

**“A STUDY OF SURGICAL MANAGEMENT OF FRACTURE SHAFT
OF HUMERUS BY INTRAMEDULLARY INTERLOCKING
NAILING”**

By

Dr. NITHIN KRISHNA.V.P



DISSERTATION SUBMITTED TO
SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH,
KOLAR, KARNATAKA

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

**MASTER OF SURGERY
IN
ORTHOPAEDICS**

Under the guidance of

Dr MANOHAR.P.V

Professor And Head of The Department



**DEPARTMENT OF ORTHOPAEDICS
SRI DEVARAJ URS MEDICAL COLLEGE**

KOLAR-563101

APRIL-MAY 2014

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTRE, TAMAKA, KOLAR, KARNATAKA,**

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled “**A STUDY OF SURGICAL MANAGEMENT OF FRACTURE SHAFT OF HUMERUS BY INTRAMEDULLARY INTERLOCKING NAILING**” is a bonafide and genuine research work carried out by me under the guidance of **Dr.MANOHAR.P.V** Professor and Head of the Department Of ORTHOPAEDICS Sri Devaraj Urs Medical College, Tamaka, Kolar.

Date:

Place : Kolar

Signature of the Candidate

Name: Dr. NITHIN KRISHNA.V.P

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTRE, TAMAKA, KOLAR, KARNATAKA,**

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled “**A STUDY OF SURGICAL MANAGEMENT OF FRACTURE SHAFT OF HUMERUS BY INTRAMEDULLARY INTERLOCKING NAILING**” is a bonafide research work done by Dr. NITHIN KRISHNA.V.P in partial fulfilment of the requirement for the degree of **MASTER OF SURGERY** in **ORTHOPAEDICS**.

Date:

Place : Kolar

Signature of the Guide

Dr. MANOHAR.P.V

Professor And Head of The Department
Department Of Orthopaedics
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH
CENTRE, TAMAKA, KOLAR, KARNATAKA,**

**ENDORSEMENT BY THE HOD, PRINCIPAL / HEAD OF
THE INSTITUTION**

This is to certify that the dissertation entitled “**A STUDY OF SURGICAL MANAGEMENT OF FRACTURE SHAFT OF HUMERUS BY INTRAMEDULLARY INTERLOCKING NAILING**” is a bonafide research work done by Dr. NITHIN KRISHNA.V.P under the guidance of **Dr.MANOHAR.P.V** Professor and Head of The Department

Signature of the HOD

Dr.Manohar.P.V
Professor and HOD.

Department Of Orthopaedics
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:
Place: Kolar

Signature of the Principal

Dr. M.B.Sanikop,
Principal,

Sri Devaraj Urs Medical College.
Tamaka, Kolar.

Date:
Place: Kolar

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH
CENTRE, TAMAKA, KOLAR, KARNATAKA,**

ETHICAL COMMITTEE CERTIFICATE

**This is to certify that the Ethical committee of Sri Devaraj Urs Medical
College, Tamaka, Kolar has unanimously approved**

Dr. NITHIN KRISHNA.V.P

**Post-Graduate student in the subject of ORTHOPAEDICS at
Sri Devaraj Urs Medical College, Kolar to take up the Dissertation work
entitled**

**“A STUDY OF SURGICAL MANAGEMENT OF FRACTURE
SHAFT OF HUMERUS BY INTRAMEDULLARY INTERLOCKING
NAILING”**

To be submitted to

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTRE, TAMAKA, KOLAR, KARNATAKA,**

**Member Secretary
Sri Devaraj Urs Medical College,
Kolar-563101**

Date :

Place : Kolar

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH
CENTRE, TAMAKA, KOLAR, KARNATAKA,**

COPY RIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the Sri Devaraj Urs Academy Of Higher Education And Research Centre, Kolar, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic /research purpose.

Date :

Place : Kolar

Signature of the candidate

Name : Dr. NITHIN KRISHNA.V.P

ACKNOWLEDGEMENT

First and foremost I am thankful to the ‘**Almighty God**’ for all his blessings and giving me the strength both mentally and physically to complete this task. I express my special regards to all my patients, without whom this study would have been impossible.

It gives me great pleasure in preparing this dissertation and I take this opportunity to thank everyone who have made this possible.

I would like to express my deep gratitude and sincere thanks to my guide **Dr Manohar.P.V** Professor And Head of The Department for preparing me for this task, guiding me with his vast professional expertise and knowledge, showing great care and attention to details and without his supervision and guidance this dissertation would have been impossible. He has been my mentor and source of inspiration and encouragement throughout my course. I am greatly indebted to him.

I am highly indebted to **Dr Gudi.N.S, Dr B.Shaikh Nazeer** Professor and Former Head of Department of Orthopaedics, for their invaluable guidance, constant encouragement, immense patience and great care. Their stature and knowledge has been highly inspirational for the whole of my post graduation period.

It gives me immense pleasure to extend my sincere thanks to Professors **Dr Arun.H.S** and **Dr Venkatesh Reddy** whose authoritative knowledge of practical skills has guided and inculcated in me a sense of confidence. I am thankful to their valuable guidance and for understanding and accommodating me during difficult periods of this dissertation.

I am extremely thankful to Associate Professor **Dr Nagkumar** for his constant help and guidance throughout the course. He was well spring of encouragement, support and for patient perusal to which I am deeply obliged.

My heartfelt thanks to Assistant Professor **Dr Vijay Anand, Dr Prabhu, , Dr Naveen, Dr Imran Hussain, Dr Anil, Dr Vinod, Dr Manjunath, Dr Kumar and Dr Hariprasad** for their practical tips, invaluable advice and constant encouragement. My sincere thanks to all for teaching me in their own unique way and encouraging me throughout my course. I feel extremely fortunate to have worked under them.

I express my sincere thanks to my **colleagues and dear friends Dr Satya, Dr Ram, Dr Girish, Dr Gopi, Dr Praneeth, Dr Manish, Dr Hadi and Dr Shiva** for their co-operation and help in carrying out this study.

I thank my seniors **Dr Kiran, Dr Debojithi, Dr Praneeth and Dr Jayakrishna** for keeping me on my toes by asking me thought provoking questions throughout my study. I thank my **Juniors** for helping me in completing this vast work.

I would like to express my deepest gratitude to my beloved **PARENTS**, whose love and blessings made me the person I am today. I owe my gratitude to my **brother, sister, uncle Ramesh and my UG friends** for thier constant help and encouragement.

I would also like to thank all the **OT and paramedical Staff** for their help and assistance.

DR.NITHIN KRISHNA.V.P

LIST OF ABBREVIATIONS USED

Ab	Abduction
AO	Arbeitsgemeinschaft fur Osteosynthesefragen
ASIF	Association for the Study of Internal Fixation
Comm	Comminution
D3	Distal third
Ex	Excellent
F	Female
H/O	History of
I.A	Industrial accident
I.O	Intraoperative
I.P	Inpatient
I.T	Intertrochantric
K-nail	Kuntshner nail
L3	Lower third
M	Male
MC	Metacarpal
MOD	Moderate
M3	Middle third
No	Number
P3	Proximal third
RTA	Road traffic accident
SC	Supracondylar
TRNP	Transient radial nerve palsy
U3	Upper third
Yrs	Years
#	Fracture

ABSTRACT

Background

Fractures of the humeral shaft are commonly encountered in our hospital. Conservative management with hanging arm cast is preferred by some authors. Shoulder & elbow stiffness, non-union and mal-union are commonly seen with this treatment. Open reduction and internal fixation with plate and screws requires extensive soft tissue stripping, radial nerve mobilization with high rates of radial nerve palsy. An inter locking intra medullary nail system has the advantage of stability and early functional recovery with fewer complications because of less soft tissue trauma and stable fixation, inter locking nail system have been used .

Objectives

To evaluate the functional outcome of intramedullary interlocking nailing in case of fracture shaft of humerus and to study the complications encountered during the study.

Methods

Data for the study was collected from the patients admitted in hospitals attached to Devraj urs medical college, with fractures shaft of humerus. Totally thirty cases were studied. Each case was followed for about 6 to 9 months or till the fracture unites clinically and radio logically which ever was earlier. Functional outcome was assessed by UCLA shoulder score.

Results

In our study 83.3% of the cases showed excellent to satisfactory results. Good anatomical reduction, prevention of rotation and rigid fixation with early functional recovery was possible with inter locked intra medullarly nailing .

Interpretation & Conclusion

Humeral shaft fractures were common in the age group of 20 to 30 years and more common in males. a common mode of injury was RTA and more commonly right humerus was involved. Functional outcome is excellent to satisfactory in nearly 83.3% of patients. Intramedullary locked nailing has its learning curve; once the technique is mastered better results are found.

LIST OF CONTENTS

1. Introduction	1
2. Objectives	3
3. Review of Literature	4
4. Methodology	24
5. Results	40
6. Discussion	58
7. Conclusion	65
8. Bibliography	66
9. Annexures.....	73

LIST OF TABLES

Table No.	Title	Page No.
Table-I	Age distribution	40
Table-II	Sex distribution	41
Table-III	Side affected	41
Table-IV	Mode of injury	42
Table-V	Level of fracture	43
Table-VI	Type of fracture	44
Table-VII	Trauma-surgery Time interval	46
Table-VIII	Implant used, Nail length	47
Table-IX	Implant used, Nail width	47
Table-X	Fracture union	48
Table-XI	Complications	49

LIST OF GRAPHS

Sl. No.	Graphs	Page No.
1.	Age distribution	40
2.	Sex distribution	41
3.	Side affected	41
4.	Mode of injury	42
5.	Level of fracture	43
6.	Type of fracture	44
7.	Associated injuries	45
8.	Trauma to surgery time interval	46
9.	Fracture union	48
10	Complications	49

INTRODUCTION

Life is movement, movement is life! This is the basic principle of any fracture management. Full, active, pain free mobilization results in a rapid return of normal activity of an individual.

It is well known fact that fractures are capable of uniting without human assistance. The results of this natural process are very successful in terms of union but often leaves a great deal in terms of functional recovery because of shortening, mal-alignment and joint stiffness. With the passage of time knowledge improved and the need to ‘intervene’ in the fracture healing was felt.

With a changing life style, rapid industrialization and increase in road traffic accidents fractures of the humeral shaft are very commonly encountered in our hospital.

Conservative management with hanging arm cast is preferred by some authors^{1,2,3,4}. The patients we have encountered in our setup have the habit of sitting cross legged and supporting the elbow on their thighs after casting. By this the purpose of gravity setting the fracture in alignment fails. Shoulder and elbow stiffness, non-union and mal-union are commonly observed with such conservative methods⁵, especially in patients having certain risk factors like alcoholism or obesity⁶.

Open reduction and internal fixation with plate and screws requires extensive soft tissue stripping. It also associated with high rates of radial nerve palsy due to mobilization of radial nerve during surgery⁷. Stress shielding with its complication are commonly seen after plate fixation⁸. Intramedullary nails alone have the disadvantage of rotation of fracture fragments and instability with proximal migration of nail, with subsequent stiff shoulder⁹.

An interlocking intramedullary nail system has the advantage of stability and early functional recovery with fewer complications¹⁰. Since fracture treatment in general, strives for complete and early recovery of the limb function with solid union¹¹, intramedullary fixation of humeral

shaft has gained in popularity¹². It is because of less soft tissue trauma and stable fixation, interlocking nail system have dramatically broadened the indications for humeral medullary nailing¹³, and antegrade nailing is the most commonly used method¹⁴.

Though the healing time of fractures in conservative and surgically managed patients is same, the later maintains nearly normal life style during most of this healing period, without limitation by splints, casts or braces and can return to their work sooner⁵. This makes the patient to earn his livelihood earlier and indirectly reduces his economic burden. Thus, interlocked nailing of humerus is an attractive treatment option for patients with fracture of the humeral shaft where operative fixation is required¹⁵. This study is an attempt to determine the efficacy of interlocked intramedullary nailing in the treatment of humeral shaft fractures.

AIM AND OBJECTIVE OF THE STUDY

- ☐ To evaluate the functional outcome of intramedullary interlocking nailing in cases of fracture shaft of humerus.
- ☐ To study the complications encountered during the study.

REVIEW OF LITERATURE

HISTORY

The art of treatment of fractures has undergone important and basic changes in the last few centuries. Though internal fixation was a standard procedure by the middle of the last century, it has progressed steadily from beginning of this century.

5000 years ago the Egyptians used palm bark and linen bandages for management of fractures¹⁶.

In **460-377 BC Hippocrates** suggested two important principles of fracture management¹⁶

- Traction and counter traction for fracture reduction
- Exercise strengthens and inactivity causes wasting.

As early as **1775**, surgeons were at dispute over internal fixation of fractures. Up to **18th century** fractures were treated by simple splintage¹⁶.

Samuel David Gross (1805) was the first to use a form of adhesive tape for skin traction¹⁶.

Open reduction and wire suture fixation was attempted by **Rogers** as early as **1827**. This method did not receive wide acceptance because of sepsis.

Buck in 1860 used skin traction to treat fractures. Hugh Owen Thomas stressed the importance of uninterrupted and prolonged immobilization in treatment of fractures¹⁶.

In **1852, Matthysen**, a Dutch military surgeon, first used plaster of Paris

After the invention of X-rays by **Roentgen** in **1895**, fracture treatment has advanced tremendously¹⁷.

Nicolaysen in 1897 described the principles of medullary fixation of fractured bones. Details of

intramedullary fixation were published by **Nicolaysen in 1897** and **Delbet in 1906**¹⁷.

Caldwel described the hanging arm cast in **1933**, as a closed treatment method for fracture of humeral shaft. The weight of the cast and extremity reduces and maintains the reduction of the fracture. But there was the danger of over distraction at the fracture site which produced delayed union and nonunion¹⁸.

In 1937, Rush described the use of intra-medullary Steinmann pin in fracture of humerus shaft. Rush nails could not achieve rotational instability and were not applicable in comminuted and unstable fracture. Furthermore, there were complications like the nail backing out at their insertion site, making external immobilization mandatory till union occurred¹⁷.

In 1940, Kuntshner of Germany presented convincing evidence regarding the value of intramedullary fixation devices and enjoyed great popularity, but they were only applicable to short oblique fractures near humeral isthmus. Their application in comminuted distal fractures required supplementation by circlage wires, screws, plates and casting to prevent shortening and rotation. Johnson studied complications associated with antegrade and retrograde K-nailing for fractures of the humerus. There were several complications including radial nerve damage and backing out of the nail through their insertion site¹⁸.

Robert Jones believed in early fixation of fresh fractures. He introduced methods of reduction of fresh fractures under anaesthesia in **1941**. The discovery of anaesthetic agents have given a great freedom to the surgeons to manipulate the reductions¹⁷.

Titanium was first used in bone surgery in the **1950s**¹⁸.

Bagby and Janes (1956) described a 'modified collision' plate. In this model the screw head had a conical undersurface, which engaged with the edge of the plate hole¹⁶.

In 1958, Dr. Muller along with a group of Swiss surgeons formed a study group, the **AO group**, also known as Association for Study of Internal Fixation (ASIF) in English speaking countries.

This group dedicated itself to research into osteosynthesis. The design of appropriate instrumentation for fracture surgery and the documentation of its results¹⁶.

In October 1963, Arthur Holstein and Gwilym B. Lewis reported a fracture syndrome with fracture in the distal one-third of the humerus, spiral with radial angulation at the fracture site and overriding of the distal fragment with involvement of the radial nerve, both sensory and motor components. They strongly advised against attempted closed reduction and recommended primary open reduction through an anterolateral approach¹⁹.

The first attempts at biological plating were by **Biotzy and Weberpers in 1964**²⁰.

In 1966, L. Klenerman, in his review of 98 patients with fractures of the shaft of the humerus, concluded that in the treatment of delayed union intramedullary fixation and the application of slivers of iliac bone is effective in stimulating the fracture to join²¹.

In 1972, Klemm and Schellman described locking reamed intramedullary nailing¹⁷.

The humeral functional brace was first described by **Sarmiento in 1977**. A functional brace is an orthosis that effects fracture reduction through soft tissue compression¹⁸.

In 1980, intramedullary fixation of fracture of the shaft of humerus using **Ender nailing** was done.

In 1985, Heitemeyer et al, developed the bridging plate²⁰.

