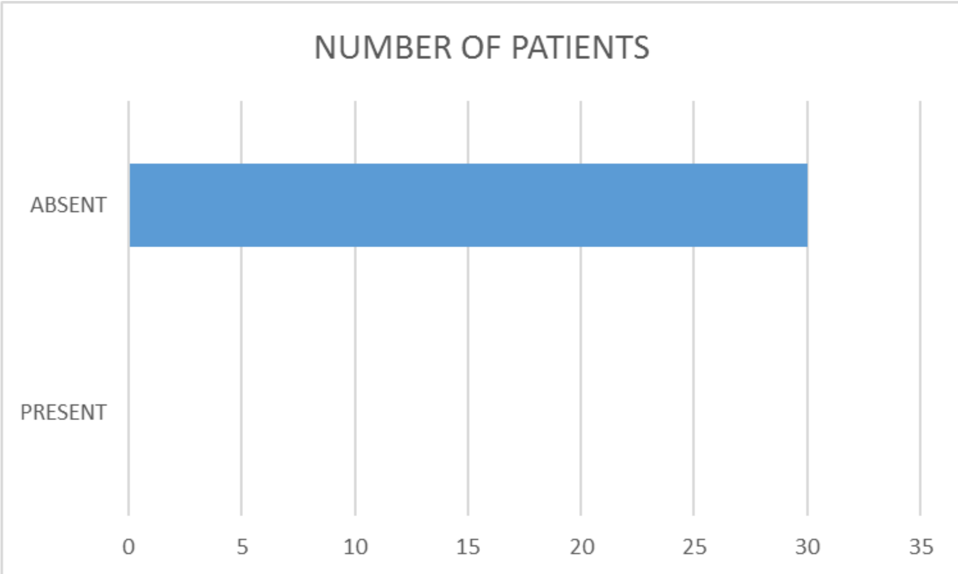


TABLE NO 14

SL NO	DEFORMITY	NUMBER OF PATIENTS	PERCENTAGE
1	PRESENT	0	0
2	ABSENT	30	100%
3	TOTAL	30	100%

Range of Movements:

The range of movements were divided into four groups as M I, M II, M III MIV as mentioned in the key to master chart. Of the thirty patients, seventeen patients had M I range of movements, eight patients had M II range of movements, two patients had M III range of movements & three patients had M IV range of movements at the end of six months.

GRAPH NO 14

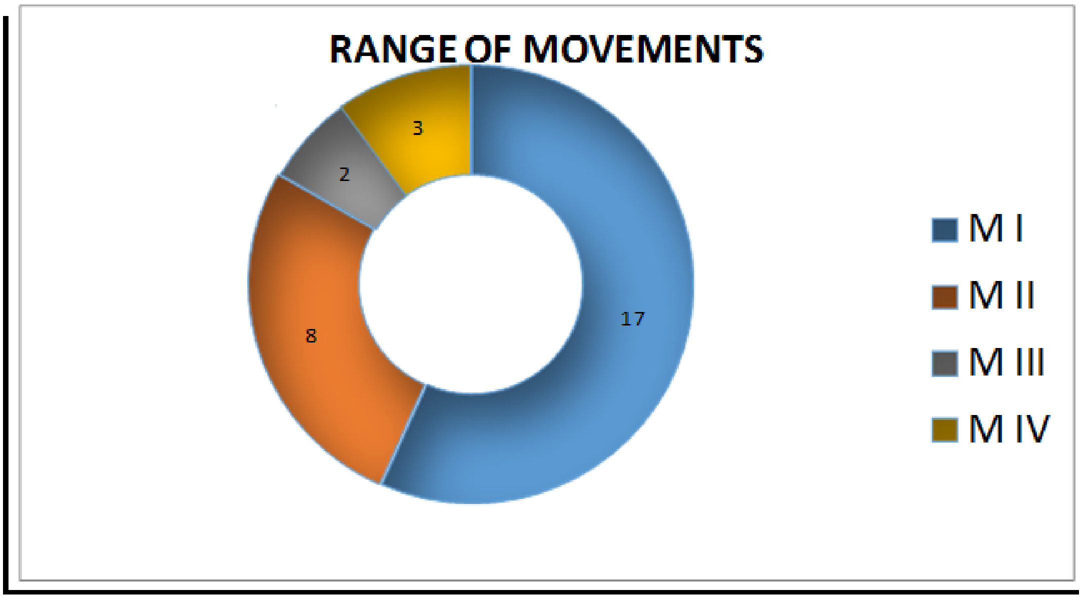


TABLE NO 15

SL.NO	RANGE OF MOVEMENTS	NUMBER OF PATIENTS	PERCENTAGE
1)	M I	17	56.6%
2)	M II	8	26.7%
3)	M III	2	6.7%
4)	M IV	3	10%
	TOTAL`	**30**	**100**

Functional Outcome as per UCLA and MEPI score:

The functional outcome is assessed by UCLA shoulder scoring system and Mayo Elbow Performance Index (MEPI). There were eighteen patients each with excellent results with both UCLA and MEPI scoring. There were six good results with UCLA and seven with MEPI. The rest included the fair and poor results.

GRAPH NO 15

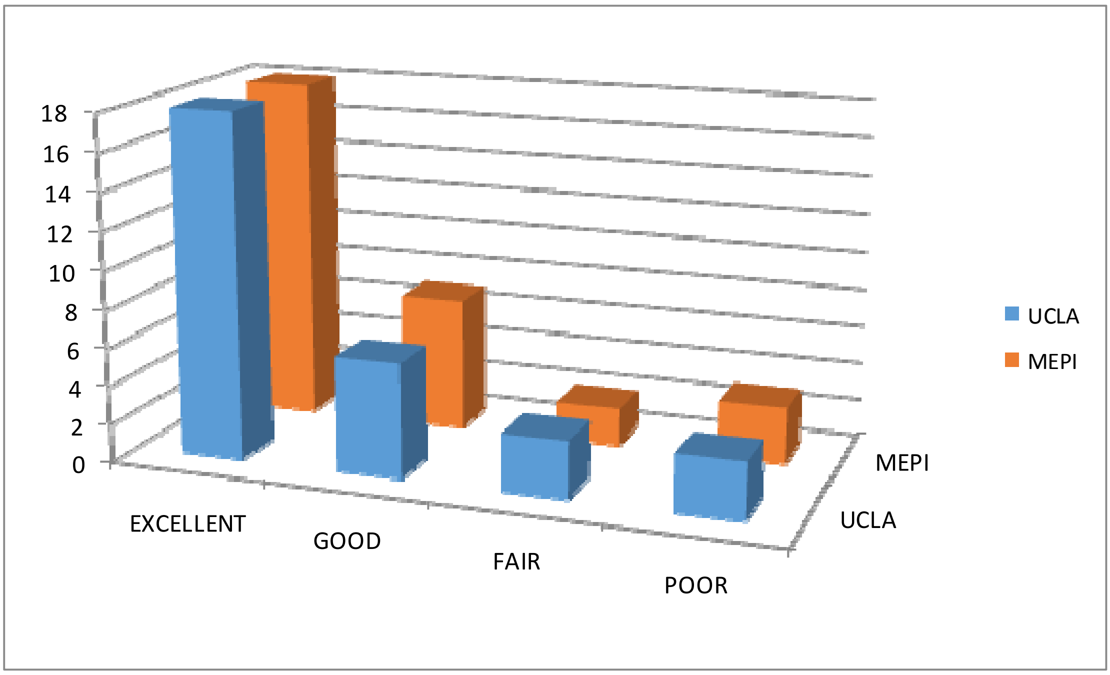


TABLE NO 16

SL.NO	FUNCTIONAL OUTCOME	UCLA	PERCENTAGE	MEPI	PERCENTAGE
1)	EXCELLENT	18	60%	18	60%
2)	GOOD	6	20%	7	23.3%
3)	FAIR	3	10%	2	6.7%
4)	POOR	3	10%	3	10%
	TOTAL	**30**	**100**	**30**	**100**

Complications:

There was one patient with radial nerve injury which recovered completely by three months. One patient had delayed union which healed spontaneously without any intervention. There were two patients with non-union which required revision plating with bone grafting.

