"TO EVALUATE SUPRACONDYLAR INTRAMEDULLARY NAILING IN SUPRACONDYLAR AND INTERCONDYLAR FRACTURE OF FEMUR IN ADULTS - A HOSPITAL BASED PROSPECTIVE STUDY"

By

Dr. ABHINAV THAKUR

Dissertation submitted to the
KLE University, Belgaum, Karnataka

In Partial Fulfillment
of the requirements for the degree of

MASTER OF SURGERY

in

ORTHOPAEDICS

Under the Guidance of
Dr. SHAILESH V. UDAPUDI M.S ,D(Ortho)
Professor

DEPARTMENT OF ORTHOPAEDICS,
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELGAUM – 590 010,
KARNATAKA

MAY - 2010

KLE UNIVERSITY, BELGAUM, KARNATAKA

DECLARATION

I hereby declare that this dissertation entitled **"TO EVALUATE SUPRACONDYLAR INTRAMEDULLARY NAILING IN SUPRACONDYLAR AND INTER-CONDYLAR FRACTURE OF FEMUR IN ADULTS - A HOSPITAL BASED PROSPECTIVE STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. SHAILESH V. UDAPUDI M.S, D(Ortho),** Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, Nehru Nagar, Belgaum-590010.

Date:

Place: Belgaum (Dr. ABHINAV THAKUR)

KLE UNIVERSITY, BELGAUM, KARNATAKA

CERTIFICATE

This is to certify that the dissertation entitled "**TO EVALUATE SUPRACONDYLAR INTRAMEDULLARY NAILING IN SUPRACONDYLAR AND INTER-CONDYLAR FRACTURE OF FEMUR IN ADULTS - A HOSPITAL BASED PROSPECTIVE STUDY"** is a bonafide research work done by **Dr. ABHINAV THAKUR** in partial fulfillment of the requirement for the degree of **M.S. (Orthopaedics).**

Date:
Place: Belgaum

Dr. SHAILESH V. UDAPUDI M.S, D(Ortho)
Professor,
Department of Orthopaedics,
J. N. Medical College,
Nehru Nagar, Belgaum – 10

KLE UNIVERSITY, BELGAUM, KARNATAKA

ENDORSEMENT

This is to certify that the dissertation entitled "**TO EVALUATE SUPRACONDYLAR INTRAMEDULLARY NAILING IN SUPRACONDYLAR AND INTER-CONDYLAR FRACTURE OF FEMUR IN ADULTS - A HOSPITAL BASED PROSPECTIVE STUDY"** is a bonafide research work done by **Dr. ABHINAV THAKUR** under the guidance of **Dr. SHAILESH V. UDAPUDI** **M.S, D. Ortho** Professor, Department of Orthopaedics, J. N. Medical College, Nehru Nagar, Belgaum-590010.

Dr. V. G. Murakibhavi **M.S ,D (Ortho) AO fellow**
Professor and Head,
Department of Orthopaedics,
J. N. Medical College,
Nehru Nagar, Belgaum – 10

Date:
Place: Belgaum

Dr. V. D. Patil **MD, DCH**
Principal,
J. N. Medical College,
Nehru Nagar,
Belgaum – 10

Date:
Place: Belgaum

KLE UNIVERSITY, BELGAUM,

KARNATAKA

COPYRIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the KLE University, Belgaum, Karnataka shall have the rights to preserve, use and disseminate this dissertation in print or electronic format for academic / research purpose.

Date :

Place : Belgaum

(Dr. ABHINAV THAKUR)

© KLE University, Belgaum, Karnataka

ACKNOWLEDGEMENT

First and foremost I would like to express my sincere gratitude and appreciation for my guide, **Dr. Shailesh V. Udapudi** **M.S, D(Ortho),** Professor, Department of Orthopaedics, for his constant guidance, valuable suggestions, unparalleled encouragement and co-operation provided to me throughout the course of study. It has been a great pleasure and privilege to work under him. Without his immense professional insight and guidance I could have not completed this study.

I would like to thank **Dr. V. G. Murakibhavi** **M.S, D(Ortho), AO fellow,** Professor and Head, Department of Orthopaedics, for his keen interest, unparalleled encouragement and co-operation during this study.

I express my sincere gratitude to **Dr. V. D. Patil** **MD, DCH** Principal J. N. Medical College, Belgaum, **Dr. M. V. Jali** **MD**, Director and Chief Executive, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum for allowing me to utilize the facilities in above institution for the dissertation.

I take this opportunity to thank **Dr. S. M. Antin** **M.S, D(Ortho), Dr. B. B. Putti** **M.S Ortho, AO Fellow** for their kind support and constant encouragement.

I sincerely thank **Dr. R. B. Uppin, Dr. Kiran Patil, Dr. S. H. Motimath, Dr. Somnath Sanikop, Dr. Ravi Jatti, Dr. A. B. Patil, Dr. Mahantesh Patil, Dr. Sanjeev Patil, Dr. Ravinder Gurav, Dr. Santosh** and all other Teachers of Jawaharlal Nehru Medical College, Belgaum for their kind support and timely help during the study.

I sincerely thank all my post graduate colleagues for their help in the study. I am also thankful to my seniors **Dr. Vikrant, Dr. Abhishek, Dr. Chethan, Dr. Rajesh, Dr. Chetan, Dr. Amit and my colleagues**

Dr. Dinesh, Dr. Veman, Dr. Vishal, Dr. Adarsh, Dr. Sunil, Dr. Navjot, Dr. Sai , Dr. Vinay, Dr. Pankaj for their kind help rendered throughout the course of my study.