Rokkanen et al (1985) proposed using biodegradable polymeric materials, so that the implant dissolves after a certain time in the body avoiding a second operation for removal of implant. No such material has yet become available for use with conventional techniques of internal fixation, which combines adequate strength ductility, maintenance of compression and degradability without marked tissue reaction. Tissue tolerance and local effects on infection resistance is still an unsolved problem²².

Seidal in 1989 developed locking nail for the humerus. Closed nail techniques have decreased blood loss, infection rates and duration of stay in hospitals. Furthermore there is a rigid fixation and no external splintage is required. But increased incidences of shoulder stiffness, mechanical problems and non-union have also been noted with this technique. Inadequate locking also resulted in nail migration¹⁷.

Between **1990-1994** at university of Michigan Hospitals, **Redmons J Braintal** managed pathological fractures with intramedullary interlocking nail and concluded that this procedure is the treatment of choice for pathological fractures²³.

In 1991, Habernek and Orthner did modification to proximal locking system.

In 1991, Russell and associates introduced Russell Taylor intramedullary interlocking humeral nail. **Lavette et al in 1991** described the technique for Russell Taylor humeral interlocking system²⁴.

In 1995, Rodriguez-Merchan-E.C, treated closed fractures of humerus shaft using compression plate and locking nails and had a 100% union rate with one case of delayed union in the compression plate group²⁵.

In 1998, Jin Linn did a comparative study of humeral locked nailing and plate fixation and reported that humeral locked nailing had significantly shorter operation time, less blood loss and eventual union was achieved better in nail group, but union rate and time to unite were not significantly different. Functional recovery was essentially same in both groups²⁶.

In 2000, McCormack R.G. et al, in their comparative study between Open Reduction Internal Fixation by either an Intramedullary Nail or a Dynamic Compression Plate of fractures of the shaft of the humerus suggested that open reduction and internal fixation with a DCP remains the best treatment for unstable fractures of the shaft of the humerus. Fixation by Intramedullary Nail may be indicated for specific situations, but is technically more demanding²⁷.

Chapman JR, Henley MB, Agel J, Benca PJ in 2000 reported that Intramedullary nailing and compression plating both provide predictable methods for achieving fracture stabilization and ultimate healing²⁸.

Mauch J, Renner N, Rikli D in 2000 concluded that unreamed humerus nail is a real alternative to plate osteosynthesis. Compared with most series of plate osteosynthesis published in the literature the risk for iatrogenic lesions of the radial nerve appears to be lower. Even in this small series a rather high rate of non-unions was found²⁹.

In 2002, Koch P.P, Gross D.F and Gerber C studied the results of functional bracing of humeral shaft fractures and found that conservative treatment of humeral shaft fractures without neurological deficit with the Sarmiento brace remains the Treatment of choice³⁰.

Martinez AA, Cuenca J, Peguero A, Herrera A, Panisello JJ in 2002 concluded that retrograde Marchetti-Vicenzi nailing is an acceptable alternative for the treatment of acute humeral shaft fractures with a low complication rate³¹.

Sanzana ES, Dummer RE, Castro JP, Diaz EA in 2002 in a study on intramedullary nailing functional results were excellent in 48 cases (92%), moderate in three (6%), and poor in one (2%)³²

Arpacioglu MO, Pehlivan O, Akmaz I, Kiral A, Oguz Y in 2003 Interlocking intramedullary nailing provides adequate fixation and early mobilization, and results in satisfactory radiographic and functional results in the treatment of humeral shaft fractures³³.

Hossain S, Roy N, Ayeko C, Elsworth CF, Jacobs LG in 2003 the Marchetti-Vicenzi humeral nail appears as a relatively safe implant and its use has been associated with preservation of good shoulder and elbow functions³⁴.

In 2003, Kesemenli CC. et al, in their comparative study concluded that despite higher non

union rates, Intramedullary Nailing is the treatment of choice because of such advantages as low morbidity, small dissection of soft tissues, and a greater ease of application³⁵.

In **2004, Karataglis D**, et al studied the results of 39 humeral shaft fracture (37 patients) treated with antegrade locked nailing reported that this method offers a dependable solution for the treatment of humeral shaft fractures especially in polytrauma patients and cases of segmental or pathological fractures³⁶.

In **2004, Flinkkila T, Hyvonen P, Siira P, Hamalainen** studied the results of shoulder ROM recovery following antegrade intramedullary nailing and plate fixation and concluded that shoulder ROM and strength does not recover to normal after humerus shaft fracture and antegrade nailing if done properly is not responsible for shoulder joint impairment³⁷.

Chao T. C, Chou W. Y, Chung J. C, Hsu C. J. in 2005 for patients with multiple trauma or high operative risk, ender nail fixation served as a safer and faster procedure. Interlocking nail fixation offers a stable fixation via a smaller incision but more fracture comminution might happen³⁸.

In **2006, Bhandari M, Devereaux PJ, McKnee MD, Schemitsch EH** in their comparative study between Internal Fixation by either an Intramedullary Nail or a Dynamic Compression Plate of fractures of the shaft of the humerus found that plate fixation may reduce the risk of reoperation and shoulder impingement³⁹.

In **2008, Huerta Lazcarro J, Luna Pizarro D** studied the prevalence of radial nerve lesion after fixation of humeral shaft fracture with DCP versus Intramedullary Nail in 87 humeral shaft fractures and reported that the surgical technique with DCP represents a higher incidence of radial nerve lesion probably due to the exposure and proximity to the radial nerve during surgery⁴⁰.

Cheng H. R., Lin J in 2008 with proper patient selection, antegrade and retrograde nailing have similar treatment results, including healing rate and eventual functional recovery for middle

humeral fractures⁴¹.

O'Donnell T. M, McKenna J. V, Kenny P, Keogh P, O'Flanagan S. J in 2008 the injuries seen may contribute to pain and dysfunction of the shoulder following treatment, and their presence indicates that antegrade nailing is only partly, if at all, responsible for these symptoms⁴².

Li W. Y, Zhang B. S, Zhang L, Zheng S. H, Wang S in 2009 both the antegrade intramedullary nailing and the retrograde intramedullary nailing are good alternatives for the treatment of humeral shaft fractures⁴³.

Zang W, Liu Y. F, Wu Q. M. in 2009 surgical treatment of mid-distal humeral shaft fractures associated with radial nerve damage by minimally invasive osteosynthesis may be effective⁴⁴

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 insignificant⁴⁵.

Ristic V, Maljanovic M, Arsic M, Matijevic R, Milankov M in 2011 in a comparative study of various methods of treatment of fracture shaft of humerus concluded that the best average functional results were recorded in the nailing group because of rigid fixation, solid callus formation and return to everyday activities in the shortest time⁴⁶.

ANATOMY

HUMERUS⁴⁸

"The humerus is the longest and strongest bone in the upper limb. It has expanded ends and a shaft. The proximal end, a round 'head', forms with the scapular glenoid cavity, the shoulder joint. The distal end, loosely termed 'condylar', is adapted to the forearm bones at the elbow joint.

The Proximal End⁴⁸

This includes a head, neck and greater and lesser tubercles (tuberosities). The head at the proximal end is slightly less than half a spheroid, the articular surface being covered with hyaline cartilage. When the arm is by the side the head is directed posteromedially and upwards. The humeral articular surface exceeds that of the glenoid cavity.

The anatomical neck is a slight constriction directly adjoining the articular heads margin. It is least apparent near the greater tubercle.

The lesser tubercle (tuberosity) is an elevation on the anterior aspect of the proximal end, just beyond the anatomical neck, having a smooth muscular impression palpable through the deltoid 3cm below the acromial apex.

The greater tubercle (tuberosity) is the most lateral part of the proximal end of the humerus, projects beyond the acromion and covered by the deltoid produces the shoulder's round contour. The posterosuperior aspect bears three smooth impressions for the supraspinatus (upper most), infraspinatus (middle), teres minor (lowest).

Between the tubercles is the inter-tubercular sulcus. The humeral proximal end tapers into shaft as an ill-defined surgical neck.

The Shaft⁴⁸

The shaft is almost cylindrical proximally, it is prismatic distally and anteroposteriorly compressed. Its three surfaces and borders are not equally obvious. Anatomically, the shaft may be considered to extend from the upper border of the insertion of pectoralis major muscle proximally to the supracondylar ridges distally.

The anterior border descends from the front of the greater tubercle, forms the lateral edge of the intertubercular sulcus, ending at the coronoid fossa distally.

The lateral border is sharp and rough distally, barely discernible in its proximal two-thirds, although sometimes traceable to the posterior aspect of the greater tubercle. Centrally the lateral border is interrupted by a wide, shallow groove (radial or spiral groove) descending obliquely laterally and forwards.

The medial border is continuous with the lesser tubercle proximally. It forms the medial lip of the intertubercular sulcus and forms the medial supracondylar ridge distally. It is indistinct in its proximal half and rounded in its distal half.

The anterolateral surface is between the anterior and lateral borders. Just Proximal to its midpoint is the rough deltoid tuberosity. Behind this the radial groove descends fading distally when it reaches the lateral border a little beyond the tuberosity.

The anteromedial surface lies between the anterior and medial borders. Its proximal third forms the rough floor of the inter-tubercular sulcus, but the rest is smooth. The nutrient foramen, with its canal directed distally, opens near its mid point.

The posterior surface between the medial and lateral border, is the most extensive. A ridge, sometimes rough, crosses the proximal third descending laterally. The middle third is crossed by the commencement of the radial groove. The distal third is an extensive flat surface, which widens distally.

Distal End of the Humerus⁴⁸

It is basically a modified condyle, is wider transversely and has articular and non-articular parts. The articular part consists of the lateral, convex capitulum and a medial pulley-shaped trochlea. The non-articular condyle includes medial and lateral epicondyles, olecranon, coronoid and radial fossae.

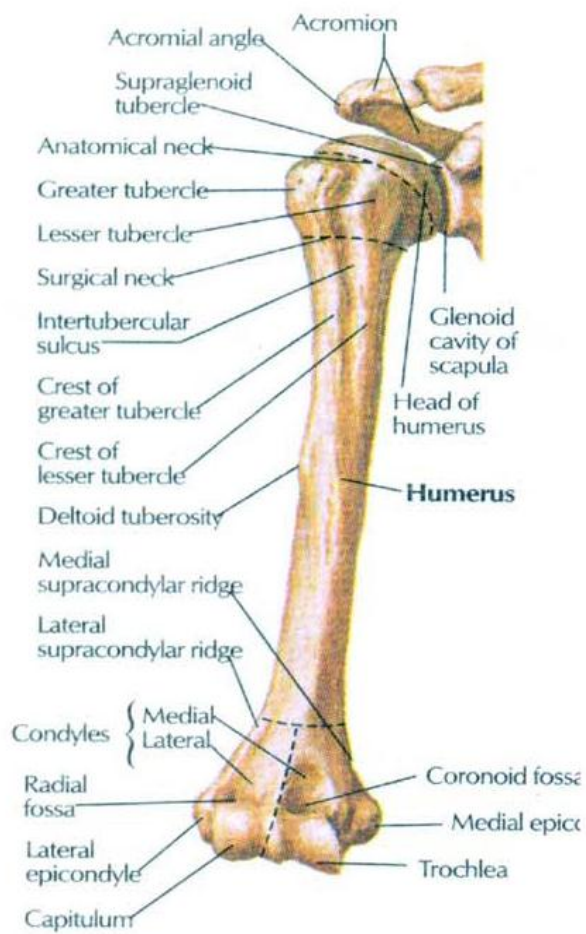
The capitulum includes the anterior and inferior surface of the condyle laterally, but not its posterior surface. It articulates with the discoid radial head.

The Trochlea is like a part of a pulley, occupying anterior, inferior and posterior surfaces of the humeral condyle medially. It articulates with the trochlear notch of the ulna.

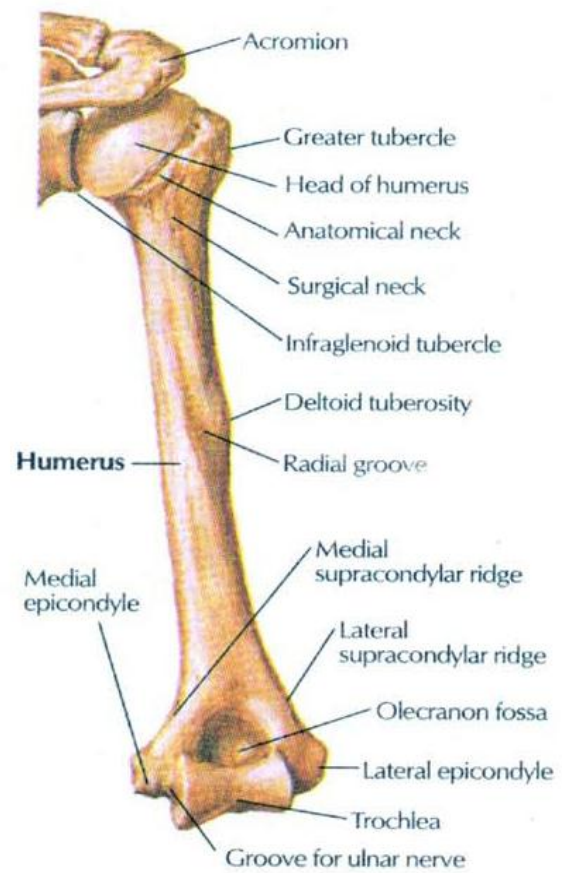
The medial epicondyle is a blank medial projection on the medial condyle. It is crossed by the Ulnar nerve in a shallow sulcus, on its smooth posterior surface. The medial humeral border ends at the medial epicondyle.

The lateral epicondyle forms the lateral non-articular part of the condyle. It has an anterolateral impression for the superficial forearm extensors.

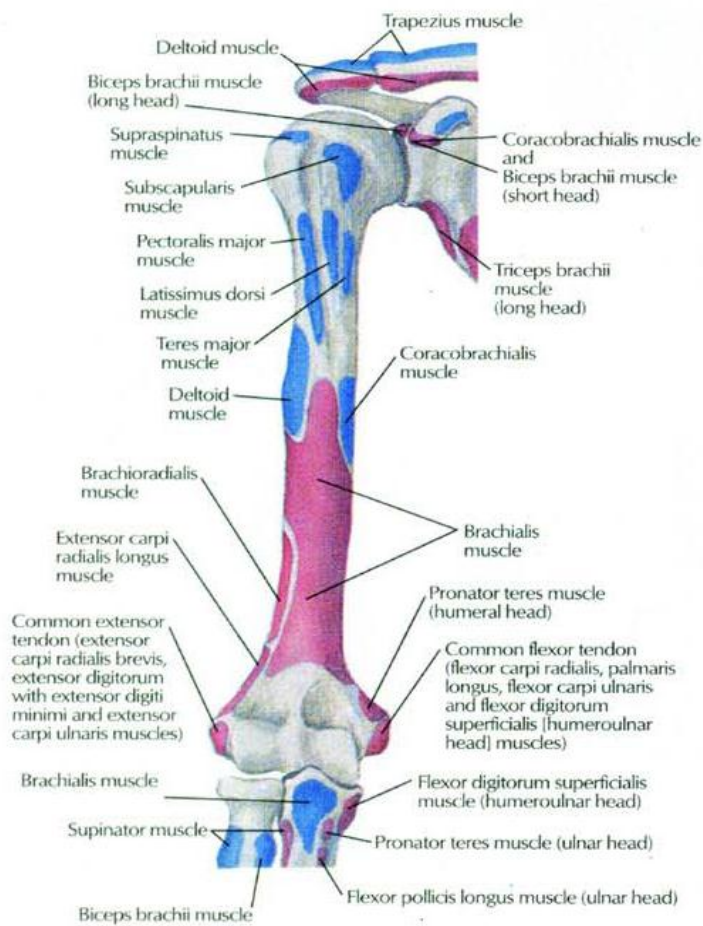
The middle third is the most vulnerable portion of the shaft where fracture and radial nerve palsy most commonly occur.