GRAPH NO 16

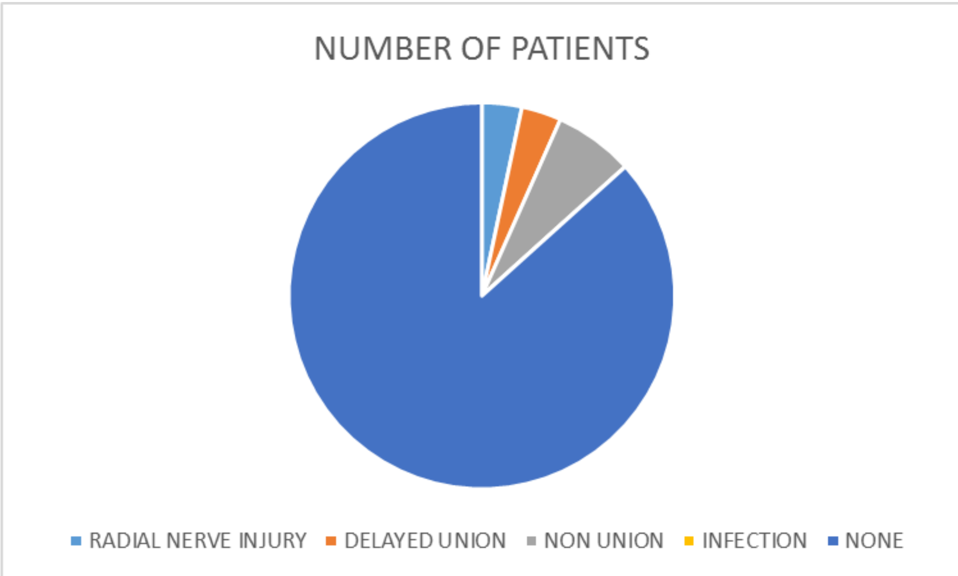


TABLE NO 17

SL NO	COMPLICATIONS	NUMBER OF PATIENTS	PERCENTAGE
1	RADIAL NERVE INJURY	1	3.3%
2	DELAYED UNION	1	3.3%
3	NON UNION	2	6.7%
4	INFECTION	0	0
5	NONE	26	86.7%
	TOTAL	30	100%

Results :

In the present study of thirty cases of diaphyseal fractures of Humerus managed by Locking compression plate were assessed & evaluated as per the criteria formulated. There were sixteen cases (53.3%) had excellent results, eight cases (26.7%) had good results, three cases (10%) had fair results & three cases (10%) had poor results.

GRAPH NO 17

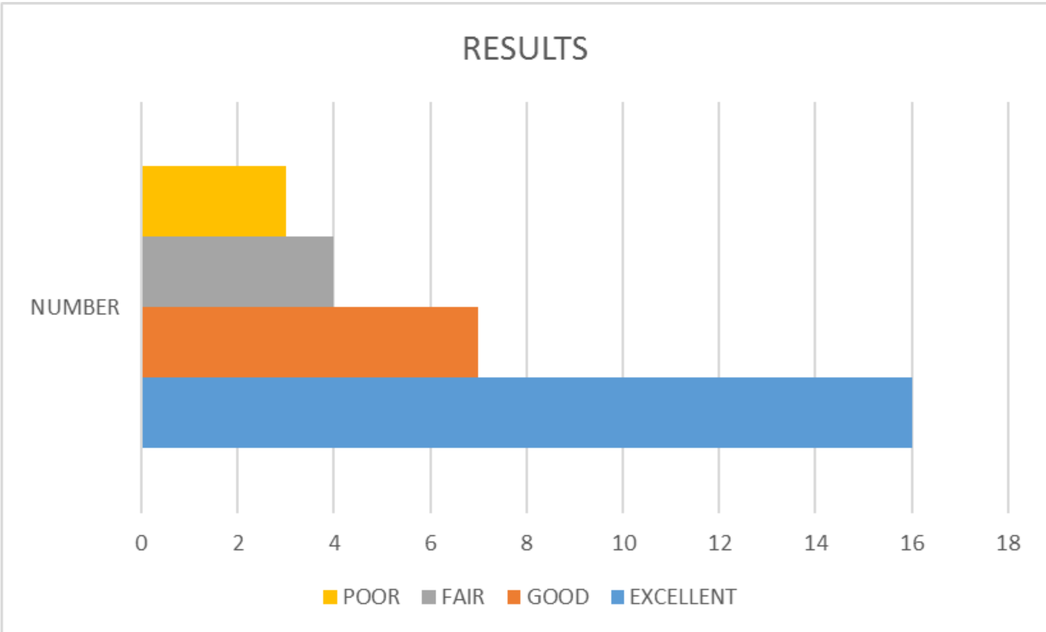


TABLE NO 18

SL NO	RESULT	NUMBER	PERCENTAGE
1	EXCELLENT	16	53.3%
2	GOOD	7	23.4%
3	FAIR	4	13.3%
4	POOR	3	10%
	TOTAL	30	100%

DISCUSSION

Diaphyseal fracture of Humerus is a relatively common injury among adults. The management of fracture shaft of Humerus forms a important daily routine of the orthopaedic surgeon. Fracture shaft of Humerus are at an increase in the present day due to high speed transportation & rapid industrial development.

The success with which most fractures of humeral shaft can be treated non-operatively has presented a dilemma for the surgeon. Open reduction & internal fixation is the most common method of surgical management of diaphyseal fracture of Humerus, although there might be complications like non- union, infection & radial nerve palsy. It is not surprising that the risks of these complications are greater with any form of
surgical intervention.

Malunion of fracture Humerus may not pose much problem as the shoulder joint can functionally compensate for all, but for severe malalignment.

In the present study, thirty cases of Diaphyseal fractures of Humerus were surgically managed by locking compression plate. The purpose of the study is to evaluate the outcome of the management of Diaphyseal fractures of Humerus with locking compression plate.

The data collected in this study is assessed, analyzed, compared with other series & the results are evaluated.

Age Incidence:-

In the present study, the average age for Diaphyseal fracture of Humerus was 37.8 years ranging from twenty years to fifty seven years. Most (33.3%) of the cases were in the age group of 31-40years

The average age incidences reported in other series are as follows:

TABLE NO 19

SI.NO.	SERIES	YEARS	AVERAGE AGE(Years)
1	SAM.G.HUNTER[56]	1982	38
2	M.J.BELL[26]	1985	31.5
3	JOHN.L.ESTERHAI,Jr.	1985	55
4	Robert Vander Griend[7]	1986	36
5	Augusto Sarmiento[32]	1990	28
6	R.G.McCormack[24]	2000	49
7	Tzu-Liang Hsu[50]	2005	46.2
8	PRESENT STUDY	2015	37.8

The results of Robert Vander Griend et.al. [(10)] 1986 and Sam. G. Hunter et.al. [(28)] in 1982 who also studied on diaphyseal humerus fractures showed similar results.

Sex Incidence:-

In the study, most i.e. twenty six patients (86.7%) were male & four (13.3%) were females. Diaphyseal fractures of Humerus are more common in males compared to females this may be due to the activity of males. The male to female ratio in this study is 6.5:1.

The average male & female incidences in other studies were as follows:

TABLE NO 20

SI.NO.	SERIES	YEARS	Male	Female
1	SAM.G.HUNTER[56]	1982	33(55.9%)	26(44.1%)
2	R.Bhalla[31]	1982	33(75.0%)	11(25.0%)
3	M.J.BELL[26]	1985	27(71.1%)	11(28.9%)
4	Robert Vander Griend[7]	1986	21(58.3%)	15(41.7%)
5	Augusto Sarmiento[32]	1990	37(57.0%)	28(43.0%)
6	D.Ring[49]	2000	9(60.0%)	6(40.0%)
7	Tzu-Liang Hsu[50]	2005	66(62.9%)	39(37.1%)
8	PRESENT STUDY	2015	26(86.7%)	4(13.3%)

In all the studies there is preponderance of male compared to females.

This study had a higher preponderence to males than rest of the studies.

Mode of Injury:-

Among all the other modes of injury road traffic accidents are the most commonest (83.3 %). This is slightly on a higher side to the study made by Robert Vander Griend [(10)] in 1986 & Tzu-Liang Hsu et.al. [(27)] in 2005. This reflects a higher percentage of patient population with road traffic accidents presenting to our emergency. The least common would be industrial. In the study made by Sam. G. Hunter[(28)] in 1982 fall was the commonest mode of injury. This gives us the idea of the force of trauma, which further helps in the management of the fracture.

TABLE NO 21

SI. NO.	SERIES	Yrs	R.T.A	FALL	ASSAULT	INDUSTRIAL
1	Jayendra	1982	59.7%	19.4%	17.7%	3.2%
2	Robert Vander Griend[7]	1986	72.2%	11.2%	8.3%	8.3%
3	Augusto Sarmiento[32]	1990	39.9%	27.6%	18.4%	14.1%
4	Tzu-Liang-Hsu[50]	2005	71.4%	19.1%	9.5%	-
5	Present Study	2015	83.3	6.7%	6.7%	0%

Type of Fracture:-

Twelve cases (40%) had transverse fractures, five cases (16.7%) had oblique fractures. There were two patients with only spiral fracture (6.7%). There were ten patients with spiral wedge and bending wedge fractures, thus 33.3% were included under comminuted fractures. This is comparable to the study made by Tzu-Liang Hsu et.al. (27) in 2005 where transverse fractures were common while comminuted fractures are more common in the study by Balla et al[31]

TABLE NO 22

SI.	Series	Yrs	Transvers	Obliqu	Spira	Segmenta	Com m
1	SAM.G.HUNTER[5]	198	35.0%	36.7%	_	_	28.3%
2	R.Bhalla[31]	198	27.0%	18.0%	6.0%		49.0%
3	Robert VanderGriend	198	27.8%	27.8%		_	44.4%
4	Tzu-Liang-Hsu[50]	200	52.4%	37.%		_	10.5%
5	Present Study	201	40%	16.7%	6.7%	3.3%	33.3%

Side of Injury:-

In the present study, there is not much difference in the side. Of thirty cases (43.3%) patients had fracture on the right side & (56.7%) had fracture on the left side. In the study made by Jayendra Kumar. J. Shah Et.al [19] in 1982 and by Robert Vander Griend[10] had similar results.

TABLE NO 23

SI.NO.	SERIES	YEAR	Right	Left
1	Jayendra Kumar.J.Shah[42]	1982	46.8%	53.2%
2	Robert VanderGriend[7]	1986	41.7%	58.3%
3	Augusto Sarmiento[32]	1990	66.0%	34.0%
4	D.Ring[49]	2000	33.3%	66.7%
5	Present Study	2015	43.3 %	56.7%

Radial Nerve Injury:-

Three patients presented with associated radial nerve palsy, in which two of them recovered. During surgery the radial nerve was found to be intact, so no additional procedure done. One of the patients had a partial cut of the radial nerve for which nerve repair was done which didn't yield good results, hence tendon transfer was done at the end of nine months. One patient had iatrogenic radial nerve injury which recovered completely by three months.

TABLE NO 24

SI.NO.	SERIES	YEAR	Radial nerve	Iatrogenic
1	M.J.Bell[26]	1985	21.1%	--
2	Robert VanderGriend[7]	1986	25.5%	_
3	R.G.McCormack[24]	2000	_	6.8%
4	Tzu-Liang-Hsu[50]	2005	_	3.5%
5	Present Study	2015	10 %	3.3%

Approach:-

Most of the patients (73.3%) of fracture shaft of Humerus was approached anteriorly and the rest (26.7%) by posterior approach. In the series of M. J. Bell [26] in 1985 & Robert Vander Griend[7] in 1986 have preferred antero-lateral approach.

TABLE NO 25

SI.NO.	SERIES	Year	Anterio-lateral	Posterior
1	M.J.Bell[26]	1985	100.0%	-
2	Robert Vander Griend[7]	1986	90.0%	10.0%
3	Present Study	2015	73.3%%	26.7%

Total Duration of Hospital Stay:-

In the present study, majority (73.4%) of the patients were discharged by two & half weeks. Rest of the patients required longer duration of stay because of other associated injuries.

Time duration from the time of injury: Most of them are operated within five days to one week once they are fit for surgery except one patient who presented to us after 2weeks.

Type of Plate: The 4.5mm locking compression has been used in all the patients except in one patient where 3.5mm is used as the bone is thin.

Time taken for Fracture union:-

Of thirty patients majority of the patients (80%) showed fracture union between thirteen to twenty weeks. In two patients fracture united by twenty-three weeks. One patient there was delayed union which healed in 31weeks without any intervention[61]. I n two patients there were no signs of union for which revision plating was done with bone grafting.

TABLE NO 26

SI.NO.	SERIES	Year	Average duration
1	M.J.Bell[26]	1985	19 weeks
2	Robert Vander Griend[7]	1986	15.6weeks
3	Ji Wan Kim[21]	2015	15.8weeks
4	Present Study	2015	17.4 weeks

It appears that open reduction internal fixation with Locking compression plating results in union comparable with previous studies along with rigid construct which allows early mobilization of the limb.

Complications:-

There was one patient with iatrogenic radial nerve injury which recovered by three months. In two patients there were no signs of union for which revision plating was done with bone grafting.

TABLE NO 27

SI.NO.	SERIES	Year	Non-Union	Infection	Radial nerve injury
1	M.J.Bell[26]	1985	2.6%	2.6%	21.1%
2	Robert VanderGriend[7]	1986	_	_	25.0%
3	R.G.McCormack[24]	2000	2.3%	_	_
4	Yu Fan[61]	2015	6.7%	--	10%
5	Present Study	2015	6.7 %	_	3.3%

In the study by R. G. McCormack. et. al. (18) in 2000 where they have compared the fixation of the fracture shaft of Humerus with plating & Intramedullary Interlocking nailing. They have noticed that the incidence of non-union is more with Intramedullary Interlocking nailing. They also noticed that the incidence of other complications like Iatrogenic radial nerve palsy, late fracture, intra operative comminution, Infection, shoulder impingement & adhesive capsulitis of shoulder was more with Intramedullary Interlocking nailing. Open reduction &Internal fixation plating, we encountered minimal complications. In a study by Yu Fan in 2015 showed similar results of complications with non-union and radial nerve injury.[61]

Results:-

In the present study, thirty patients of diaphyseal fracture of Humerus were managed with locking compression plate. The data collected in the study were assessed, analyzed & results were evaluated based on Pain, Deformity, Range of movements of shoulder & elbow graded as M I, M II, M III & M IV, Fracture union, Functional outcome as per UCLA shoulder score and Mayo Elbow Performance Index graded as excellent, good, fair and poor & Complications. Of the thirty patients there were sixteen patients (53.3%) with excellent results, seven patients (23.4%) had good results, fair results were seen in four patients (13.3%) & three patients (10.0%) had poor results. In sixteen patients with excellent results, only one patient had mild pain, none of the patients had deformity, range of movement of shoulder & elbow was full range, i.e. M I fracture united between thirteen to sixteen weeks, one patient union occurred at seventeen weeks with excellent other outcome measures, the functional outcome score was excellent & there were no complications. Taking all these criteria into consideration this group was graded as excellent.

In Seven patients with Good results, four patients had mild pain, none of the patients had deformity, range of movement of shoulder & elbow were within M I or M II, fracture united by sixteen weeks, their functional outcome score was excellent or good & there were no complications. Taking all these criteria into consideration this group was \ graded as good.

There were four patients with fair results; one patient had mild pain, no patient had deformity, range of movement of shoulder & elbow were within M II or M III, fracture united by twenty four weeks, their functional outcome score were in good or fair & there were no complications in two patients. One patient had iatrogenic radial nerve injury which recovered completely by three months. One patient there was delayed union which healed in thirty-one weeks without any intervention, mild pain, and M I range of motion and good functional outcome. Taking all these criteria into consideration this group was graded as Fair.

There were three patients with poor results.

A patient with road traffic accident as the mode of injury, with mild degree of pain, no deformity, range of movement was M III, there were no signs of union at the fracture site at six months, so revision plating was done with bone grafting & the fracture healed later, functional outcome score of grade IV & no complications. Taking all these criteria into consideration this patient was graded as Poor.

In one patient with road traffic accident who had associated ipsilateral both bone forearm fracture with moderate amount of pain, fracture union at twenty weeks had M IV range of motion with poor functional outcome. Taking all these criteria into consideration this patient was graded as Poor.

Another patient with assault as mode of injury, who presented and operated after 2weeks from the time injury, had moderate degree of pain, no deformity, range of movement was M III with no signs of union underwent revision plating with bone grafting and functional outcome score was grade IV. The transverse fracture in this case may be the cause of non-union. Taking all these criteria into consideration this patient was also graded as Poor. M. J. Bell[26] in 1986 assessed his results on the criteria of pain, range of movement & fracture union. He observed good results at the end of six months.

With a few exceptions most of the patients achieved union by the end of six months, regained a full pain free range of movement & had good functional outcome score. The complications of internal fixation that are most frequently mentioned are non-union, infection, injury to the radial nerve & prolonged disability. Careful exposure, protection of the radial nerve, rigorous application of the technique & principles of locking compression plating appears to minimize these complications and also implant failure as compared to dynamic compression plating.