Anterior view



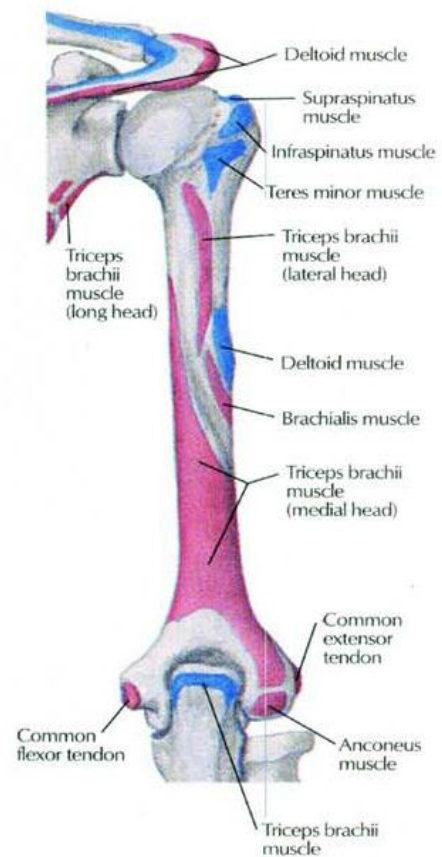
Posterior view



Anterior view

Muscle attachments

■ Origins
■ Insertions



Posterior view

BLOOD SUPPLY OF THE HUMERUS

The blood supply to the humeral diaphysis arises from branches of the brachial artery.

Nutrient artery of the humerus arises near the mid-level of the upper arm and enters the nutrient canal near the attachment of coracobrachialis, it is directed distally. On entering the medullary cavity it divides into ascending and descending branches. These approach the epiphyses where they are joined by terminals of numerous metaphyseal and epiphyseal arteries.

Accessory nutrient artery may be present. In some patients at the origin of the radial sulcus. It may arise from the profunda brachii artery or the anterior Circumflex artery.

The outer cortical zones receive blood supply from periosteal vessels, derived from arteries of neighboring muscles.

The blood supply to the humerus is so vigorous that union is rapid in case of a fracture. The middle third of the bone is the most vulnerable in relation to delayed union or non-union. This is because the nutrient artery enters the bone very constantly at the junction of the middle and lower thirds and the foramina of entry are concentrated in a small area of the distal half of the middle third of the shaft on the medial side of the bone. Thus fractures through the shaft of the humerus at the junction of middle and lower thirds may destroy the main nutrient artery at the time of injury.

THE ARM⁴⁹

The arm is divided into anterior and posterior compartments by extensions of deep fascia, which are called the medial and lateral intermuscular septae. Two additional septae are present in the anterior compartment of the arm. The transverse septum separates the biceps from the brachialis. The anteroposterior septum separates the brachialis from the muscles attached to the lateral supracondylar ridge.

MUSCLES OF THE ANTERIOR COMPARTMENT OF THE ARM⁵⁰

Coracobrachialis

This muscle forms an inconspicuous rounded ridge on the upper medial side of the arm. It acts as a flexor and adductor of the arm. It is perforated by the musculocutaneous nerve, which supplies it.

Biceps Brachii

It is a large fusiform muscle in the flexor compartment. It acts as a powerful supinator and flexor of the elbow and to a slight extent as a flexor of the shoulder joint.

Brachialis

It is supplied by the musculocutaneous and radial nerve and is a flexor of the elbow joint.

MUSCLES OF THE POSTERIOR COMPARTMENT OF THE ARM⁵⁰

Triceps

The triceps fills most of the extensor compartment of the upper arm. It arises by three heads the long head, the lateral head and the medial head. It is supplied by the radial nerve (C6, 7, 8) and is the major extensor of the forearm at the elbow joint. The arm muscles do not provide fracture stabilization forces.

BLOOD VESSELS OF THE ARM

BRACHIAL ARTERY

It is a continuation of the axillary artery, begins at the distal border of the tendon of teres major and ends about a centimeter distal to the elbow joint by dividing into radial and ulnar arteries.

The artery is wholly superficial, crossed by bicipital aponeurosis anteriorly at elbow and median nerve lateromedially at the level of insertion of coracobrachialis.

BRANCHES:

- Arteria Profunda Brachii
- Nutrient artery of the humerus
- Inferior Ulnar collateral (supratrochlear) Artery
- Muscular Arteries.

VEINS

Venae comitantes accompany Brachial Artery and all its branches the brachial veins flank the brachial artery with tributaries similar to the arterial branches and near the lower margin of subscapularis they join the axillary vein.

NERVES IN THE ARM⁵¹

RADIAL NERVE

The radial nerve arises from the posterior cord (C5, 6, 7, 8, T1) with the arteria profunda brachii and later its radial collateral branch, it inclines dorsally between the long and medial head of the triceps after which it passes obliquely across the back of the humerus first between the lateral and medial heads of the triceps, then in a shallow groove deep to the lateral head. The distance from the posterior tip of the acromion to the crossing of the nerve with the medial border of the humeral shaft is $12.9 + 1.5\text{cm}$. On reaching the lateral side of the humerus it pierces the lateral intermuscular septum to enter the anterior compartment. The average distance from the lateral epicondyle to the point where the radial nerve penetrates the lateral intermuscular septum is $11.9 + 1.0\text{cm}$. It then descends deep in a furrow between the brachialis and the brachioradialis. The radial nerve escapes injury in many of these fractures of humeral shaft for in most cases the nerve is protected from the sharp bone edges by a layer of triceps or brachialis muscle. It is in

fractures at junction of middle and third where the nerve is tethered to the bone as it pierces the lateral septum that damage is most likely to occur.

Muscular branches

Medial muscular branches arise from the radial nerve on the medial side of the arm and supply the medial and long head of the triceps. A large posterior branch arises in the radial groove and supplies the medial and lateral head of the triceps and the anconeus. Lateral muscular branches arise in front of the lateral intermuscular septum and supply the brachialis, brachioradialis and extensor carpi radialis longus.

Cutaneous branches

The small posterior cutaneous nerve of the arm arises in the axilla and passes medially to supply the skin on the dorsal surface of the arm nearly as far as the olecranon. It communicates with the intercostobrachial nerve. The lower lateral cutaneous nerve of the arm perforates the lateral head of the triceps, Passes to the front of the elbow and supplies the skin of the lateral part of the lower half of the arm.

MEDIAN NERVE

The median nerve has two roots from the lateral (C5, 6, 7) and medial (C8, T1) cords. It is closely related to the brachial artery throughout its course in the arm. In the arm it gives vascular branches to the brachial artery and usually a branch to the pronator teres.

ULNAR NERVE

The ulnar nerve arises from the medial cord (C8, T1). In the arm it runs distally medial to the brachial artery as far as the mid arm. Here it pierces the medial intermuscular septum. At the elbow it is in a groove on the dorsum of the medial epicondyle.

SURGICAL ANATOMY

The shaft of the humerus presents a number of unique anatomic features which have a bearing in the current rationales of therapy. As the humerus functions principally as a lever, weight bearing or compression forces are not a problem in the management of humerus fractures. Realignment of the fracture fragment is facilitated by the physiological dependent position and by relaxation of the developing musculature under the influence of gravity. These factors make the humerus the most easily reducible of all the long bones. Reduction and casting is frequently accomplished under sedation. Perfect alignment and opposition is not essential. Twenty degrees of anterior and thirty of varus are tolerated without compromising function or appearance.

The critical zone is at the junction of the middle and lower third of the shaft. Here the Radial nerve is fixed and is in direct contact with the bone as it penetrates the lateral intermuscular septum. The shaft blood supply is limited compared to metaphyseal areas. Middle shaft fractures may damage the nutrient artery, thus contributing to delayed and 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.^{52,53,54,55}

Elderly patients who suffer a humeral shaft fracture as a result of a fall often have less comminuted fracture patterns⁵⁶. 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 pectoralis 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.

Klenerman⁵⁷ 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 fracture⁵⁸ :

- a) Proximal to the pectoralis major insertion
- b) Distal to pectoralis 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 group⁵⁹ 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

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.

The modified **Gustilo-Anderson** classification⁶⁰ groups the open injuries of humeral shaft into five categories.

Type I : Open fractures which have a clean wound less than 1 cm long.

Type II : Laceration more than 1 cm long but without extensive soft tissue damage.

Type III A : Open fractures with extensive soft tissue damage, skin flaps or avulsion.

Type III B : Open fractures with extensive soft tissue loss with periosteal stripping and bony exposure.

Type III C : Open fractures with associated arterial injury that requires repair regardless of the soft tissue wound.

Methods of treatment of humeral shaft fractures

There are various operative and non-Operative methods of treatment for humeral shaft fractures. Good to excellent results have been obtained in most series of humeral shaft fractures treated by closed or open reduction and internal fixation.

Non Operative methods:-

i) **Hanging arm cast:** The hanging arm cast, described by Caldwell, uses dependency traction provided by the weight of the cast to effect fracture reduction. It requires patient to remain semi erect or up right at all times. It may cause distraction at the fracture site with resulting delayed union. The indications for the use of hanging arm cast include displaced mid shaft humeral fractures with shortening. Use of hanging arm cast is not indicated for transverse fractures, because of the potential risk for distraction and healing complications. Proper use of hanging arm cast has resulted in 96% union rate.

ii) **Coaptation splints**⁶¹ : U-shaped coaptation splint with collar and cuff is indicated for the acute treatment of a humeral shaft fracture with minimal shortening. It is a molded plaster slab around the medial and lateral aspects of the arm. The split should hang free of the body. Disadvantage of coaptation splint include loss of elbow extension, axillary irritation, patient discomfort and bulkiness of the device. It is common for plaster slab to slip requiring reapplication. Similar to the hanging arm cast, the coaptation splint is frequently exchanged for functional cast brace, 1 to 2 weeks after injury as the patient's pain subsides.

iii) **Thoraco brachial immobilization:** It is useful for non-displaced or minimally displaced fractures in children or elderly who are unable to tolerate other methods of management. In these cases, patient comfort, and not fracture reduction is the critical

consideration. It is made from a single piece of stockinet and this velpau shoulder dressing is inexpensive, comfortable and can be easily applied.

iv) **Shoulder spica cast:** The indications for the use of shoulder spica cast are unclear. The primary indication may be when closed reduction of the fracture requires significant abduction and external rotation of the upper extremity. This has disadvantages like difficulty in application, cast weight, bulkiness and patient discomfort.

v) **Skeletal traction:** Skeletal traction is rarely indicated for the treatment of closed or open humeral shaft fractures. When indicated, traction is applied through a trans olecranon Kirshner wire or Steinmann pin and introduced from medial to lateral side, to avoid injury to ulnar nerve.

vi) **Functional Bracing**^{1,4}: The humeral functional brace was first described by Sarmiento. It is an orthosis, that effects fracture reduction through soft tissue compression. This device maximizes the use of shoulder and elbow movements. Contra indications to the use of functional brace include (1) massive soft tissue injury or bone loss (2) unreliable or uncooperative patient (3) inability to obtain or maintain acceptable fracture alignment. The Brace is worn for a minimum of 8 weeks after application.

Operative treatment:-

i. **Plate and Screws fixation**^{62,63,64,65}: Anatomical fracture reduction and stable fixation of the humeral shaft is possible with plate and screws fixation, without violation of the rotator cuff. At surgery, minimal stripping of the soft tissue should be performed and butterfly fragments should not be devitalized. Minimum Purchase of 3 holes in the proximal fragment and 3 in the distal should be present. Anterolateral approach with the help of lag screws must be used whenever possible.

ii. **External fixation** : The indications for the external fixation of the humeral shaft fractures include open fractures with extensive soft tissue injury, fractures overlying burns and infected non unions. Complications of external fixation include pin tract infection, neuromuscular, muscle and tendon impingement and non union. It is very uncomfortable to the patient and requires much patient co-operation.

iii. **Intramedullary fixation** : An intramedullary fixation is satisfactory for most diaphyseal fractures of the long bones. Intramedullary fixation lies along the mechanical axis and acts as load sharing device. Stress shielding with resultant cortical osteopenia is minimized with intramedullary nails and hence re-fracture after implant removal is rare. Intramedullary nails do not require extensive exposure required for plate application. With the use of image intensifier, these devices can be inserted in a closed manner, without exposing the fracture hematoma. It results in a lower infection rate and a higher union rate with a minimal soft tissue scarring.

a) **Flexible intramedullary nails** ^{66,67,68,69}: Flexible intramedullary devices available for the use in the management of humeral shaft fractures include Ender nails, Hackethal nails and Rush rods. With these devices, multiple implants are required to achieve fracture stability. They can be inserted retrograde from the distal humerus or antegrade near the rotator cuff. Violation of the rotator cuff during insertion can result in loss of shoulder motion. Flexible intramedullary nails do not provide rigid fixation. They do not prevent fracture shortening nor do they provide significant rotational control.

b) **Un-Locked intramedullary nails**: The Kuntscher nail which was not conceived primarily for use in humerus, is rarely used. Shoulder pain and reduced range of movements from sub-acromial impingement due to nail protrusion and rotator cuff injury are common.

c) **Inter locked nails:** The success of interlocked nails for the treatment of unstable femur and tibia fractures has resulted in the design of several types of locked intramedullary humeral nails. These nails usually rely on proximal screws, and distal screws or fins fixation to provide stability. They can be used to stabilize fracture from 2 cm distal to the surgical neck to 3 cm proximal to the olecranon fossa. Interlocked humeral nails can be inserted antegrade through the rotator cuff, greater tuberosity, or retrograde proximal to the olecranon fossa. Antegrade inserted interlocked humeral nail is becoming implant of choice for humeral shaft fractures, when open reduction is indicated.

BIOMECHANICS OF INTRAMEDULLARY NAILING^{70,71}

An intramedullary nail being located in the center of the bone provides rigid temporary stiffness to the bone. It acts as an internal splint and works as a load sharing device, permitting load transmission across the fracture site and thus promoting fracture healing. These nails are best suited to control the bending and translational stresses. Interlocking screws are effective in controlling the rotational stress on the bone. During the period of fracture healing. Internal fixation aids in transmission of forces from one end of the fractured bone to the other, thereby producing stresses in the implant. The mechanical behavior of the implant is determined by both material and geometry. The rigidity or stiffness of a cylindrical structure in bending and torsion is proportional to the fourth power of the radius (i.e., the polar moment of inertia). The further that material is distributed from the bending or torsional axis, the stiffer the structure becomes.

Working length is the most crucial factor in determining the success of the fixation. It is defined as the length of the nail spanning the fracture site from its distal most point of fixation in the proximal fragment to the proximal most point of fixation in the distal fragment. This defines the length of bone carrying the load across the fracture site. The bending stiffness of a nail is inversely proportional to the square of its working length. The torsional stiffness is inversely proportional to the working length. Therefore, the shorter the working length, the stronger the fixation.

STATIC LOCKING AND BRIDGING FIXATION

Screw insertion at the two ends of the humeral nail provides for the rotational stability by inter locking the nail with the proximal and the distal fragment. Inter locking essentially maintains the bone length and more importantly controls the rotational stability at the fracture site. This is very significant in humerus as the stresses are more of a rotational type rather than a compression distraction type.

Static locking achieves a bridging fixation.

In bridging fixation the implant extends across the fracture site and is fixed to the major proximal and distal bone fragments by locking screws located away from the fracture site. Static locking is effective in treating fractures with severe comminution, delicate soft tissue cover, long oblique or spiral fracture patterns. In these situations it is undesirable to open the fracture site and devascularize the fracture ends.

MATERIAL PROPERTIES^{71,72}

The material used should be biocompatible to withstand corrosion and of sufficient strength to withstand the stresses. Material properties depend upon the composition of the material, the processing involved, the grain size and the porosity. Different materials have different elastic modulus thus with different tensile strengths.

The best material suited for fracture fixation being 316L stainless steel and titanium alloy. 316L Stainless steel is composed of iron, 17% chromium, and 12% nickel, 3% manganese and 2% molybdenum with <0.03% carbon. It has got excellent corrosion resistance. It has a modulus of elasticity comparable to human bone. Titanium alloy is made up of a composite of titanium, aluminum and vanadium. This has got the modulus of elasticity closest to the human bone but is very much corrosion resistant due to the property of formation of oxide film. It has an excellent resistance to fatigue due to cyclical loading.

FRACTURE HEALING IN CLOSED INTRAMEDULLARY NAILING⁷⁰

After Intramedullary nailing fracture healing proceeds mainly by the formation of periosteal callus. Closed nailing technique, without exposing the fracture site preserves the fracture hematoma which is very essential for fracture healing. Periosteum accounts for the vascularity of outer one-third of the diaphyseal cortex. In cases with comminution at the fracture site the soft tissue attachment provides for the vascularity of the comminuted fragments. Open reduction further destroys the blood supply by stripping the periosteum off the bone. Closed nailing preserves the periosteal blood supply and promote fracture union by utilizing the osteogenic potential of the pluripotent cells in the fracture hematoma. Thus closed intramedullary nailing goes with the concept of biological fixation. More over with closed nailing there is reduced blood loss, infection rates and hospital stay.