In the present study of thirty patients, 73.3% had no pain & range of movement of M I or M II, 80% fractures united by twenty weeks, in 80% functional outcome as per UCLA and Mayo Elbow Performance Index was in grade I or grade II & one iatrogenic radial nerve injury which recovered completely and two complications of non- union with no screw loosening or implant failure. Taking these results into consideration, a solid plate-screw construct of the LCP which can be used in both young and elderly osteoporotic patients with added advantage of early mobilization, Open reduction Internal fixation with Locking Compression Plate is emerging to be the best treatment for fractures of the shaft of the humerus.

CONCLUSION

In the present study thirty patients with Diaphyseal fractures of Humerus were surgically managed with locking compression plate. The data was assessed, analyzed, evaluated & the following conclusions were made:

- Diaphyseal fractures of Humerus is common in adults between the age of 20 to 57years, due to high velocity transportation. The injured are within the earning age group.
- Diaphyseal fractures of Humerus is common in Males, because of their increased activities.
- There is not much difference in the side of the fracture shaft of Humerus.
- Road traffic accidents & fall are common modes of injury.
- Direct injuries are the most common Mechanism of injury.
- Transverse fractures are the common type of fractures.
- Locking compression plating is a superior method of surgical management of Diaphyseal fractures of Humerus .
- Antero-lateral approach is preferred in mid-shaft fractures and Posterior approach is preferred approach in distal one-third fractures as the Locking compression plate is placed on the tensile side of the bone.
- Early mobilization of the neighboring joints can be begun as the fixation is rigid procedure helps in regaining good range of movement of the shoulder & elbow joint.

SUMMARY

In this study, thirty patients of Diaphyseal fractures of Humerus, surgically managed by Locking compression plate, between November 2013 to April 2015 at R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar .

.The age of the patients in the study ranged from twenty to fifty-seven years, average being 37.8years.

- In the study, twenty-six were male patients& four were female patients.
- Seventeen patients had the injury on the left side, thirteen patients had the injury
  on the right side.
- In the study, twenty-five of the patients sustained fracture shaft of Humerus following road traffic accident, two following fall, two following assault & none
  following industrial injury.
- The mechanism of injury was direct injury in 90% & indirect injury in 10%
- In the study, the Diaphyseal fractures of Humerus were classified as per AO classification(5) of the thirty patients twelve patients had A3(transverse) type fracture, five each had type A2(oblique),B1(spiral wedge) and B2(bending wedge) fracture, two had A1(spiral) type and one had type C2(segmental) fracture.
- Twenty-two patients had isolated fracture of the Humerus, three patients had other long bone fractures & three patients had post traumatic radial nerve injury.
- All the patients were operated within 1 week after they were fit for surgery

except one patient who presented after 2weeks from the time of injury.

- In the study 86.7% of the patients were discharged by the end of two & half weeks. Rest 13.3% stayed longer than two & half weeks because of associated injuries.
- Most (80%) of the patients showed fracture union by twenty weeks. In one patient fracture united by thirty one weeks & in two patients there was nonunion.
- During follow-up at the end of six months 90% of the patients had no pain or mild pain & only one patient had moderate pain.
- No deformities were encountered at the end of six months.
- By six months 85% of the patients had full or almost full range of movements & 15% of the patients had moderate to severe restriction of movements.
- According to UCLA and Mayo Elbow Performance Index, 80% of the patients through UCLA and 75% through MEPI had excellent to good functional outcome.
- In the study there was one complication of iatrogenic radial nerve injury which recovered by three months. There were two patients with non-union for which revision plating was done with bone grafting & later the fracture united.
- In the study of thirty patients, 53.3% of patients had excellent results, 23.4% of patients had good results, 13.3% of patients had fair results & 10% of patients had poor results.
- By the analysis of the data collected in the present study, Locking compression plate is establishing its position as the implant of choice in the management of Diaphyseal fractures of Humerus when the principles of fracture fixation and locking compression plate are followed appropriately.

BIBLOGRAPHY

1. Rockwood Green's – Fractures in Adults. Fourth edition, 1996: 1025-1053.

2. Whitson R O. Relation of radial nerve to the shaft of the Humerus. J 1954;36A: 85-91.

3. Laing P G. The Arterial supply of the adult Humerus. J Bone Joint Surg 1956;38A:1105-1116.

4. Holstein A, Lewis G B. Fractures of the Humerus with Radial nerve paralysis. J Bone Joint Surg 1963;45A:1382-1388.

5. Klenerman. L. Fractures of shaft of the Humerus. J Bone Joint Surg 1966;48B: 105-111.

6. Mohandas P V A , Ravindran S, Management of fresh fractures of the shaft of the humerus by Internal Fixation. Indian J Orthop 1982;16:44-51.

7. Griend R V ,Tomasin J,Ward E F, Jackson.Open Reduction & Internal Fixation of Humeral Shaft Fractures J Bone Joint Surg 1986;68A:430- 433.

8.Cornier P, Pietu G, Dujardin C, Bigorre N, Ducellier F,Gerard R. The concept of locking plates.Orthop Traumatol Surg Res 2010;96S:S17-S36

9.Sommer C, Gautier E, Muller M, Helfet DL, Wagner M. First clinical results of locking compression plate (LCP). Injury 2003 ; 34: B43-54.

10.Niemeyer P, Südkamp N P. Principles and Clinical Application of the Locking Compression Plate (LCP).Acta Chirurgiae Orthopaedicae Et Traumatologiae Čechosl 2006;73:221–228.

11.Ahmad M, Nanda R, Bajwa A S, Candal-Couto J, Green S, Hui A C.Biomechanical testing of the locking compression plate: When does the distance between bone and implant significantly reduce construct stability.Injury 2007; 38: 358-364

12.Heineman, D. J., Poolman, R. W., Nork, S. E., Ponsen, K. J., & Bhandari, M. Plate fixation or intramedullary fixation of humeral shaft fractures: An updated meta-analysis. Acta orthopaedica 2010; 81(2), 216-223.

13.Denies, E., Nijs, S., Sermon, A., & Broos, P. Operative treatment of humeral shaft fractures. Comparison of plating and intramedullary nailing. Acta Orthop. Belg., 2010; 76, 735-742.

14.Shetty, M. S., Kumar, M. A., Sujay, K. T., Kini, A. R., & Kanthi, K. G. Minimally invasive plate osteosynthesis for humerus diaphyseal fractures. Indian J Orthop 2011; 45(6), 520.

15.Ghosh, Soumya, et al. Comparative study of operative treatment of mid shaft fracture of humerus by locking plate versus intramedullary interlocking nail.Medical Journal of Dr. DY Patil University 6.4 (2013): 390.

16.Yang Q et al.Surgical Treatment of Adult Extra-Articular Distal Humeral Diaphyseal Fractures Using an Oblique Metaphyseal Locking Compression Plate via a Posterior Approach.Med Princ Pract 2012;21:40–45

17.Neuhaus V , King J D, Jupiter J B. Fixation of Osteoporotic Fractures in the Upper Limb with a Locking Compression Plate. Acta Chirurgiae Orthopaedicae Et Traumatologiae Čechosl 2012;79:404–410

18.Pal C P, Goyal A, Shakunt R K, Kumar D, Singh A, Dinkar K S. A comparative study of the results of locking compression plating and stack nailing in diaphyseal fracture of humerus.Journal of Orthopaedics, Traumatology and Rehabilitation 2013;6:74-77.

19.Kumar M N, Ravindranath V P, Ravishankar M R.Outcome of locking compression plates in humeral shaft nonunions.Indian J Orthop. 2013;47:150-155.

20.Singh A K, Narsaria N, Seth R R, Garg S. Plate osteosynthesis of fractures of the shaft of the humerus: comparison of limited contact dynamic compression plates and locking compression plates.Journal of Orthopaedics and Traumatology 2014;15:117-122

21.Kim J W, Oh C W, Byun Y S, Kim J J, Park K C. A prospective randomized study of operative treatment for noncomminuted humeral shaft fractures: conventional open plating versus minimal invasive plate osteosynthesis. J Orthop Trauma. 2015;29(4):189-94

22.Gray's Anatomy - 36th edition, 1980.

23.Carroll, S. E. A study of the nutrient foramina of the humeral diaphysis. J Bone Joint Surg Br 1963; 45(1); 176-181.

24.McCormack R G et al .Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. J Bone Joint Surg 2000 ;82-B: 336-339.

25. Tinqstad E M. et al. Effect of immediate weight bearing on plated fractures of the humeral shaft. J trauma 2001;49(2): 278-80.

26. Bell M J et al.The result of plating humeral shaft fractures in patients with multiple injuries. J Bone Joint Surg 1965;67(2): 293-6.