PRINCIPLES OF INTRAMEDULLARY NAILING⁷⁰

Interlocking intramedullary nailing is a safe and effective means of fracture fixation. The early mobilization for the neighboring soft tissues and joint is a proof enough for the amount of stability provided by the fixation. This is a biological means of fixation and aims at providing early useful movements of the extremity.

Careful preoperative planning and operative technique, familiarity with instrumentations and skilled radiographic monitoring are of outmost importance. Preoperative injury films must be carefully inspected for the fracture pattern, degree of comminution, canal size, deformity and presence of associated injuries.

Closed nailing must be attempted whenever possible. This is a more scientific and biological way of fixing the fracture.

Location of the proper entry point for nail insertion is a critical step in closed nailing. An improper portal of entry allows angular deformity at the fracture site or even worse, causes comminution during reaming or nail insertion. For humerus entry port is just medial to the greater tuberosity, this makes an angle of 50 with the medullary canal and accordingly the proximal portion of the nail is angled.

With antegrade insertion, it is important to bury the proximal end of the nail below the bone surface to prevent encroachment of the nail on the subacromial space.

Wherever possible nailing must be performed within few hours of injury, before the onset of soft tissue shortening and edema, this makes fracture reduction easier.

Bony union is the primary objective of the surgical procedure. Nail is in no way a good substitute for bony union.

IMPLANT DESIGN

Nails used by us were AO type humerus interlocking nails made of stainless steel 316L. The nails are available in diameters of 6mm, 6.5mm, 7mm, 7.5mm and 8mm. The 6mm nail is solid while the 6.5mm, 7mm, 7.5mm and 8mm nails are cannulated, which can be inserted over a 2mm guide wire. The 6.5mm and 7.5mm nails used were unreamed nails whereas the other were reamed. These nails are available in varying lengths from 200mm onwards at an increment of 10mm. The distal end is blunt and beveled to allow for an easy negotiation of the fracture site. These are provided with a minimal bend of 50° at a constant distance from the proximal end to account for the eccentricity of the entry point. The nails will have an internal thread at its proximal end to seat the locking nut in the jig. The proximal end of the nail is broadened to accommodate for the thicker locking screws. These slots are circular and provide for static locking. The proximal locking screws are passed from lateral to medial direction with the help of jig. The distal end of the nail is provided with two circular slots for static locking of the distal locking screw. These slots provide for an anterior to posterior insertion of the locking screw with free hand technique. The locking screws are trochar tip, self cutting cortical screws. They are of 2.9mm diameter for 6mm and 6.5mm nails and 3.9mm diameter for 7mm, 7.5mm and 8mm nails.

PRE-OPERATIVE MANAGEMENT:

Patients were admitted and U slab was given pre-operatively. An anteroposterior and lateral view x-ray were taken. Radial nerve was tested by looking for wrist drop and finger drop and sensation in the autonomous zone for radial nerve that is the 1st web space. Routine blood investigation and blood grouping were done. After treating associated injuries and obtaining physician opinion patients were posted for surgery.

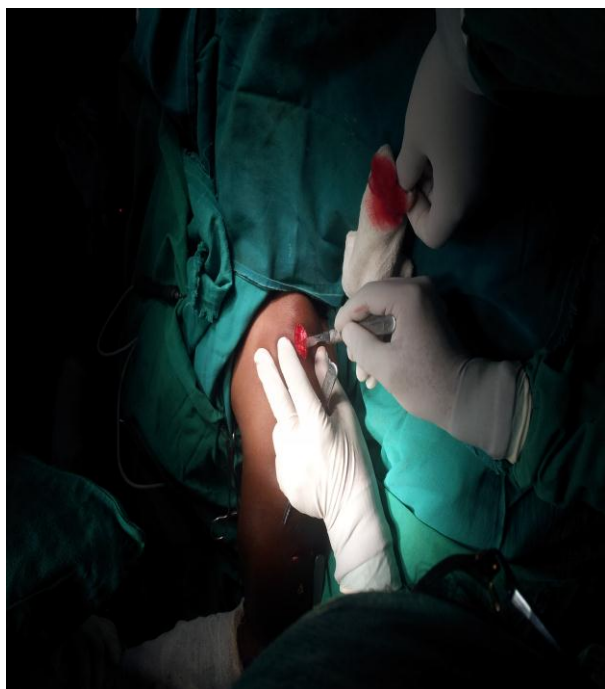
inj.Cefixime was given pre-operatively. All cases were operated under general anaesthesia. Surgery was done on an average of 2-3 days from the date of injury.

OPERATIVE PROCEDURE:

Proper length and diameter nail was selected.

With the patient in supine position head turned to contra lateral side for increase exposure of the shoulder.

1. Arm was painted and sterile drapes were applied
2. Longitudinal incision was made over the lateral point of acromion process and extended distally centered over the tip of greater tuberosity.
3. Entry point was made with an awl just medial to the greater tuberosity and the position was confirmed with C-Arm.
4. The selected nail was attached to zig and was passed through the entry point in to the medullary canal.
5. The nail was advanced distally until it was 1 to 2cm proximal to the olecranon fossa by doing close reduction at the fracture site.
6. The nail position was confirmed in the distal fragment by anteroposterior and lateral views by C-arm, by internally and externally rotating the arm.
7. Proximal locking was done with the help of a zig lateral to medial.
8. Distal locking was done in AP orientation with help of free hand technique.
9. Zig was removed and wound was closed in layers.



Incision



Entry point



Insertion of awl



Reaming of proximal humerus



Nail incersion



Distal locking under C-ARM



Distal locking



Closer

POST OPERATIVE MANAGEMENT :

Postoperative Inj.Cefixime intravenous for three days and Analgesics were given, later oral antibiotics were given for five days. None of the patients had radial nerve palsy post operatively. Sutures were removed on the 14th post operative day. Assisted active range of motion exercises started for shoulder from second post operative day. Sutures were removed on the 14th post operative day and patient was discharged on an average of 14th post operative day.

FOLLOW UP:

Patients were called for serial follow up on 6th week, 3rd month and 6th month. Serial follow up by x-ray were done. Assessment of shoulder, and elbow movements were done. Clinical and radiological union – of the fracture site were assessed. Final evaluation was done on the 6th month.

Functional results were graded by the criteria of UCLA shoulder rating scale and was graded as excellent/good and fair/poor depending upon the range of movements, subjective complaints like pain was also taken into account^{80,81}.

UCLA scoring

Section 1 – Pain

- | | |
|--|------|
| ☐ Present always and unbearable; strong medication frequently | - 0 |
| ☐ Present always but bearable' strong medication occasionally | - 2 |
| ☐ None or little at rest' present during light activities salicylates used frequently | - 4 |
| ☐ Present during heavy or particular activities only; salicylates used occasionally | - 6 |
| ☐ Occasional and slight | - 8 |
| ☐ None | - 10 |

Section 2 – Function

- | | |
|--|------|
| ☐ Unable to use limb | - 0 |
| ☐ Only light activities possible | - 2 |
| ☐ Able to do light 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 bra | - 6 |
| ☐ Slight restriction only; able to work above shoulder level | - 8 |
| ☐ Normal activities | - 10 |

Section 3 - Active forward flexion **(manual muscle testing)**

- | | |
|------------------------------------|---|
| ☐ 150° | 5 |
| ☐ 120°-150° | 4 |
| ☐ 90°-120° | 3 |
| ☐ 45°-90° | 2 |
| ☐ 30°-45° | 1 |
| ☐ <30° | 0 |

Section 4-Strength of forward flexion

- | | |
|--------------------------------|---|
| Grade 5 (normal) | 5 |
| Grade 4 (good) | 4 |
| Grade 3 (fair) | 3 |
| Grade 2 (poor) | 2 |
| Grade 1 (muscle concentration) | 1 |
| Grade 0 (nothing) | 0 |

Section5 - Satisfaction of patient

- | | | |
|--------------------------|-------------------------|---|
| ☐ | Satisfied and better | 5 |
| ☐ | Not satisfied and worse | 0 |

Total UCLA Shoulder score is: _____

Interpreting the UCLA Shoulder rating scale >27 Good/Excellent <27 Fair/Poor

The maximum score is 35 points. Excellent / good indicates satisfactory results, where as fair / poor indicates unsatisfactory results.

OBSERVATIONS AND RESULTS

The present study consists of 30 cases of humeral shaft fracture treated by closed intramedullary interlocking nailing by antegrade method. The study is conducted over a period of two years between september 2011 to september 2013 . All the patients were available for follow up.

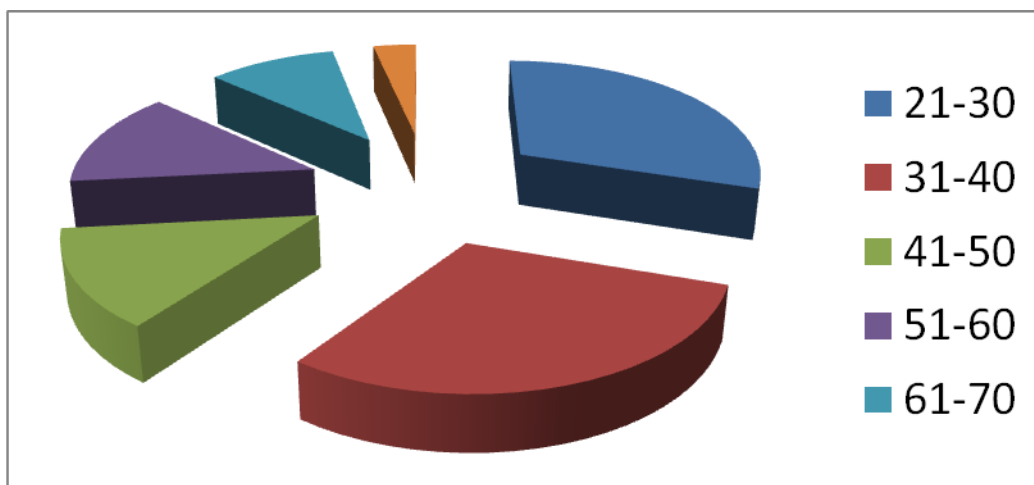
Following observations were made :

AGE DISTRIBUTION:

Our patients age range from 21 years to 75 years with an average of 42.8years.(Table-I)

Table - I

Age	No. of Patients	Percentage
• 21 - 30	9	30%
• 31 - 40	8	26.67%
• 41 - 50	4	13.33%
• 51 - 60	4	13.33%
• 61 - 70	4	13.33%
• 71 - 80	1	3.34%

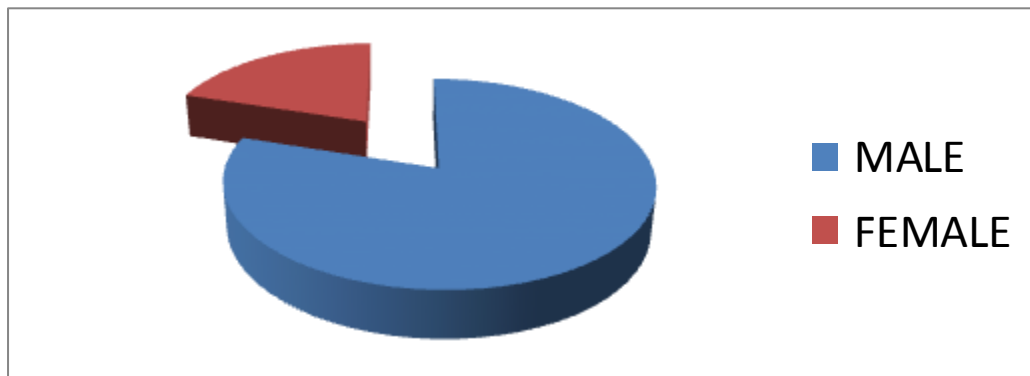


SEX DISTRIBUTION:

Majority of the patients 24 (80%) were Males and only 6 (20%) were Females.(Table-II)

Table - II

Sex	No. of Patients	Percentage
• Male	24	80%
• Female	6	20%

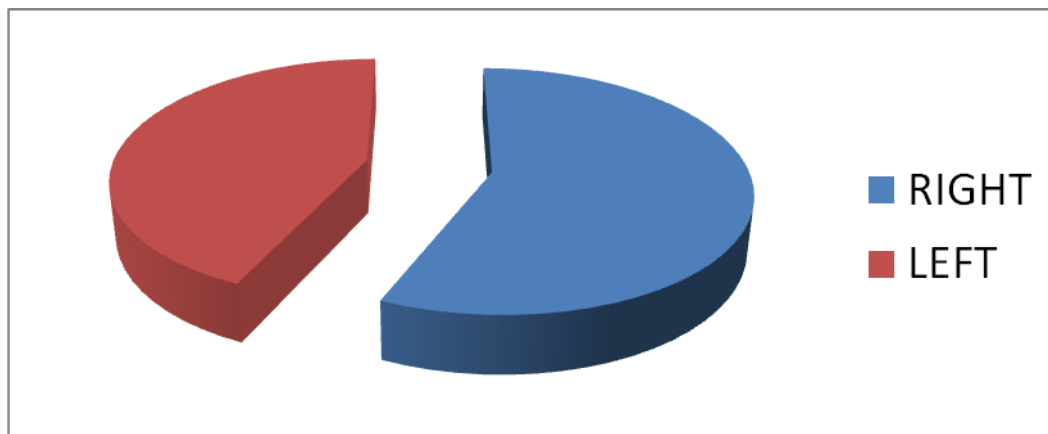


SIDE AFFECTED:

Right humerus was involved in 17 (56.7%) patients and left in 13 (43.3%) patients.(Table-IV)

Table - III

Side	No. of Patients	Percentage
• Right	17	56.7%
• Left	13	43.3%

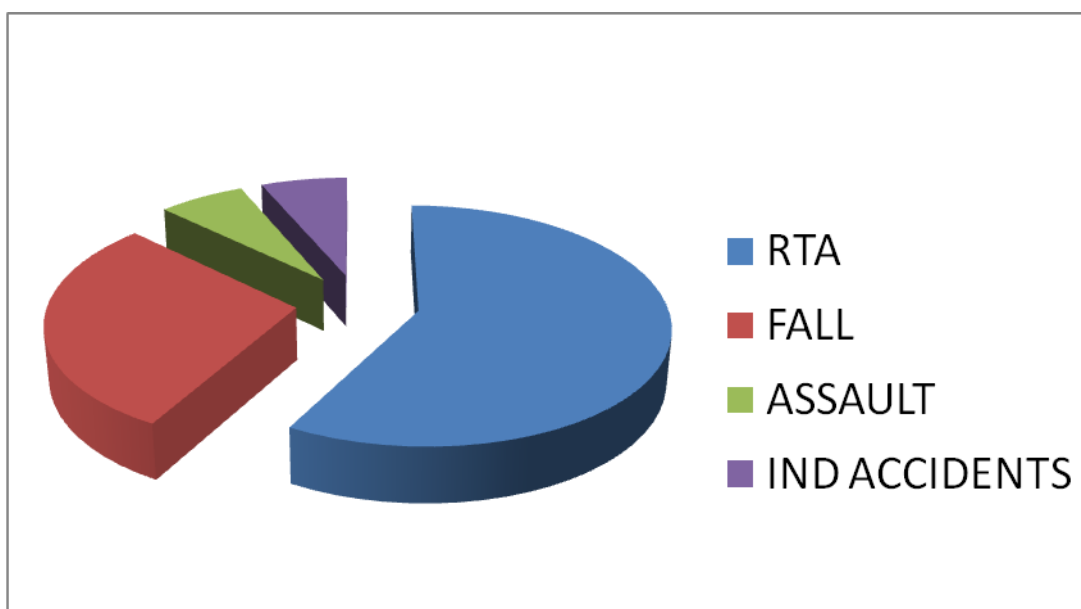


MODE OF INJURY:

Road traffic accident (RTA) was the commonest mode of injury. It accounts for 18 (60%) out of 30 patients. 9(30%) patients presented with H/O fall. Two (6.7%) presented with a H/O assault and one patient (3.3%) with a H/O industrial accident. (Table-V)

Table - IV

Mode of Injury	No. of Patients	Percentage
• RTA	18	60%
• Fall	9	30%
• Assault	2	6.7%
• Industrial Accident	1	3.3%

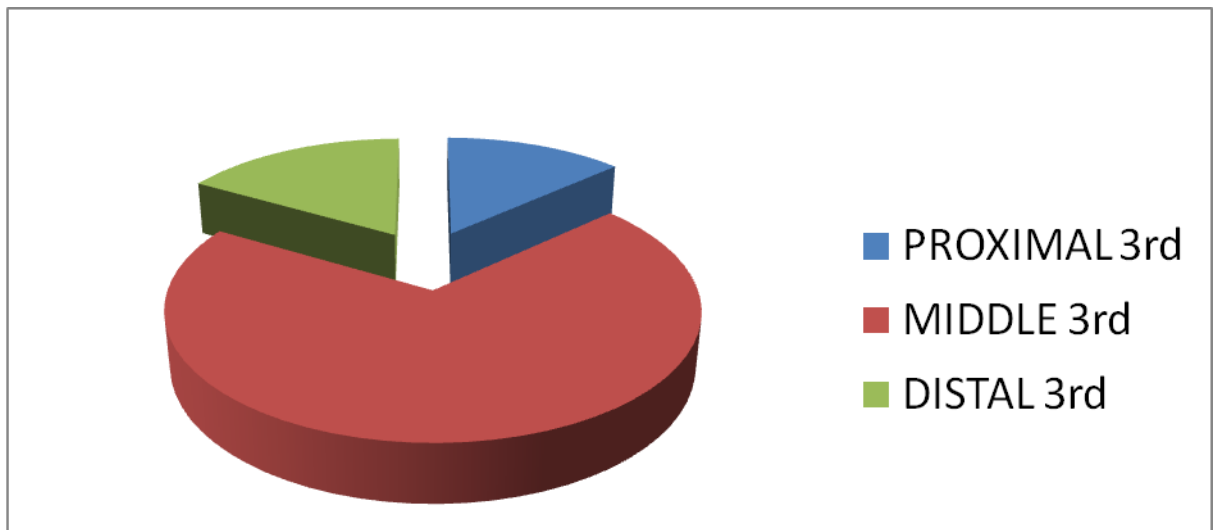


LEVEL OF FRACTURE:

In 20 (66.7%) cases fracture was at middle 3rd level, in 5 (16.7%) cases at distal 3rd level and in 5 (16.7%) cases it was at proximal 3rd level. (Table-VI)

Table - V

Level	No. of Patients	Percentage
• Proximal 3rd	4	13.3%
• Middle 3 rd	21	70%
• Distal 3rd	5	16.7%

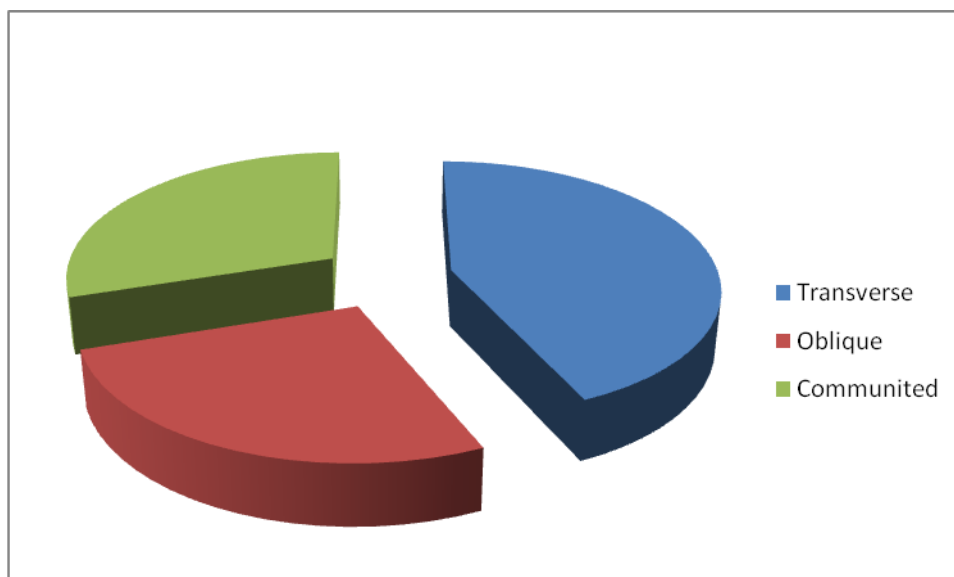


TYPE OF FRACTURE:

13 were transverse fractures 8 were oblique fractures and 9 communitied fractures.
(Table-VII)

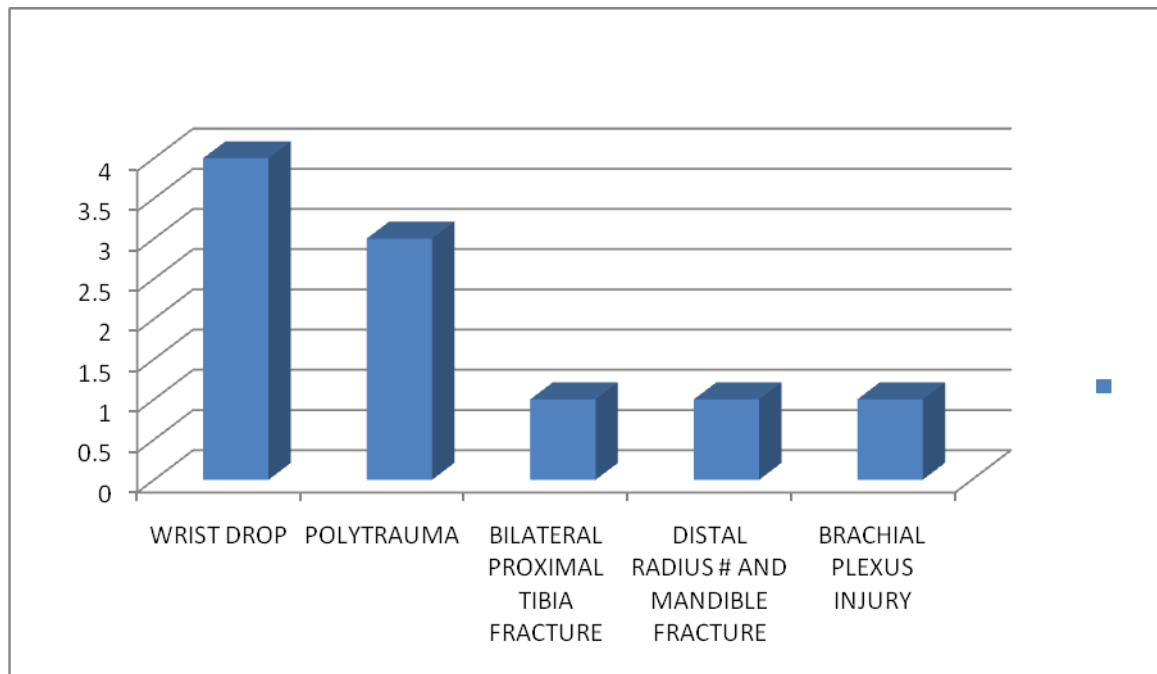
Table - VI

Type	No. of Patients	Percentage
• Transverse	13	43.3%
• Oblique	8	26.7%
• Communitied	9	30%



ASSOCIATED INJURIES:

- 8 of our patients had associated injuries.
- 2 cases had wrist drop which recovered post operatively.
- 3 cases of polytrauma of which 1 patient had wrist drop.
- 1 case with distal radius fracture and fracture mandible with wrist drop was encountered.
- 1case also had bilateral proximal tibia fractures.
- 1case had associated brachial plexus injury.



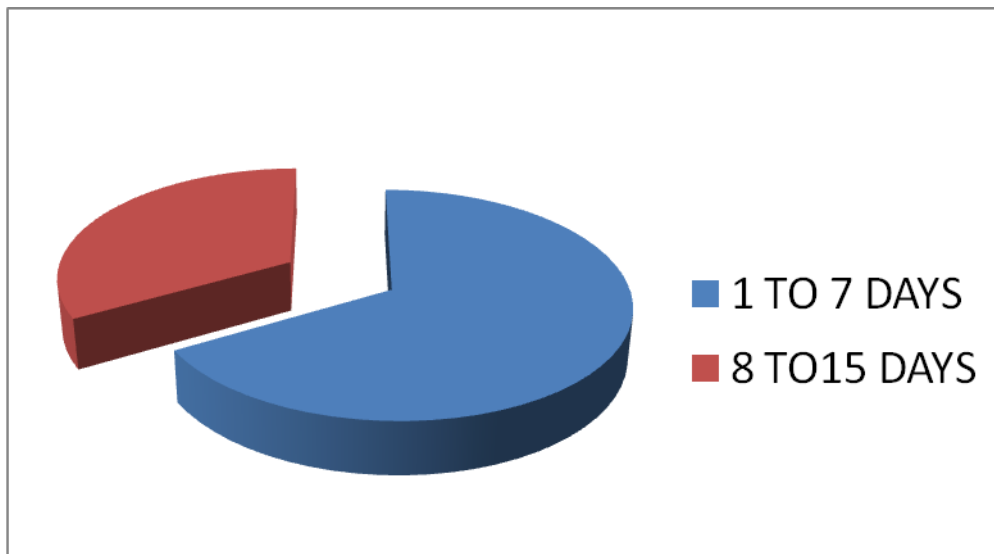
TRAUMA - SURGERY TIME INTERVAL:

Most of the cases were operated within a week after trauma. On an average time interval was 6.6 days. (Table - VIII)

Table - VII

Trauma-Surgery	No. of Patients	Time Interval
• 1 to 7 days	20	66.7%
• 8 to 15 days	10	33.3%

Delay in surgery was due to late presentation or managing associated injuries or for seeking fitness for surgery.



IMPLANT USED:

Most commonly 260mm length nail was used in 11 cases. (Table-IX)

Table - VIII

Nail length	No. of Cases	Percentage
• 220 mm	6	20%
• 230mm	0	0%
• 240mm	2	6.67%
• 250 mm	4	13.33%
• 260 mm	11	36.67%
• 270 mm	4	13.33%
• 280mm	3	10%

In 13 cases 7mm wide reamed nails were used followed by 8mm in 8 cases and 6mm solid nails in 3 cases, and 5 cases by 6.5mm and 1 case by 7.5mm unreamed nails were used (Table-X)

Table - IX

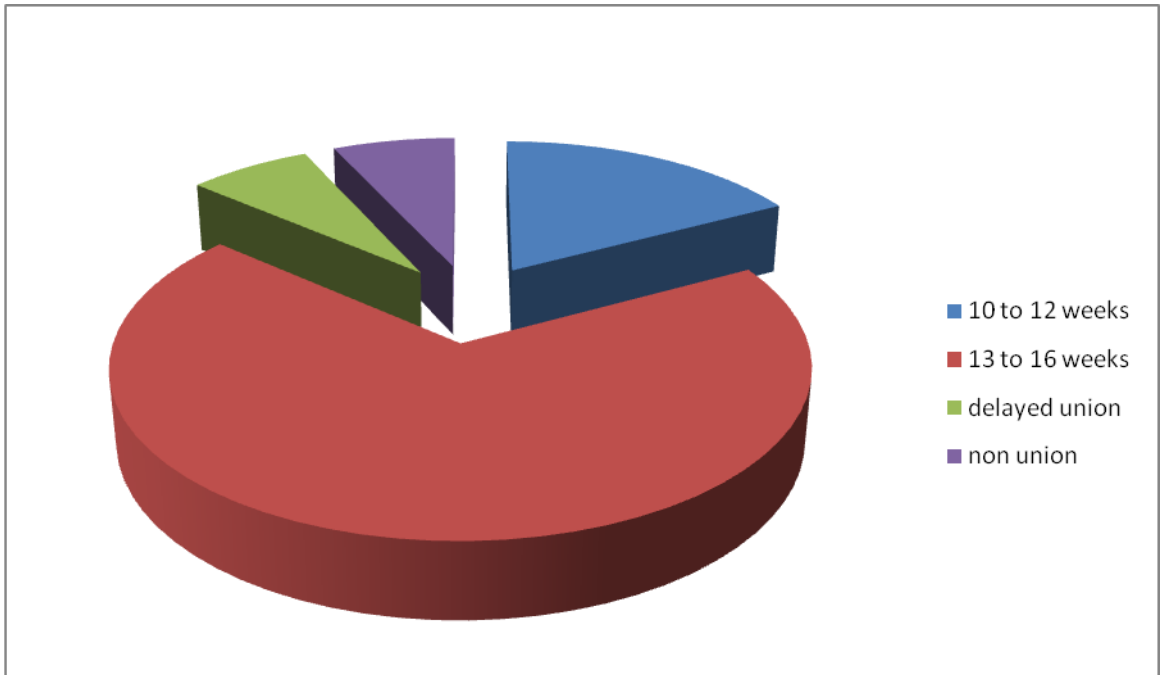
Nail width	No. of Cases	Percentage
• 6 mm	3	10%
• 6.5mm	5	16.67%
• 7 mm	13	43.33%
• 7.5mm	1	3.33%
• 8 mm	8	26.67%

FRACTURE UNION :

Period of fracture union ranged from 10 to 16 weeks, average period being 13.5 weeks. (Table-XII)

Table - X

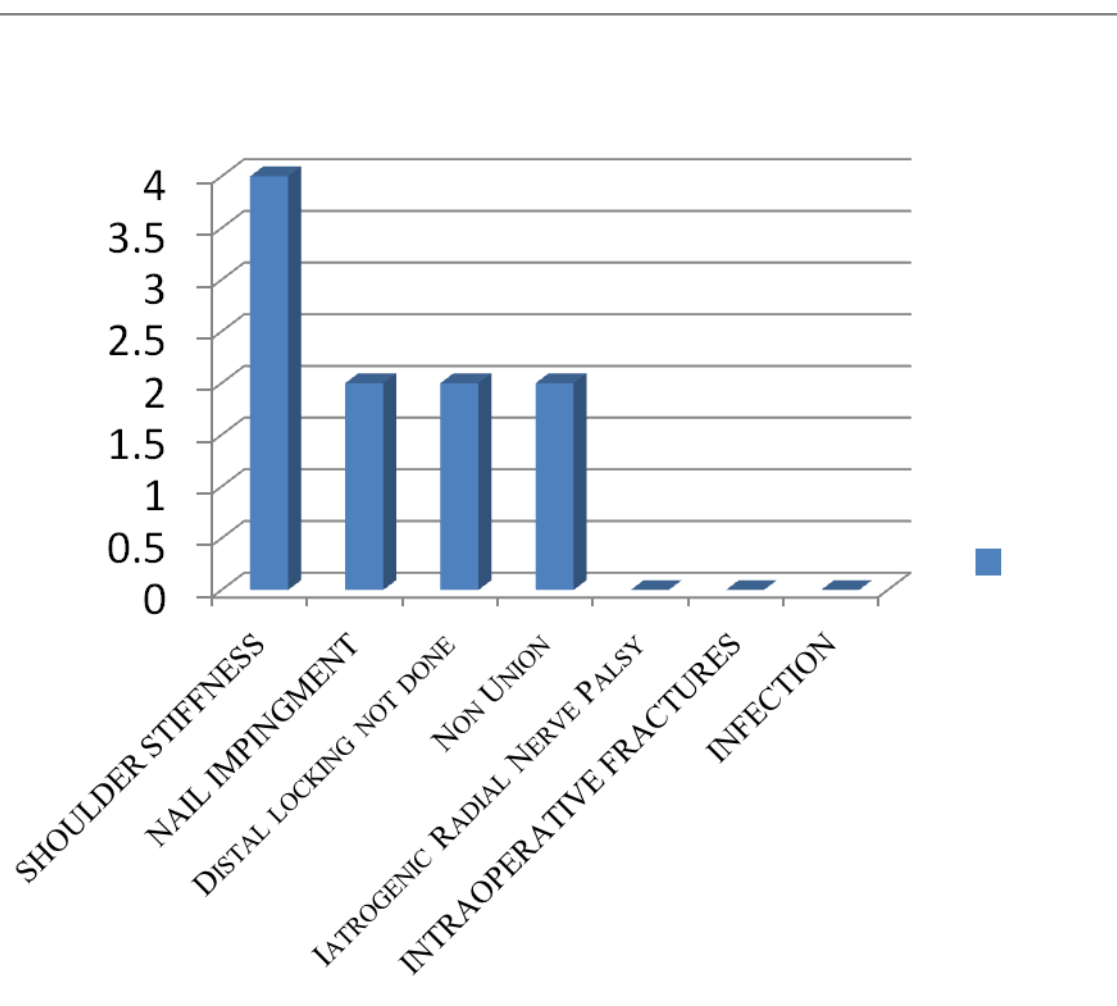
Period of Union	No. of Patients	Percentage
• 10 to 12 weeks	6	20%
• 13 to 16 weeks	20	66.7%
• More than 16 weeks	2	6.7%
• Non-union	2	6.7%