27. Strong G T, Walls N. and McQueen M M. The epidemiology of humeral shaft fracture. J Bone Joint Surg 1986; 80-B (2): 249-53.

28. Klenerman L, Fractures of the shaft of the humerus. J Bone Joint Surg 1966;48-B:105-11.

29. Rommens P M, Blum J ,Runkel M. Retrograde nailing of humeral shaft fractures.CORR 1998;350: 26-39

30. Muller M E, Algower M, Schneide R , WilLinegger H, Manual of internal fixation techiniques recommended by AO-ASIF group,Berlin, Springer-Verlag 1991:126-127

31.Bhalla R , Narang T S ,Lobo L H. Functional Brace Treatment of the fracture of the Shaft of the Humerus. Indian J Orthop 1982;16:9-3.

32. Sarmiento A, Horowitch A, Aboulafia A,Vangsness V T Jr.functional bracing for Comminuted Extra-Articular fractures of distal Third of the Humerus. J Bone Joint Surg 1990 ;72B:283- 287

33. Sarmiento A , Zagorski J B, Zych G A, Latta L L, Capps C A. Functional Bracing for the Treatment of fractures of the Humeral Diaphysis. J Bone Joint Surg 2000;82A :478-486.

34. Danis R. The aim of internal fixation. Clin Orthop 1979;138: 23-5.

35. Krettek C, Gosling T. Principles of internal fixation. In: Bucholz R W, Heckman J D, Court-Brown C M, editors. Rockwood and Green's fractures in adults. 6th edn. Philadelphia, USA: Lippincot Williams and Wilkins 2006: 209-56.

36. Perren S M. The evolution of internal fixation of long bones fractures, the scientific basis of biological internal fixation: choosing a new balance between stability and biology. Review. J Bone Joint Surg Br 2002; 84-B(8): 1093- 110.

37. Hidaka S, Gustilo R B. Refracture of bones of forearm after plate removal. J Bone Joint Surg Am 1984 ; 66(8): 1241-43.

38. Perren S M. Evolution and rationale of locked internal fixator technology. Introductory remarks. Injury 2001; 32:B3-9

39. Wagner M. General principles for the clinical use of LCP. Injury 2003 ; 34: B31-42.

40. Perren S M. Backgrounds of the technology of internal fixators. Injury 2003

; 34:B1-3.

41.Frigg R. Locking compression plate (LCP). An osteosynthesis plate based on the dynamic compression plate and the point contact fixator (PC-Fix). Injury 2001; 32: B63-6

42. Kumar J, Shah J ,Bhatti N A .Radial Nerve Paralysis Associated with Fractures of the Humerus. C.O.R.R 1983:172-176.

43. Dabezies E J, Banta C J,Murphy C P D,Ambrosia R D. Plate fixation of the Humeral shaft for acute fractures with & without Radial nerve injuries. J Orthop Trauma 1992;6:10-13.

44. Olarte C M, Darowish M , Ziran B H. Radial nerve Transposition with humeral fracture fixation: preliminary results.C.O.R.R 2003;413:170-174.

45. Jesse B J.Complex Non-union of the Humeral Diaphysis. J Bone Joint Surg 1990;72A: 701-703.

46. Foster R J , Dixon G L Jr, Bach A W ,Appleyard R W , Green T M. Internal Fixation of Fractures & Non- Union of the Humeral Shaft. J Bone Joint Surg 1985 ;67A: 857-864.

47. Rubel I F , Kloen P , Campbell D, Meng, Mark Schwartz, Alan Liew, Elizabeth Myers , Helfet D L.Open Reduction & Internal Fixation of Humeral Nonunions. J Bone Joint Surg 2002;84A:1315-1322.

48.Esterhai J L, Brighton C T , Heppenstall R B, Albert Thrower .Nonunion of the Humerus. C.O.R.R 1986:228-234.

49.Ring D , Jupiter J B , Quintero J, Sanders R A, Marti R K . Atrophic Ununited Diaphyseal fractures of the Humerus with a bony defect. J Bone Joint Surg 2000 ;82B:867-871.

50.Hsu T L, Chiu F Y , Chen C M, Chen T H .Treatment of Nonunion of Humeral Shaft Fracture with Dynamic Compression Plate & Cancellous Bone Graft J Chin Med Assoc 2005;68:73-76.

51. McKibbin B. The biology of fracture healing in the long bones. J Bone Joint Surg Br 1978 ; 60-B: 150-62.

52. Atkins R M, The musculoskeletal system. In: Duthie R B, Bentley R, editors. Mercer's orthopaedic surgery. 9th edn. London, UK: Arnold 2003:43-144.

53. Olerud S, Lillestrom G D. Fracture healing in compression plate osteosynthesis. Acta Orthop Sand 1971: 72

54.S. Terry Canale - Campbell's Operative Orthopaedics - tenth edition copyright vol-3, 2003, 3002-3016.

55. Stanley Hoppenfeld & Peit deBoer. M. A.- Surgical exposures in Orthopaedics. Third edition, 2003, 79-84.

56.Sam. G. Hunter, M.B. – The Closed Treatment of Fractures of The Humeral Shaft C.O.R.R. 1982; 164:192-198.

57. Kiviluoto O. & Santovirta S.: Fracture of Olecranon. – Acta Orthop Scand 1978;49:28-31

58.Ellman H, Hanker G, Bayer M (1986) Repair of the rotator cuff. End-result study of factors influencing reconstruction. J Bone Joint Surg Am 68(8):1136–1144

59. Ellman H (1987) Arthroscopic subacromial decompression: analysis of one- to three-year results. Arthroscopy 3(3):173–181

60. Gill DR, Morrey BF (1998) The Coonrad-Morrey total elbow arthroplasty in patients who have rheumatoid arthritis. A ten to fifteen- year follow-up study. J Bone Joint Surg Am 80(9):1327–1335.

61.Fan, Y., Li, Y. W., Zhang, H. B., Liu, J. F., Han, X. M., Chang, X., ... & Zhang, B. Z. . Management of Humeral Shaft Fractures With Intramedullary Interlocking Nail Versus Locking Compression Plate. Orthopedics 2015; 38(9), e825-e829.

FIGURE NO 18 # PATIENT IMAGES

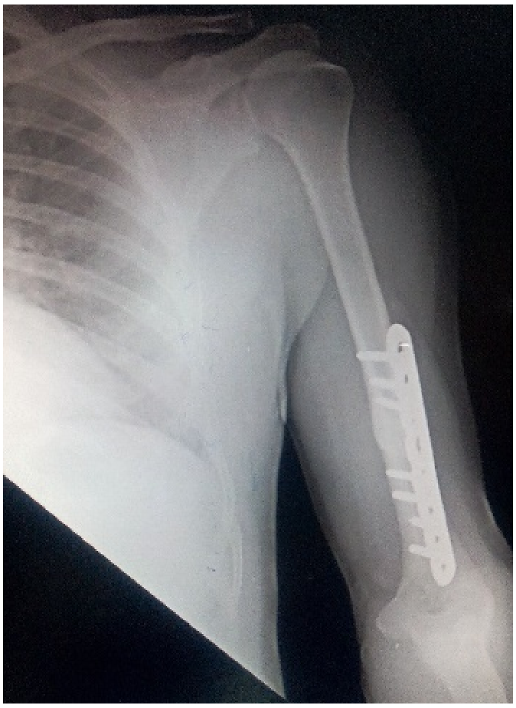
CASE 1:

Preop AP view

Preop lateral view

Postop AP view

Postop lateral view



At 20weeks-AP view **20weeks-Lateral view**

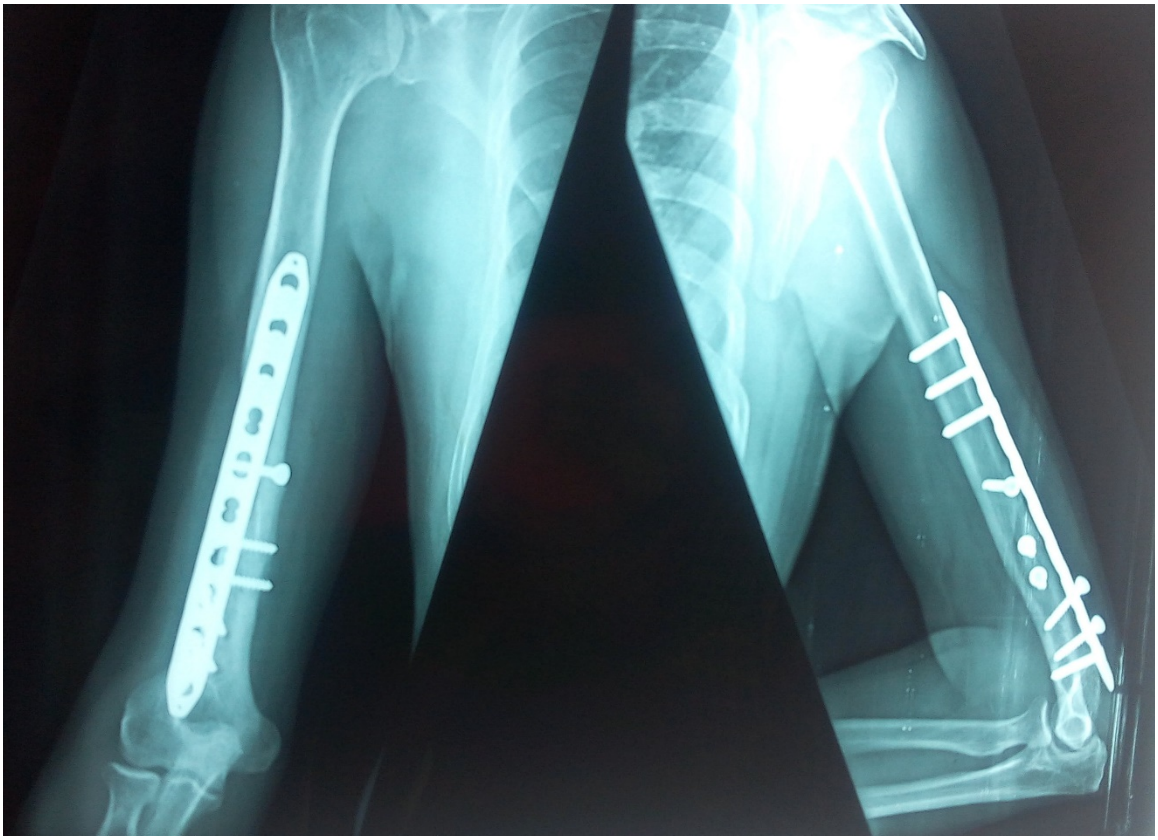
<u>FIGURE NO 19</u>

CASE 2:

Preop A P view **Lateral view**

Post op A P view

Lateral view

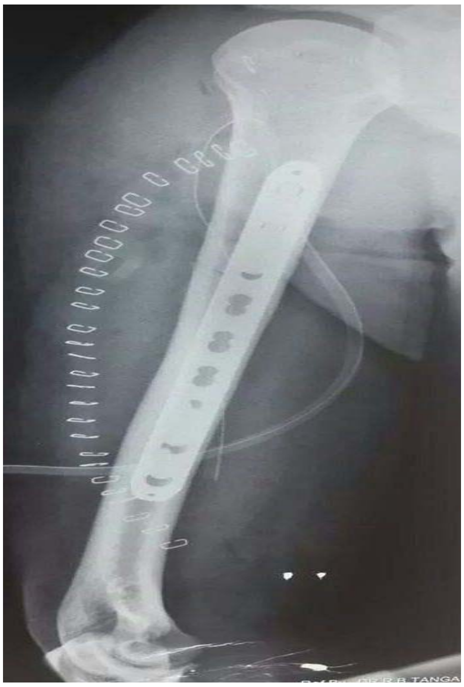


UNION AT 13WEEKS

FIGURE NO 20

Case 3:

Pre op A P view **Lateral view**



Postop A P view **Postop lateral view**

Union at 13 weeks

FIGURE NO 21

CASE 3: NON UNION

Preop A P view

Preop lateral view

Postop AP view

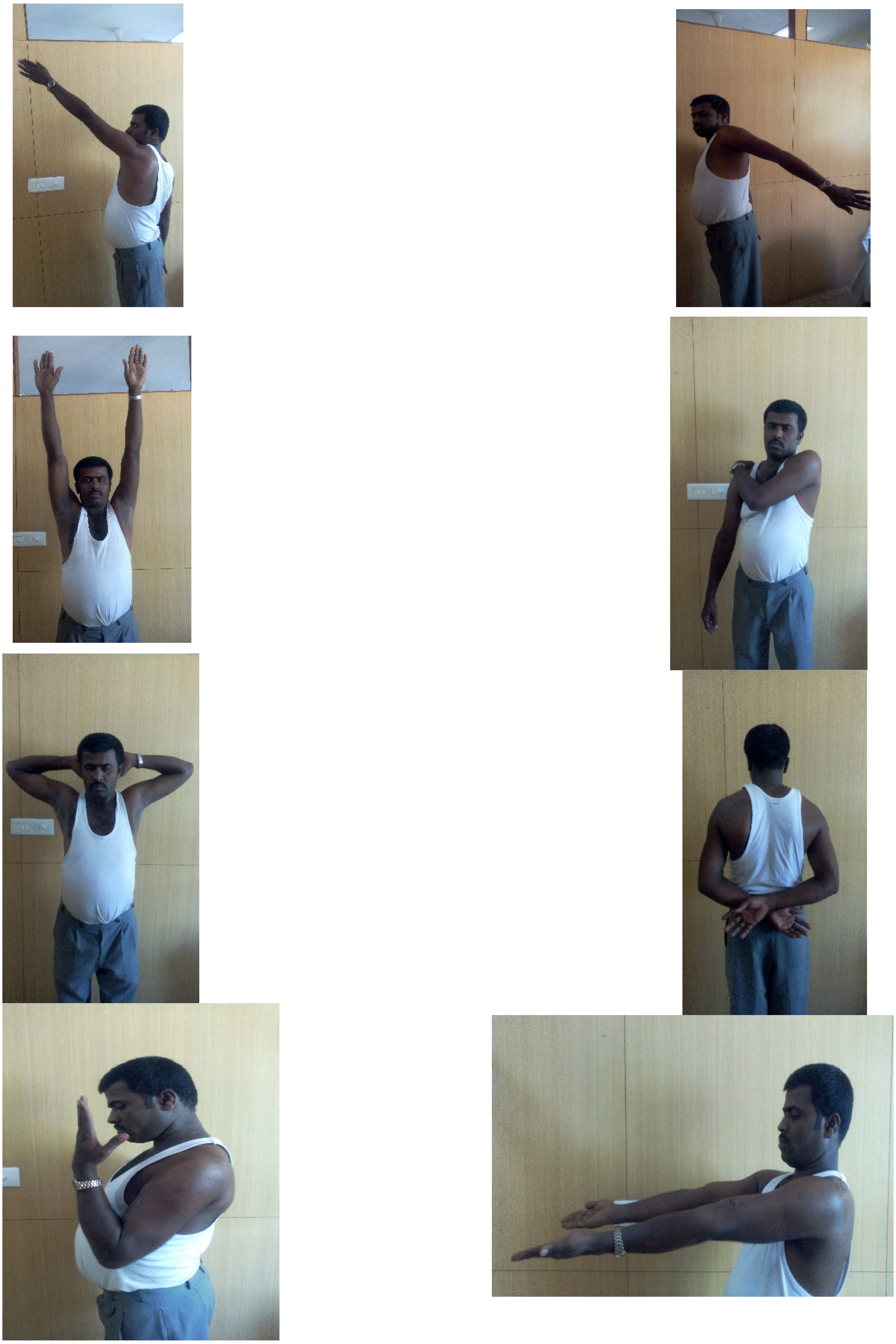
Postop lateral view

24weeks AP view non union

24weeks lateral view

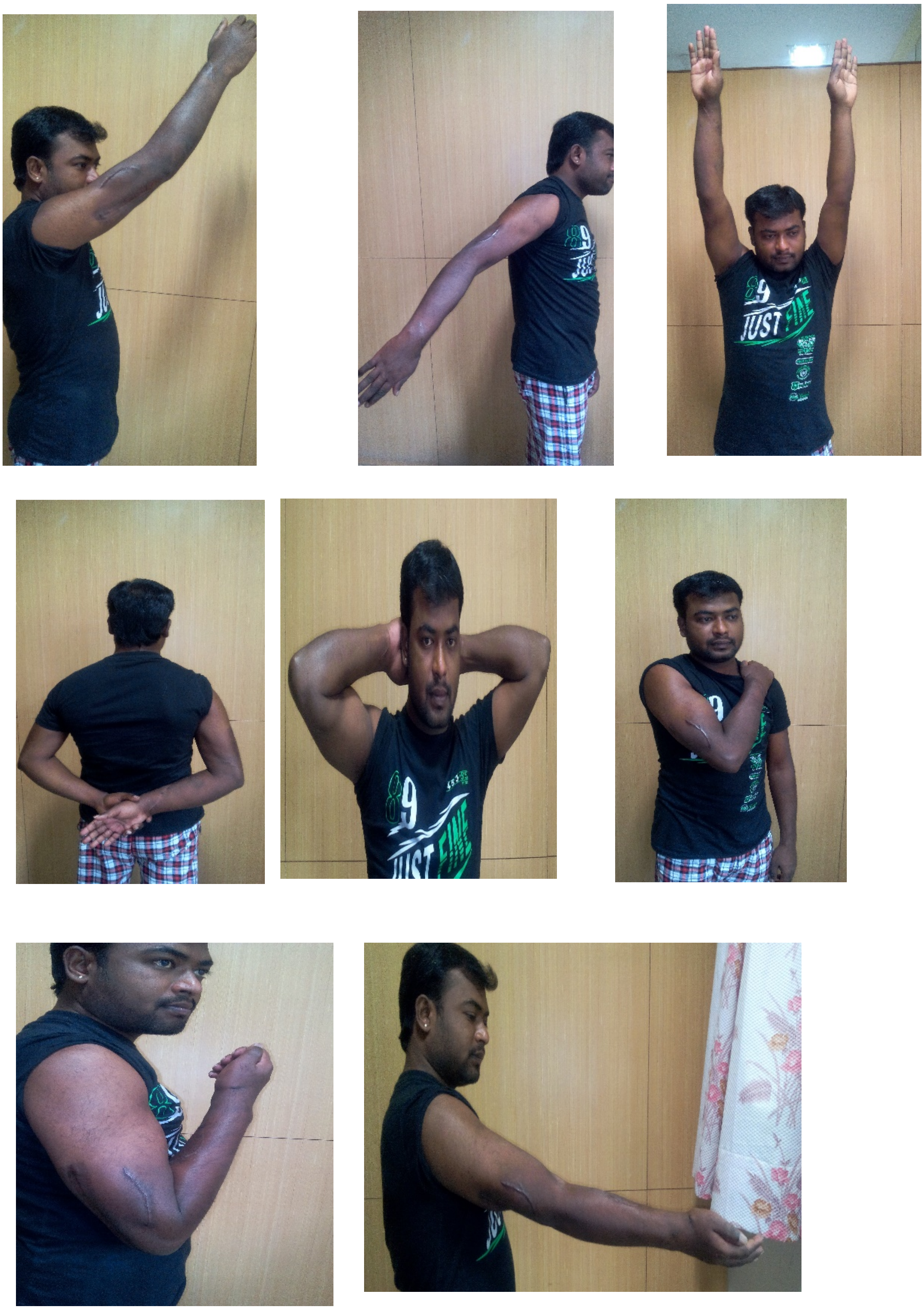
CLINICAL PHOTOGRAPHS: At 24weeks

<u>FIGURE NO 22</u>



CLINICAL PHOTOGRAGHS: At 24 weeks

<u>FIGURE NO 23</u>



CLINICAL PHOTOGRAPHS: Poor functional outcome

FIGURE NO 24

ANNEXURE – I

PROFORMA

NAME: Age/Sex: Occupation:

D.O.A.: D.O.D.: I.P.No: Address:

Complaints & Duration:

H.O.P.I.: Mode of injury: Site: Systemic illness:

Past His: Personal His: Family His:

G.P.E.: Built: Nourishment: P/I/C/C/L/E

Systemic Examination: C.V.S.: R.S.: P.A.:

Local Examination: Signs of fracture: Simple/compound:

Peripheral pulsations: Nerve injuries: Associated injuries:

Movements:

Shoulder/Elbow:

Measurements: Arm: Forearm:

Provisional clinical diagnosis:

Management:

X-ray:

Surgical procedure:

Post-op Period:

Follow up: 4weeks 8weeks 12weeks 16weeks 6months

Pain:

Deformity:

Movements: Shoulder:

Elbow:

Fracture union

Functional outcome:

Complications:-

Non-union :-

Infection :-

Radial nerve injury :-

Results:

ANNEXURE – II

CONSENT FORM FOR ANAESTHESIA/SURGERY

I, ________________ Son/Daughter/Wife of ________________, in my full senses hereby give my whole-hearted consent for surgery which to be performed on me/ my son/ my daughter/ my wife named _____________, aged ____________ under any type of anesthesia deemed fit for the procedure. The nature of the surgery and the risk involved in the procedure has been explained to me in my own understandable vernacular language to my satisfaction. I understand that for academic and scientific purpose, the procedure may be photographed or video recorded, or used for statistical measurements and I give my consent for the above.

Date:

Signature

Thumb Impression of the Patient

Guardian

Name:

Designation:

Guardian

Relationship

ANNEXURE – III

CRITERIA

SAM. G. HUNTER'S CRITERIA

Grade I - Total restriction preventing all movements.

Grade II - Severe restriction preventing or severely impending daily Activity.

Grade III - Restriction permitting daily activity with some difficulty.

Grade IV - Minimal restriction not impending daily activity.

Grade V - No restriction of activity.

R. G. McCORMACK'S CRITERIA

1) Pain.

2) Deformity.

3) Range of Movement.

4) Time for Union.

5) Functional outcome

6) Complications.

7) Need for further procedures.

KIVILUOTO & SANTOVIRTA'S CRITERIA (for elbow)

Excellent: Symptoms free motion equal to intact side.

Good : Occasional pain & restriction of motion less than 10 degrees as compared to the intact side.

Fair : Occasional pain & restriction of motion less than 30 degrees Orrestriction of motion over 30 degrees with no pain.

Poor : Occasional pain With restriction of motion more than 30 degrees.

ANNEXURE – IV

FUNCTIONAL OUTCOME

UCLA SHOULDER SCORING SYSTEM

	Score
Pain	
Present always and unbearable; strong medication frequently	1
Present always but bearable; strong medication occasionally	2
None or little at rest, present during light activities; salicylates frequently	4
Present during heavy or particular activities only; salicylates frequently	6
Occasional and slight	8
None	10
Function	
Unable to use limb	1
Only light activities possible	2
Able to do housework or most activities of daily living	4
Most housework, shopping and driving possible; able to do hair and to dress and undress, including fastening brassiere	6
Slight restriction only; able to work above shoulder level	8
Normal activities	10
Active forward flexion	
> 150°	5
120°–150°	4
90°–120°	3
45°–90°	2
30°–45°	1
< 30°	0
Strength of forward flexion (manual muscle testing)	
Grade 5 (normal)	5
Grade 4 (good)	4
Grade 3 (fair)	3
Grade 2 (poor)	2
Grade 1 (poor muscle contraction)	1
Grade 0 (nothing)	0
Satisfaction of the patient	
Satisfied and better	5
Not satisfied	0

EXCELLENT – 34 OR 35 points

GOOD – 29-33 points

FAIR – 21-28 points

POOR – 0-20 points

MAYO ELBOW PERFORMANCE INDEX

MAYO ELBOW PERFORMANCE SCORE

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

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

Patient Score= 100

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

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

The results are assessed based on above criteria i.e. Pain, Deformity,

Range of Movement, Time of union, Functional outcome as per UCLA and MEPI Score were considered as Primary Outcome. The Secondary outcome of the study were the

occurrence of complications & need for further procedures.

OUR CRITERIA

	Excellent	Good	Fair	Poor
Pain (as per V.A.S.)	Nil//Mild (+)	Nil/Mild (+)	Mild/Moderate (+) (++)	Moderate/ Severe (++) (+++)
Deformity(of both rotatory or angulatory)	Nil	Nil	$<10^0$	$>10^0$
R.O.M.				
Shoulder:	M I	M II	M III	M IV
	Full Range Flex-0 to170/180. Ext- 0 to 40/45. Abd-0 to170/180. I.R.-0 to 80/90. E.R.-0 to 80/90.	Flex-0 to140/170 Ext- 0 to 30/40. Abd-0 to140/170 I.R.-0 to 70/80. E.R.-0 to 70/80	Flex-0 to120/140 Ext- 0 to 20/30. Abd-0 to120/140 I.R.-0 to 60/70. E.R.-0 to 50/80	Flex-0 to70/120 Ext- 0 to 10/20. Abd-0 to70/120 I.R.-0 to 50/60. E.R.-0 to 30/50
Elbow:	M I	M II	M III	M IV
	Full range			
	Flex-0/10 to 140/150	10/20 to 130/140	20/30 to100/130	30/40 to 90/100
	Ext- 30/40 to 170/180	40/50 to 160/170	50/80 to 150/160	80/90 to 140/150
Fracture Union:	12-16weeks	17-20weeks	21-24weeks	>24weeks
Functional outcome				
UCLA	30-35	28-33	21-27	0-20points
MEPI	>90	75-89	60-74	<60points

Complications:

E) Non union

F) Delayed union

G) Infection

H) Radial nerve injury

The individual cases are evaluated based on these evaluation criteria.