Complications

Table - XI

Complications	No. of Patients	Percentage
• Shoulder stiffness	4	13.3%
• Nail Impingement	2	6.7%
• Non-union	2	6.7%
• Distal locking not done	2	6.7%
• Iatrogenic Radial nerve palsy	0	0%
• Intra op communication at fracture site	0	0%
• Infection	0	0%



Range of movements:

Case 3



Case7



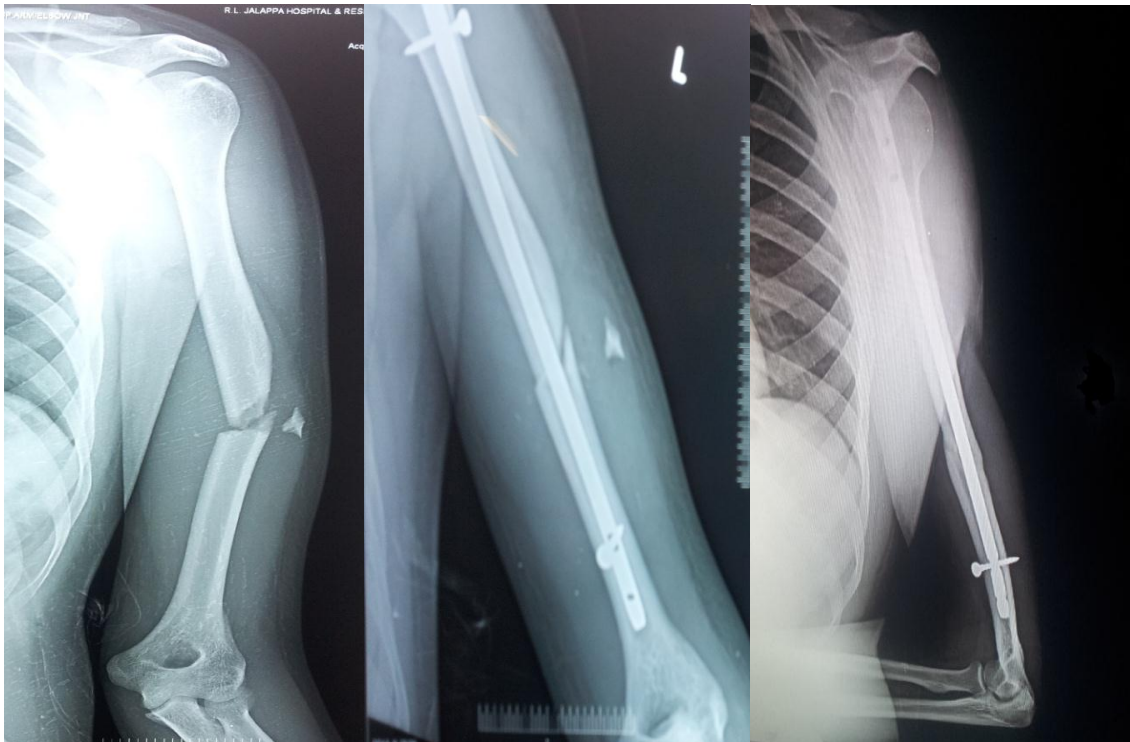
Case 21



Case 23



case 3

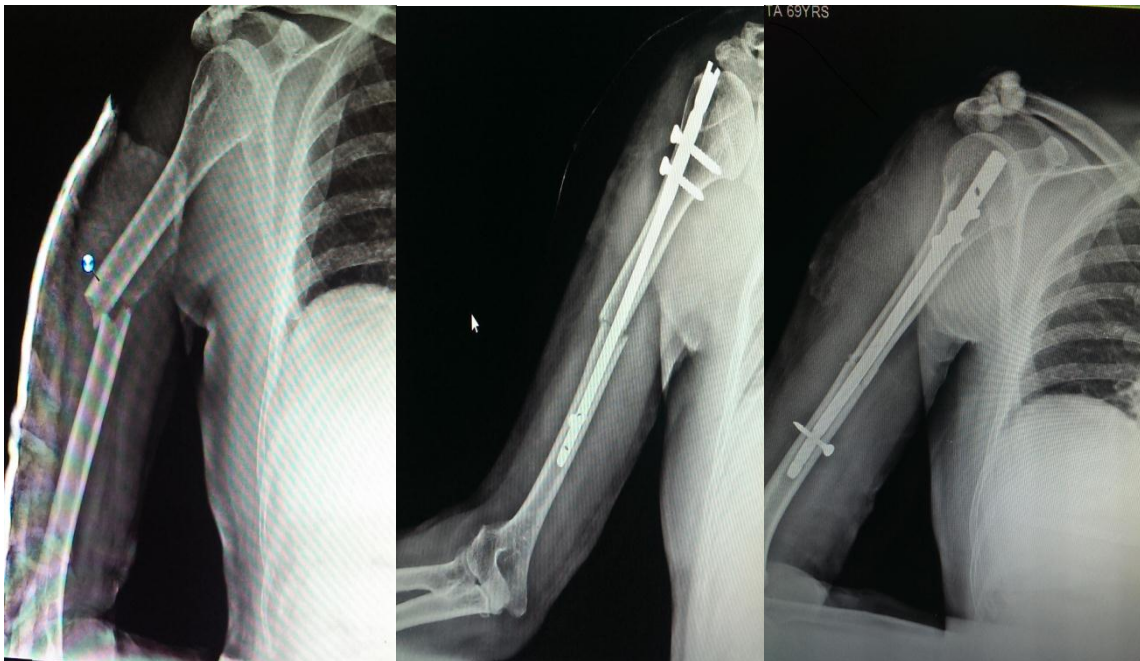


Pre op

Immediate post op

12 weeks

case 18

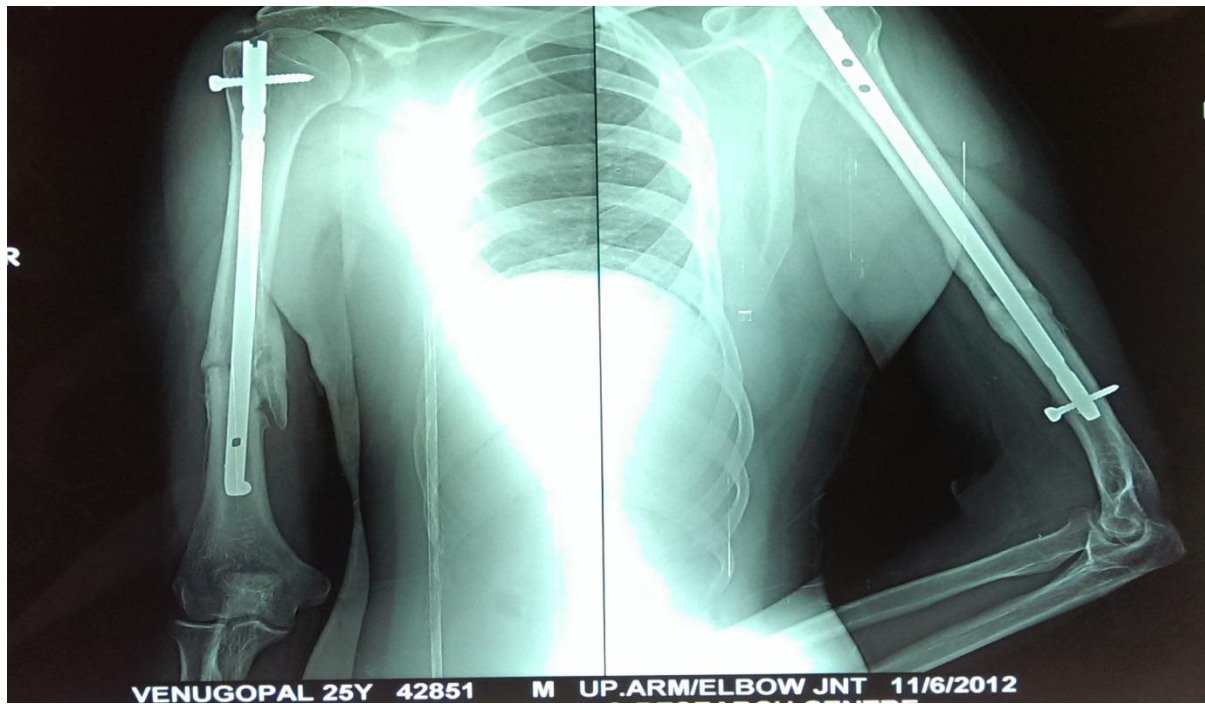


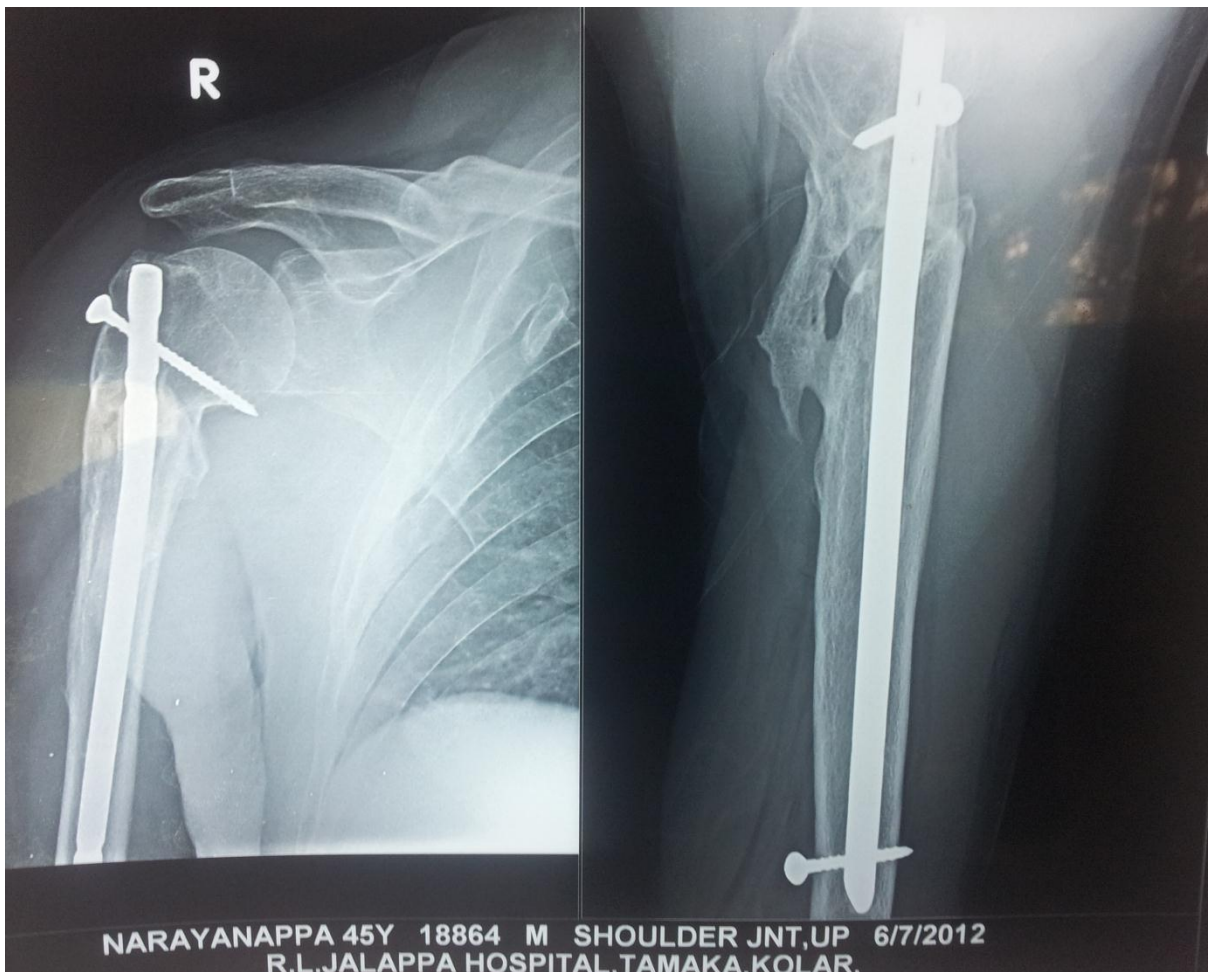
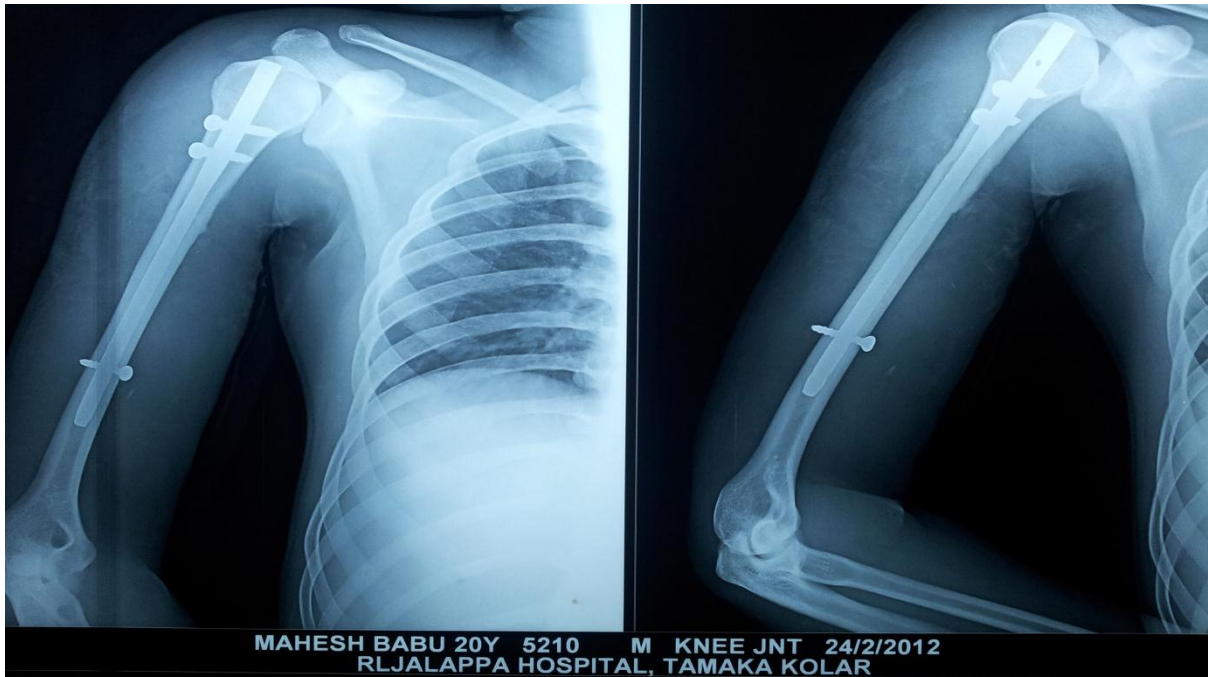
Pre op

Immediate post op

10 weeks

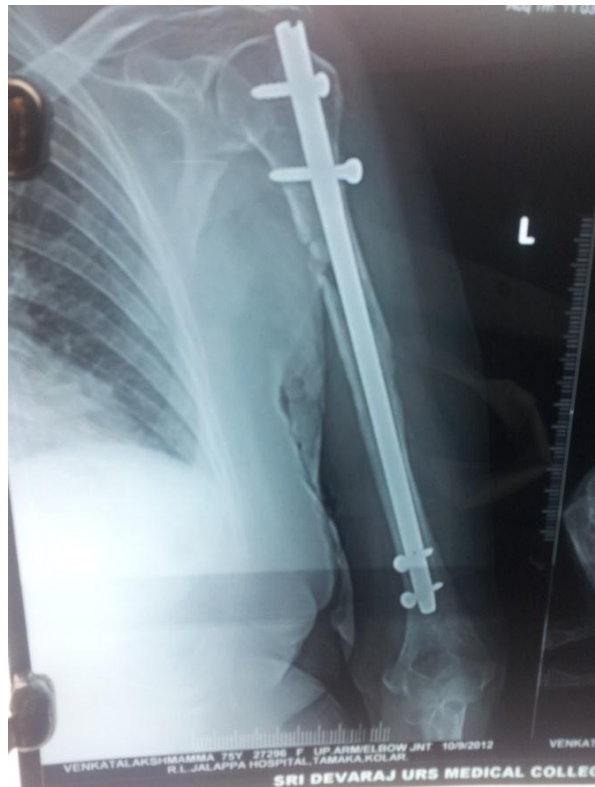
Fracture unions





Complications:

Shoulder impingement



Non union



DISCUSSION

The Humeral shaft is a richly vascularised bone which is covered by muscle bellies all around. In case of a fracture, bone fragments retain good perfusion leading to good healing⁷. Conservative management is successful in achieving more than 90% of union^{13, 8} and is still preferred for isolated low energy humeral shaft fractures⁷³. It is also used as initial treatment for displaced spiral and oblique humeral fractures. In transverse and short oblique fractures, the contact area of the fracture fragments is very small and fracture instability is relatively high, thus leading to a high number of delayed and un-united fractures¹⁵. In long spiral fractures interposed muscle bellies can hinder direct contact between the fracture fragments. In obese patients the cast or brace does not give adequate stability⁷⁷. Good co-operation of the patients is required, which is very difficult in uneducated patients. For the patients and surgeons, plaster cast treatment or immobilization of an upper extremity against the thoracic wall are not as popular as they were one generation ago⁵⁸. Another major disadvantage of conservative treatment is the stiffness of the adjacent joints especially shoulder, requiring prolonged rehabilitation. Operative stabilization is known to improve the healing, fracture alignment and functional result in patients with high energy humeral shaft fractures⁹. Though surgical results are seldom superior to conservative measures, there is a growing trend for operative treatment⁵⁸.