KEY TO MASTERCHART

Sl. No. – Serial number.

Name – Name of the Patient.

Age/ Sex – Age & Sex of the patient

IP No. – Inpatient number.

Side – Side of fracture, Right is denoted as [R] & Left as [L].

Type of injury –Closed[C] Open type I,II[O I,O II]

Mode of injury – The Mode of injury is noted as, road traffic accident

[RTA], assault [ALT] & self fall. [SF].

Mechanism of injury – The mechanism of injury is noted as Direct [D] & Indirect injuries[I].

Associated injuries – Associated injuries with which the patient presents like Contralateral Shaft Femur [C.S.F.], Contralateral Shaft Tibia [C.S.T.], Ipsilateral Both Bone

Forearm [I.B.B.F.], Radial Nerve Injury [R.N.I.] and Ipsilateral elbow dislocation [I E D] with Sc[scaphoid fracture]

Radiology – The radiology confirms the level of injury, which helps us to classify according to types of Mueller's AO classification

A: Simple fractures

A1 Spiral

A2 Oblique

A3 Transverse

B: Wedge fracture

B1 Spiral wedge

B2 Segmental wedge

B3 Fragmented wedge

C: Complex Fractures

C1 Spiral

C2 Segmental

C3 Irregular

Approach – The Approach is mentioned as posterior [P] & antero-lateral [AL].

Pain – Presence of pain is graded as severe (+++), moderate (++), mild (+) & nil (0) according to

visual analog scale.

Deformity - Of the arm is assessed & noted as Present [P] or Absent [A].

Movements – The movements of the shoulder & elbow are graded as M I, M II, M III & M IV

Movements	M I	M II	M III	M IV
Shoulder	Full Range Flex-0 to170/180. Ext- 0 to 40/45. Abd-0 to170/180. I.R.-0 to 80/90. E.R.-0 to 80/90.	Flex-0 to140/170. Ext- 0 to 30/40. Abd-0 to140/170. I.R.-0 to 70/80 E.R.-0 to 70/80.	Flex-0 to120/140. Ext- 0 to 20/30. Abd-0 to120/140. I.R.-0 to 60/70 E.R.-0 to 50/80.	Flex-0 to70/120. Ext- 0 to 10/20. Abd-0 to70/120. I.R.-0 to 50/60. E.R.-0 to 30/50.
Elbow	Full Range Flex-0/10 to140/150. Ext-30/40 to170/180	Flex-10/20 to130/140. Ext- 40/50 to160/170	Flex-20/30 to100/130. Ext-50/80 to150/160	Flex-30/40 to90/100. Ext-80/90 to140/150

Functional outcome: According to UCLA shoulder scoring and Mayo Elbow Performance Index {Annexure-IV}

Complications – Post-operative complications are absent [Nil], Infection [I.N.F.], Non-union

[N.U.], Radial Nerve Injury [R.N.I.]

Results – Final results were assessed & noted as Poor [P], Fair [F], Good [G] & Excellent [E].

Sl No	Hosp no.	Name	Age	Sex	Side	Open/closed	Mode of injury	Mech of injury	Asso injuries	Type	Approach	Hosp stay	Union	Pain	Deformity	Movement	Complication	UCLA/MEPI	Out Come
1	985407	SRINIVAS	35	M	LEFT	C	SF	I	R.N.I	A3	P	1 wk	13 wks	0	A	M I	Nil	34/95	E
2	990720	NAYAB PASHA	20	M	LEFT	O II	RTA	D	Nil	A3	AL	1wk	15wks	0	A	M I	Nil	34/100	E
3	993181	VENU	20	M	LEFT	C	RTA	D	Nil	B1	P	1.5wks	14wks	0	A	M I	Nil	35/85	E
4	994127	VENKATESHAPPA	31	M	LEFT	C	RTA	D	Nil	A3	AL	1wk	16wks	+	A	M I	Nil	33/85	E
5	1008965	VENKATESHAPPA	45	M	LEFT	C	RTA	D	Nil	A3	AL	3wks	17wks	0	A	M I	Nil	34/95	E
6	2066	SATHISH	23	M	LEFT	C	RTA	D	Nil	B2	AL	2wks	15wks	0	A	M I	Nil	34/100	E
7	3955	MUNIYAPPA	47	M	LEFT	C	RTA	D	I ED&Sc	A3	AL	1wk	23wks	0	A	M II	Nil	25/70	F
8	31101	MADHUMATHI	53	F	LEFT	C	RTA	D	Nil	A2	AL	1 wk	25wks	+	A	M III	R N I	27/80	F
9	36818	MURALI	32	M	LEFT	C	RTA	D	Nil	A3	AL	2wks	17 wks	0	A	M I	Nil	35/100	E
10	62630	ASHOK	28	M	RIGHT	C	RTA	D	CST/RNI	B2	P	2wks	15wks	0	A	M II	Nil	28/85	G
11	69650	MUNIYAPPA	55	M	RIGHT	O I	RTA	D	R.N.I	B2	AL	2wks	22wks	0	A	M III	Nil	28/85	F
12	70829	VENUGOPAL REDDY	48	M	LEFT	C	RTA	D	Nil	A3	AL	3wks	NU	+	A	M IV	N U	10/55	P
13	77749	SARVANAN	36	M	LEFT	C	RTA	D	Nil	C2	AL	2.5wks	18wks	0	A	M II	Nil	30/75	G
14	85453	UMA	35	F	LEFT	C	RTA	D	Nil	B2	AL	2wks	14wks	0	A	M I	Nil	35/95	E
15	85515	SONNAPPA	50	M	RIGHT	C	RTA	D	Nil	A3	AL	2.5wks	16wks	0	A	M I	Nil	35/100	E
16	83801	MANJUNATHA	32	M	LEFT	O I	RTA	D	C.S.F	B1	P	2.5wks	17wks	+	A	M II	Nil	34/85	G
17	87625	SHARADA	57	F	RIGHT	C	RTA	I	Nil	A2	AL	2wks	15wks	0	A	M I	Nil	34/90	E
18	87910	RAFIQ	33	M	LEFT	C	RTA	D	Nil	A3	AL	2wks	16wks	0	A	M I	Nil	35/100	E
19	92757	GANGADHAR	23	M	RIGHT	C	RTA	D	Nil	A2	AL	2wks	19wks	0	A	M II	Nil	28/80	G
20	97169	SEENAPPA	43	M	LEFT	C	SF	D	Nil	A1	AL	2wks	15wks	0	A	M I	Nil	35/95	E
21	94612	VENKATESH	39	M	RIGHT	C	ALT	D	Nil	A3	AL	3wks	NU	0	A	M IV	N U	12/55	P
22	104221	SIDDHARTH	26	M	RIGHT	C	RTA	D	Nil	A3	P	2wks	31wks	+	A	M I	D U	29/90	F
23	108166	NARAYANAPPA	52	M	RIGHT	C	ALT	D	Nil	B1	AL	3wks	18wks	0	A	M II	Nil	30/85	G
24	111011	NARAYANASWAMY	26	M	LEFT	C	RTA	D	Nil	A2	AL	2wks	16wks	0	A	M I	Nil	35/100	E
25	118439	RANGANATH	41	M	RIGHT	C	RTA	D	Nil	A1	AL	2wks	13 wks	0	A	M I	Nil	34/95	E
26	120896	VENKATESHAPPA	55	M	RIGHT	C	DOM	I	Nil	B1	P	2wks	13 wks	0	A	M I	Nil	35/95	E
27	122311	MANJULA	32	F	LEFT	C	RTA	D	Nil	A2	P	2.5wks	18wks	+	A	M II	Nil	28/85	G
28	127737	JAGANNATH	32	M	RIGHT	C	RTA	D	Nil	B1	AL	2wks	16wks	0	A	M I	Nil	35/100	E
29	127364	NANDISH	30	M	RIGHT	C	RTA	D	Nil	B2	AL	1 wk	17wks	+	A	M II	Nil	33/85	G
30	142514	MUNISHAMAPPA	55	M	RIGHT	O I	RTA	D	I.B.B.F	A3	P	3wks	20 wks	++	A	M IV	Nil	20/50	P