Plate osteosynthesis is an accepted surgical option¹³. The main disadvantage of plate osteosynthesis is that they need large tissue dissection⁵⁸ with extensive soft tissue stripping¹⁵ and its inherent complications. It also requires the mobilization of the radial nerve both during insertion and removal⁷ with high rate of secondary radial nerve palsies. Plate osteosynthesis use is limited in patients with osteoporosis, where a strong bone-implant interface is difficult to achieve¹⁵.

External fixation lacks in comfort to the patient, and makes nursing care even more difficult. Schanz screws may hinder the free movement of the shoulder and elbow joint by perforate muscle bellies of the deltoid and triceps muscles⁵⁸. Other complications of external fixation include pin-tract infection, neurovascular and tendon impalement and non-union. The

indications for external fixation of humeral shaft fractures include open fractures with extensive soft tissue injury, fractures with overlying burns and infected non unions¹⁸.

Flexible intramedullary nails with the techniques of Rush⁶⁸, Ender⁶⁷, and Hackethal⁶⁶ can be inserted proximally or distally. Rush pins and Ender's nails internally splint the fractured humeral shaft and secure the axial alignment. These are associated with problems like rotatory instability, nail migration, non union and poor joint function⁹. These nails do not provide rigid fixation and do not prevent shortening⁸. Their routine use is not recommended^{74, 58}. The Kuntscher nail, which was not conceived primarily for use in the humerus, was rarely used in humeral shaft fractures⁷⁵. Shoulder pain and reduced range of movements from subacromial impingement due to nail protrusion and rotator cuff injury at the time of nail insertion are common, as the nail is straight.

The interlocked nail is an implant that offers axial alignment, axial and rotational stability⁷⁶. The first specific humeral interlocking nail was developed by Seidelin in 1980. This thick and rigid nail has to be inserted after reaming of the humeral canal through an antegrade approach. In its proximal part, the nail is interlocked conventionally by one or several screws and in distal part, rotational stability is secured by spreading flanges⁷⁷. The large portal of entry for Seidelin's nail damages the cartilage of the humeral head at its lateral margin, and proximal nail migration with impingement syndrome is common⁷⁸. To overcome the problems of these fixation devices, new nail designs have been developed^{79, 3}. The Russell-Taylor nail was designed for antegrade nailing, although retrograde insertion has been done successfully⁵⁸. These interlocking nails have increased the indications for closed nailing of humeral shaft fractures¹³. Non union rates are less than 10%⁷.

The modified Grosse-Kempf nail, which was initially used in this study, designed by Ingman and Waters⁷⁹ requires reaming. Reaming is known to interfere with cortical blood supply and can damage the rotator cuff during surgery, leading to poor shoulder function postoperatively¹⁵. Later in the study the use of unreamed nails avoided injury to the cortical circulation and rotator cuff and they can be inserted either antegrade or retrograde.

Postoperative early mobilisation of the shoulder and elbow was very critical in attaining full range of movements. It was observed that the movements and the functional ability of the shoulder depended upon the patients adherence to rehabilitation programme and early

intensive physical therapy hastened the recovery of shoulder function. Most of our findings, including period of fracture consolidation, union rates, complications and functional results are comparable with the studies where intramedullary nailing was used to treated humeral shaft fractures.

But as the study sample was very small, for better conclusion it has to be repeated in a larger group of patients with longer follow up periods.

In view of our satisfaction with the results of closed intramedullary nailing, we report the results of our 30 cases from September 2011 to September 2013.

Age and Sex:

Most patients in our series belong to age group between 21-75 with an average of 42.8 years.

Comparison of age with Age range
various standard series:

Standard Series

J.O.Ikpeme (1994)	17-91
H.Seidel (1989)	24-80
C.M.Robinson (1992)	20-84
Present series	20-75

Our average age of patient is 42.8 years with majority of our patients in 21-30 and 31-40 age group compared to 53 years in Seidel and 59 years in Robinson series.

Comparison of sex Sex
with standard series: Sex ratio

Standard Series

J.O.Ikpeme (1994)	30 females 9 males	3.33: 1
-------------------	--------------------	---------

Hartmut Seidel (1989)	11 females 9 males	1.22: 1
C.M.Robinson (1992)	21 females 9 males	2.33: 1
Present series	6 females 24 males	0.25: 1

Marked variation in age: sex ratio reflects consideration of Indian society in which females are mostly household dwellers and the males the wage earners concerned with outdoor activity.

Level of fracture:

C.M.Robinsen et al (1992) reported in their series of 30, only one patient had fracture in lower third (3.33%) and majority of fractures in middle third i.e. 19 patients (63 %) and upper third involved in 7 patients (23.33%) remaining 3 had segmental fractures in proximal and middle third .

Hartmut Seidel (1989) reported in their series of 20 patients 13 patients (65%) had fracture in proximal third, 4 cases (20%) in middle third 3 cases (15%) in distal third.

In present series we have majority of fractures in middle third 21 patients (70%) next to it is lower third 5 cases (16.7 %) followed by 4 in proximal third (13.3%).

Type of fractures:

Hartmut Seidel (1989) reported 5 transverse fractures (25%). 6 short oblique (30%) and 5 long oblique (25%) and 4 comminuted fractures (20%) total percentage of oblique fractures in this series was 45 %.

C.Garnovs and P.G.Lunn reported 3 transverse fractures (25%), 4 spiral fractures (33.33%) and 4 comminuted and 1 compound grade-II fractures out of their 12 patients.

In our series there were 13 transverse fractures (43.3%), 8 oblique fractures (26.7%) and 9 comminuted fractures (30%).

Mechanism of injury:

P.M. Rommens reported in their series reported road traffic accident as a major mechanism of injury in 21 cases (56.75%)

C.Garnovs reported 5 patients (41.66%) with road traffic accident, 5 sustained fracture after fall (41.66%)

In our series we report 18 cases with road traffic accident accounting for 60 % of cases, next to it is fall 9 cases (30%), 2 assault cases and least is industrial accidents.

Duration between injury and operation:

C.M.Robinsen et al reported waiting period of 1 week in 23 patients and 7 were treated conservatively and nailed within 6 weeks of fracture since previously undisplaced fractures became displaced.

C,Garnovs & PG.Lunn reported interval between injury and operation in their series of 12 patients as 1-12 days.

In present series majority of fractures were fixed within 7 days i.e. 20 patients (66.7 %) with an average of 3 days after injury.

Diameter and length of nail used:

In our series the most commonly used nail is 7 mm used in 13 (43.33%) of patients. We used nail of 8 mm in 8 patients (26.67 %). 22 cm length nail was used in 20% patients and 26 cm in 11% patients.

Average Indian bones are thin and small as compared to Western standard.

Mean time of union:

Comparison of mean time Union Time
of union in different series

Series

C.M.Robinsen (1992)	18 weeks
H.Habernek (1991)	8weeks
C.H.Jensen(1992)	6 weeks
Jinn Linn et al	8.2weeks
Present series	14 weeks

In our series the mean time of union is 14 weeks which is nearly comparable to standard series.

Post-operative Radial nerve palsy:

Series	Percentage of Radial Nerve Palsy
C.M.Robinsen et al	3.33%
PM.Rommens et al	2.56%
I.A.lngmann et al	2.43%
Present series	0%

C.M. Robinson reported 1 patient of radial nerve palsy in their series of 30 patients (3.33%) P.M.Rommens reported radial nerve palsy in 1 patient of the total 39 patients (2.56%) I.A.lngmann reported 1 patient of radial nerve palsy of the total 41 patients (2.43%). In our series we had no case of radial nerve injury were encountered.

Impingement:

Series	Percentage of impingement
Hartmut Seidel	10%
C.H.Jensen	25%
C.M.Robinsen	40%
Present series	6.67%

Harmut Seidel reported impingement in 2 cases of their total 20 (10%). C.H.Jensen reported impingement in 4 patients of their total 16 patients (25%). C.M.Robinsen reported impingement in 12 patients of their total 30 patients (40%). In our series impingement occurred in 2 patients of our total 30 patients (6.67%).

As compared to above standard series percentage of impingement is less in our series. This might be due to the reason that proximal tips of the nails were counter-sunked into the head of humerus. In our series, impingement occurred because of lack of experience with this type of nailing in initial phase and this complication was minimized later on.

Complications:

In the present study we encountered following complications:

Intra-operative complications:

We had two cases where distal locking could not be done. We were unable to countersink the tip of nail into the head of humerus because of lack of experience initially which had caused impingement in 2 patients.

We had no cases of intra-operative radial nerve palsy.

We also had difficulty in doing distal locking for two cases due to initial lack of experience which later united in 13-16 weeks time as was seen with other cases where both proximal and distal locking were done.

Postoperative complications:

The most common amongst this is shoulder pain. We noticed mild shoulder pain in eight patients and moderate in four patients. Restriction of shoulder movements especially abduction occurred in three patients; major cause of this restriction was impingement which we reported as having unsatisfactory results.

Infection occurred in none of the patients. We experienced two cases of non-union for which LCP plating with bone grafting was done.

CONCLUSIONS

Humeral shaft fractures are common in the age group of 20 to 35 years and more common in males. Commonest mode of injury for humeral shaft fractures is road traffic accidents and which occurs more on right side. Middle third of the bone is the most vulnerable part for fractures, where transverse or short oblique fractures will occur. Commonest indication for surgical stabilization of humeral shaft fractures is failure to obtain reduction and multiple injuries. Good anatomical reduction, prevention of rotation and rigid fixation with early functional recovery is possible with interlocked intramedullary nailing. Bone healing occurs without much problem, as soft tissue and periosteal dissection is minimal with nailing. Functional outcome is excellent or satisfactory in nearly 83.3% of patients. Intramedullary locked nailing has its learning curve. Once the technique is mastered better results are found.

BIBLIOGRAPHY

1. Balfour.G.W. Mooney V and Ashby M.E. Diaphyseal fractures of the humerus treated with a readymade fracture brace, JBJS, Vol-64-A,No.1, Jan 1982, P:11-13.
2. Bray T.J. Techniques in fractures fixation chapter-8, New York, Gover Medical publishing,1993.
3. Crenshaw A.H (Ed), Campbell's operative orthopaedics, 8th ed, Vol-2 Missouri, Mosby year book Inc., 1992,P:784 and 1002-1016.
4. Sarmiento A et al, Functional bracing of fractures of the shaft of the hunerus. JBJS, Vol-59-A, July 1977, O:596-601.
5. Zatti G et al, Treatment of closed humeral shaft fractures with intramedullary elastic nail, Journal of Trauma, Injury, Infection and critical care, Vol-45 No.6, Dec 1998,P:1050.
6. Lin J et al, Treatment of humeral shaft fractures by retrograde locked nailing. CORR, No.342, Sept 1997. P:147-155.
7. Rommens P.M, Verbruggen J and Bross PL, Retrograde locked nailing of humeral shaft fractures – a review of 39 patients, JBJS, Vol-77-BNo.1,Jan 1995, P:84-89.
8. Zuckerman J D and Koval K J, Fractures of the shaft of the humerus in Rockwood CS Jr et al (Eds), Fractures in adults, 4th ed, Philidelphia, Lippincot-Raven1996.P:1025-1054.
9. Brumbak R.J. et al, Intramedullary stabilization of humeral shaft fractures in patients with multiple trauma, JBJS, Vol-68-A, No.7.Sept 1986, P: 960-970.
10. Haberneke H and Orthner E, Alocking nail for fracture of the humerus, JBJS, Vol- 73-B, No.4,July 1991,P:651-653.
11. Danis. R, The classic – The aims of internal fixation, CORR, No.138, Jan-1979, P:23-25.
12. Ward E F, Savoic F H III and Hughes J L., Fractures of Diaphyseal humerus in Browner B D et al (eds), Skeletal trauma, Fractures, dislocations and ligamentous injuries, 2nd ed, Philadelphia, WB Saunders Company,P:1523-1547.
13. Crenshaw A.H (Ed), Campbell's operative orthopaedics, 8th ed, Vol-2 Missouri, Mosby year book Inc., 1992,P:784 and 1002-1016.

14. Lin J et al, Biomechanical comparison of antegrade and retrograde nailing of humeral shaft fractures, CORR, No.351, June 1998, P:203-213.
15. Bassi J.S. et al, Unreamed humeral nail in fracture shaft of humerus with a new dist targeting devise, India Journal of Orthopaedics.Vol-33 No.1.Jan 1999, P:54-57.
16. Calton C. "History of Osteosynthesis" chapter-2 AO Instruments and Implants. 2nd Ed., Texhammar R.J. and Colton C L, New York Springer-Verlag.1999, 3pp.
17. Chandler R,N, "Principles of internal Fixation" Chapter-3 in Fractures in Adults. Vol1, 4"1 Ed., Rockwood C.A. Jr et al, Philadelphia. Lippincott-Raven, 1996, 159pp A.
18. Zuckerman J.D. and Koval KJ "Fractures of the shaft of the Humerus", Chapter 15 in Rockwood and Greens Fractures in Adults Vol, 1, 41" Ed. Rockwood C.A. Jr, New York: Lippincott-Raven Publishers, 1996, 1025pp.
18. Thakur A.J, "Bone Plates" Chapter 4 in "The Elements of Fracture Fixation." New York: Churchill Living stone ,1999, 57pp 5.
19. Holstein A. and Lewis L B. "Fractures of the humerus with radial nerve paralysis", JBJS,. 1963; 45A (7): 1382-88
20. Perren S.M, et al "The Concept of Biological Plating using the Limited Contact Dynamic Compression Plate (LC-DCP)" Injury. 1991; 22(1) 1-41.
21. Klenerman L "Fractures of the shaft of the humerus" JBJS. 1966;48B(1):105-111.
22. Perren S.M. et al, "Basic aspects of Internal Fixation", Chapter 1 in Manual of Internal Fixation. 3"1 Ed, Allgower M , Berlin: Springer- Verlag, 1991,1 pp.
23. Brain J. Redmond et al. " Intramedullary interlocking nailing of Pathological fractures of the shaft of the humerus" JBJS, 1996; 78-A(6) 891-896.

24. Russell TA, Lavelle DG, Nichols RL, Simard J, Taylor JC, Walker BJ. Interlocking intramedullary nailing of humeral fractures. Presented before the annual meeting of the American Academy of Orthopaedic Surgeons. Washington DC. Feb. 1992.
25. Rodriguez-Merchan E C 'Compression plating versus locked nailing in closed humeral shaft fractures failing nonoperative reduction' J-Orthop-Trauma, 1995; 9(3) 194-7.
26. Jinn Linn. 'Comparative study for the treatment of humeral shaft fracture with humeral locked nailing and plate fixation' J Orthop Trauma. 1998; 44 (5) 859-864.
27. McCormack R G. et al "Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail" JBJS, 2000 62(3): 336-339.
28. Chapman JR, Henley MB, Agel J, Benca PJ Randomized prospective study of humeral shaft fracture fixation: intramedullary nails versus plates J Orthop Trauma, 2000;(14):162-6
29. Mauch J, Renner N, Rikli D Intramedullary nailing of humeral shaft fractures--initial experiences with an unreamed humerus nail Swiss Surg, 2000;(6):299-303
30. Koch P.P., Gross D.F and Gerber C The results of functional (sarmiento) bracing of humeral shaft fractures". J shoulder Elbow Surg..2002. 11(2):143-7. 14.
31. Martinez AA, Cuenca J, Peguero A, Herrera A, Panisello JJ Marchetti-Vicenzi nailing of humeral shaft fractures Chir Organi Mov, 2002;(87):49-54.
32. Sanzana ES, Dummer RE, Castro JP, Diaz EA Intramedullary nailing of humeral shaft fractures Int Orthop, 2002;(26):211-3
33. Arpacioğlu MO, Pehlivan O, Akmaz I, Kiral A, Oguz Y Interlocking intramedullary nailing of humeral shaft fractures in adults Acta Orthop Traumatol Turc, 2003;(37):19-25
34. Hossain S, Roy N, Ayeko C, Elsworth CF, Jacobs LG Shoulder and elbow function following Marchetti-Vicenzi humeral nail fixation Acta Orthop Belg, 2003;(69):137-41

35. Kesemenli CC. et al Comparison between the results of intramedullary nailing and compression plate fixation in the treatment of humerus fractures. *Acta Orthop Traumatol Turc* 2003;37(2):120-125
36. Karatagltis D et al "Antegrade interlocking nailing of humeral shaft fractures". *injury* 2004, 9: 247-52.
37. Flinkkila T, Hyvonen P, Siira P, Hamalainen
38. Chao T. C., Chou W. Y., Chung J. C., Hsu C. J. Humeral shaft fractures treated by dynamic compression plates, Ender nails and interlocking nails *Int Orthop*, 2005;(29):88-91
39. Bhandari M, Devereaux PJ, McKnee MD, Schemitsch EH Compression plating versus intramedullary nailing of humeral shaft fractures--a meta-analysis. *Acta Orthop*. 2006 Apr;77(2):279-84
40. Huerta Lazcarro J, Luna Pizarro D A comparison of the prevalence of radial nerve lesion after fixation of humeral shaft fractures with dynamic compression plate versus intramedullary nailing. *Acta Ortop Mex*. 2008 Sep-Oct;22(5):287-91.
41. Cheng H. R., Lin J Prospective randomized comparative study of antegrade and retrograde locked nailing for middle humeral shaft fracture *J Trauma*, 2008;(65):94-102
42. O'Donnell T. M., McKenna J. V., Kenny P., Keogh P., O'Flanagan S. J Concomitant injuries to the ipsilateral shoulder in patients with a fracture of the diaphysis of the humerus *J Bone Joint Surg Br*, 2008;(90):61-5
43. Li W. Y., Zhang B. S., Zhang L., Zheng S. H., Wang S. Comparative study of antegrade and retrograde intramedullary nailing for the treatment of humeral shaft fractures *Zhongguo Gu Shang*, 2009;(22):199-201
44. Zang W., Liu Y. F., Wu Q. M. Treatment of mid-distal humeral shaft fractures associated with radial nerve palsy by minimally invasive screwed nails osteosynthesis technique *Zhongguo Gu Shang*, 2009;(22):515-7

45. Heineman DJ, Poolman RW, Nork Sean SE, Bhandari M Plate fixation or intramedullary fixation of humeral shaft fractures: an updated meta-analysis. *Acta Orthopaedica* 2010; 81(2): 218-225.
46. Ristic V., Maljanovic M., Arsic M., Matijevic R., Milankov M. Comparison of the results of treatment of humeral shaft fractures by different methods *Med Pregl*, 2011;(64):490-6
52. McCormack R G. et al "Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail" *JBJS*, 2000 82-B: 336-339.
53. Tinqstad E M. et al. "Effect of immediate weight bearing on plated fractures of the humeral shaft". *J trauma*. 2001, 49(2) 278-80.
54. Bell M.J et al. "The result of plating humeral shaft fractures in patients with multiple injuries". *JBJS*. 1965, 67(2): 293-6.
55. Griend R.VL, Tomasin J and Ward EF "Open reduction and internal fixation of humeral shaft fractures", *JBJS*. 1966; 68A: 430-33.
56. Strong G.T, Walls N. and McQueen M.M. "The epidemiology of humeral shaft fractures". *JBJS*, 1986; 80-B (2) 249-53.
57. Klenerman L, Fractures of the shaft of the humerus, *JBJS*, Vol-48-B, No.1, Feb 1966, P:105-11.
58. Rommens P.M, Blum J and Runkel M, Retrograde nailing of humeral shaft fractures, *CORR*, No.350, May 1998, P: 26-39.
59. Muller M E, Algower M, Schneide R and WilLinegger H, Manual of internal fixation techniques recommended by AO-ASIF group, Ed-3, Berlin, Springer-Verlag, 1991, P:126-127.
61. Hunter S.G. The closed treatment of fractures of the humeral shaft, *CORR*, No:164, April 1982, P:192-198.
62. Mc Pherson et al, Prospective trial comparing intramedullary nail fixation and open reduction internal in the treatment of humeral shaft fractures with surgical indications, *JBJS*, Vol-81-B, Supp-1, 1999, P:103

63. Ring D et al. The functional outcome of operative treatment of ununited fractures of the humeral diaphysis in older patients, JBJS, Vol-81-A, No-2, Feb 1999, P:177-188.
64. Vander Griend R. Tomasin J and Ward E F, Open reduction and interna fixation of humeral shaft fractures; Results using AO plating techniques, JBJS, Vol-68-A, No.3, March 1986, P:430-433.
65. Wright T W, Treatment of humeral diaphyseal nonunions in patients with severely compromised bone, Journal of the Southern Orthopaedic Association, Vol-6,No.1, Spring 1997, P:1-7.
66. Durbin R A. Gottesman M J and Saunders K C, Hackethal stacked nailing of humeral shaft fractures – experience with 30 patients, CORR, Vol-179,Oct-1983,P:168-174.
67. Hall R F Jr and Pankovich AM, Ender nailing of acute fractures of the humerus, JBJS, Vol-69-A,No.4,April 87, P:558-567.
68. Rush L V and Rush H L, Evolution of medullary fixation of fractures by the longitudinal pin, CORR, No. 212, Nov 1986,P:4-9.
69. Srinivasan K & Devaraj G P: Osteosynthesis of comminuted fracture of lower third humerus with retrograde Rush pins and cercalage wire. The journal of Karnataka Orthopaedic Association, Feb 1998, P:83.
70. Chandler RN. Principles of internal fixation. Chap-3 in Rockwood CA Jr.(edt.).Rockwood and Green's Fractures in Adults. Vol-1 4th ed.. philadelphia. Lippin Cott-Raven; 1996 : p.159.
71. Thakur AJ. The elements of fracture fixation. Churchill Livingstone 1997; 1 : 81-104.
72. Pohler, Strumanna F. Characterstics of stainless steel. Manual of internal fixation AO/ASIF 1991.
73. . Crates John and Whittle A.P. Antegrade interlocking nailing of acute humeral shaft fractures, CORR, No.350, May 1998, P:40-50.

74. . kulkarni G S (Ed), Text book of Orthopaties and Trauma, 1st ed. New Delhi, Jaypee Brothers, 1999, P:1897 – 1903.
75. Dhar D, Gupta M N and Pachnanda V K, Kuntscher nailing in fracture shaft of humerus, IJo, Vol-28,No.3, Sept 1994, P:48-50.
76. Brumback R.J. Rationale of interlocking nailing of the femur, tibia and humerus and overview, CORR, No.324,1996, P:292-320.
77. Lin J et al, Treatment of humeral shaft fractures by retrograde locked nailing. CORR, No.342, Sept 1997. P:147-155.
78. Robinson C M et al. Locked nailing of humeral shaft fractures-experience in Edinburgh over a two year period, JBJS, Vol-74-B,No,4,July 1992, P:558-562.
79. Ingman A M and Waters D.A. Locked intramedullary nailing of humeral shaft fractures-implant design, surgical techniques and clinical results, JBJS,Vol-76-B No:1,Jan 1994,P:23-29.
80. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. Clin Orthop Relat Res. 1981 Mar-Apr;(155):7-20.
81. Nutton RW , McBirnie JM , Phillips C. Treatment of chronic rotator-cuff impingement by arthroscopic subacromial decompression. JBJS Br. 1997 Jan;79(1):73-6.

ANNEXURE

Name	Age	Sex	Hospital number	Side	Type	level	MOI	Time from injury to surgery	Associated injuries	Nail size	Complications	Union	Results
Narayanappa	60	M	610053	Rt	Comm	P3	RTA	5Days	---	8*240	---	13-16wks	Ex
Srinath	40	M	746872	Rt	Comm	M3	RTA	12Days	Polytrauma+ Wrist drop	7*260	---	10-12wks	Ex
Anand	30	M	749515	Rt	Transverse	M3	RTA	4Days	---	7*260	Distal locking not done	13-16wks	Ex
Mahesh Babu	20	M	776963	Rt	Transverse	P3	RTA	14Days	B/L Proximal Tibia #	7*270	---	>16wks	Ex
Vallreddy	36	M	780196	Rt	Oblique	M3	Fall	1Day	---	8*260	---	13-16wks	Ex
Ravanamma	30	F	780819	Lt	Oblique	M3	Assault	13Days	---	7*220	Distal locking not done	13-16wks	Ex
Babu	22	M	782038	Lt	Oblique	M3	RTA	12Days	#Radius #Mandible Wrist drop	7*260	---	13-16wks	Ex
Thirumalappa	23	M	783783	Lt	Transverse	M3	RTA	4Days	---	7*220	---	13-16wks	Ex
Venugopal	26	M	790522	Rt	Comm	D3	Fall	1Day	---	8*250	---	10-12wks	Ex
Ramaswamy	65	M	799161	Rt	Oblique	D3	Hit	10Days	---	7*270	---	10-12wks	Ex
Jagadesh	28	M	799915	Lt	Transverse	M3	RTA	7Days	Wrist drop	6*250	---	13-16wks	Ex
Prasad	22	M	799916	Lt	Comm	M3	RTA	9Days	Wrist drop	6*260	---	10-12wks	Ex
Venkatalakshmi	75	F	812607	Lt	Oblique	P3	Fall	4Days	---	8*250	Shoulder impingment	13-16wks	Poor
Gopalappa	58	M	812607	Lt	Comm	D3	RTA	5Days	---	8*280	---	13-16wks	Ex
Amaramma	40	F	820623	Rt	Comm	M3	Work	16Days	---	7*220	---	10-12wks	Ex
Gopal	42	M	828067	Rt	Oblique	M3	RTA	3Days	---	6*260	---	10-16wks	Ex
Redappa	55	M	854444	Rt	Oblique	D3	RTA	1.5M	---	8*280	Shoulder stiffness	Non union	Poor
Veerabhadra	22	M	870309	Rt	Transverse	M3	RTA	4Days	Polytrauma	7*240	---	13-16wks	Ex

Shanthamma	46	F	877172	Lt	Transverse	M3	Fall	3Days	---	7*260	Non union	Non union	Ex
Ahmed Hussain	37	M	88022	Rt	Comm	M3	RTA	3Days	---	8*220	---	10-16wks	Ex
Chikkanarashimappa	45	M	910260	Lt	Oblique	P3	Fall	1Day	---	7*270	Shoulder impingment	13-16wks	Poor
Varadappa	40	M	918302	Lt	Comm	D3	RTA	2Days	Polytrauma	6.5*280	---	10-12wks	Ex
Najappa	65	M	926507	Rt	Transverse	M3	RTA	4Days	---	6.5*220	---	13-16wks	Ex
Chalapathi	40	M	926885	Lt	Transverse	M3	Fall	1Day	---	6.5*250	---	13-16wks	Ex
Subramani	36	M	934086	Lt	Transverse	M3	Fall	5Days	---	7*260	---	13-16wks	Ex
Kadiramma	56	F	943657	Rt	Transverse	M3	Fall	2Days	---	7.5*270	---	13-16wks	
Nanjundarama Guptha	69	M		Rt	Transverse	M3	RTA	1Day	---	7*260	---	13-16wks	Ex
Sridhar	38	M	953885	Rt	Transverse	M3	RTA	5Days	Brachial plexus injury	6.5*220	---	13-16wks	Poor
Munivenkatappa	48	M	958383	Lt	Comm	M3	RTA	4Days	---	7.5*220	Shoulder stiffness	13-16wks	Poor
Raniamma	70	F	1348/SNR	Rt	Transverse	M3	Fall	3Days	---	8*260	---	>16wks	Ex

PROFORMA OF THE CASE SHEET

NAME:

AGE:

SEX:

ADDRESS:

I.P. NO.:

DATE OF ADMISSION:

DATE OF SURGERY:

DATE OF DISCHARGE:

I) PRESENTING COMPLAINTS:

II) H/O OF PRESENTING ILLNESS

1. MODE OF INJURY

- MOTOR VEHICLE ACCIDENT
- MOTOR CYCLE ACCIDENT
- FALL FROM HEIGHT
- ASSAULT
- OTHERS

2. MECHANISM OF INJURY

- i) DIRECT ii) INDIRECT

3. ASSOCIATED INJURIES

III) TREATMENT HISTORY:- YES OR NO

IF YES

-OSTEOPATH

-GENERAL PRACTITIONER

-ORTHOPAEDICIAN

IV) PAST H/O INJURY / INJURIES

V) LOCAL EXAMINATION

A) INSPECTION

- 1) SIDE INVOLVED- RT/LT
- 2) OVERLYING SKIN
- 3) ATTITUDE OF LIMB
- 4) DEFORMITY
- 5) SWELLING
- 6) SHORTENING

B) PALPATION

- 1) TEMPERATURE
- 2) TENDERNESS
- 3) ABNORMAL MOBILITY
- 4) CREPITUS
- 5) BONY IRREGULARITY
- 6) TRANSMITTED MOVEMENTS
- 7) WOUND EXAMINATION
 - a) PRESENCE OF FOREIGN BODY
 - b) COLOUR OF MUSCLES

8) DISTAL NVD

C) MEASUREMENTS

LONGITUDINAL	RT	LT
--------------	----	----

IX) ASSOCIATED INJURIES

- SHOULDER
- ELBOW
- RADIUS
- ULNA
- OTHERS

**X) INVESTIGATION (PRE-OP ASSESSMENT)
RADIOGRAPHY:**

CLINICAL DIAGNOSIS

XI) MANAGEMENT

1) IMMEDIATE

- a) I.V. FLUIDS
- b) PARENTERAL ANTIBIOTICS & ANALGESICS
- c) BLOOD TRANSFUSION
- d) SPLINTING
U-slab

2) SURGICAL TREATMENT

- DOS:

- TYPE OF ANAESTHESIA:

- POSITION OF PT.

- APPROACH:

- METHOD a) ANTEGRADE b) RETROGRADE

- NAIL LENGTH: DIAMETER:

INTERLOCKING SCREWS- LENGTH:

- IMMOBILIZATION AFTER SURGERY

XI) POST OP PERIOD & FOLLOW UP

1. 1ST TO 10TH POST OP DAY

-ANTIBIOTICS & ANALGESICS

-RANGE OF MOTION

-CHECK X-RAY

2. 10TH -14TH POST OP DAY

-SUTURE REMOVAL

-RANGE OF MOTION

3. 4TH – 6TH WKS

-CHECK X-RAY

-ASSESSMENT OF RANGE OF MOTION

4. 12TH - 16TH WEEKS

-CHECK X- RAY

-CLNICAL ASSESSMENT OF FRACTURE HEALING

5. 24 WKS

- CHECK X-RAY
- FULL WT. BEARING