I also thank all the ancillary staff at our institute for their timely help.

This would have not been possible without the co-operation and understanding of my patients involved in the study. I also thank the authors of numerous publications whose knowledge have been freely utilized in the preparation.

With deep sense of gratitude and affection, I am very thankful to my grandparents **Prof. A. S. Thakur** and **Mrs. Karmi Devi Thakur,** and my parents **Dr. Prem Thakur** **M.S (General surgery)** and **Dr. Shobha Thakur** **D.G.O** who always have been a pillar of strength for me.

I thank my sister **Dr. Abhilasha Thakur Malhotra** **M.S. (E.N.T)** and brother in law **Dr. Divye Malhotra** **(Oral maxillo facial surgeon)** for the continuous support they have rendered, not only during course of this study, but in my life as well.

Finally, I thank **Almighty** for all the blessings.

Date:

Place: Belgaum

Dr. ABHINAV THAKUR

LIST OF ABBREVIATIONS USED

ABG	-	Arterial blood gas
AO	-	Arbeitsgemeinschaft fur osteosynthesefragen
AP	-	Antero-posterior
Cm	-	Centimeter
CNS	-	Central nervous system
CPM	-	Continuous passive monitoring
CT	-	Computed tomography
CVS	-	Cardiovascular system
DCS	-	Dynamic condylar screw
DLC	-	Differential leucocyte count
ECG	-	Electrocardiogram
ESR	-	Erythrocyte sedimentation rate
GSH	-	Green D, Seligson D, Henry SL
Hb	-	Haemoglobin
HBsAg	-	Hepatitis B surface antigen
HIV	-	Human immunodeficiency virus
IM	-	Intramedullary
IMSC	-	Intramedullary supracondylar nail
IV	-	Intravenous
LAT	-	Lateral
LISS	-	Less invasive stabilization system
mm	-	Millimeter
OTA	-	Orthopaedic Trauma Association
PA	-	Per abdomen

POP	-	Plaster of Paris
Pts	-	Points
RIMSN	-	Retrograde intramedullary supracondylar nailing
ROM	-	Range of movement
RS	-	Respiratory system
RTA	-	Road traffic accidents
SAH	-	Subarachnoid haemorrhage
SPO_2	-	Oxygen saturation
TLC	-	Total leucocyte count

ABSTRACT

Background and Objectives

Supracondylar and intercondylar femur fractures are fractures that involve the distal 15 cm of the femur including the distal femoral metaphysis (supracondylar) and articular surface of the distal femur (intercondylar). The present study is undertaken to evaluate and explore supracondylar nailing in supracondylar and intercondylar fractures of femur with emphasis on a stable fixation with minimum exposure, early mobilization, less complications and a better quality of life.

Methods

The present One year prospective study was conducted in the Department of Orthopaedics, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during the period of December 2008 to November 2008 on 15 patients with supracondylar and intercondylar fractures of the femur. Outcome was assessed using Sanders 40 point Functional evaluation scale and radiological union. Patients were followed up at an interval of fourth week, third month and sixth month.

Results

Majority of the patients were in the age group of 31 to 60 years. Males were most commonly affected. Predominantly right side was involved and road traffic accident was the common mode of injury. The average duration of surgery was 100 minutes. The fractures united at an average of 14 weeks. There were two cases of delayed union. No cases of nonunion or malunion were noted. There was

a functional outcome of 86% good to excellent results using Sanders 40 point Functional Evaluation Scale. There were all excellent (100%) functional results in type A (extra-articular) fractures and 71.43% good with 28.57% fair results in type B, C1 and C2 (intra-articular) fractures in this study.

Conclusion and interpretation

Supracondylar intramedullary nailing in supracondylar and intercondylar femoral fractures makes “biological osteosynthesis” possible in these difficult and complex fractures with less operative time, minimal soft tissue stripping, minimal blood loss, decreased need for bone grafting and reasonably rigid fixation in osteoporotic bones.

Keywords

Intercondylar femur fractures; Sanders 40 point functional evaluation scale; Supracondylar femur fractures; Supracondylar intramedullary nailing;

CONTENTS

SL. NO.	TOPIC	PAGE NO.
1.	INTRODUCTION	1
2.	OBJECTIVES	5
3.	REVIEW OF LITERATURE	6
4	METHODOLOGY	36
5.	RESULTS	55
6.	DISCUSSION	67
7.	CONCLUSION	79
8.	SUMMARY	80
9.	BIBLIOGRAPHY	82
10.	ANNEXURE I – CONSENT FORM	92
11.	ANNEXURE II – PROFORMA	96
12.	ANNEXURE III – PHOTOGRAPHS	102
13	ANNEXURE IV – MASTER CHART	108

LIST OF TABLES

TABLE. NO.	DESCRIPTION	PAGE NO.
1	Gender distribution	55
2	Age distribution	56
3	Side of injury	57
4	Nature of trauma	58
5	a. Type of fracture	59
	b. Closed or Compound fractures	60
6	Duration of surgery	61
7	Blood loss during the surgery	62
8	Time to radiological union	63
9	Complications	64
10	Outcome: Sanders 40 point functional evaluation scale	65
11	Assessment of outcome according to AO type of fractures	66
12	Comparison of demographic profile with other studies	68
13	Comparison of mechanism of injury and fracture characteristics	68
14	Comparison of AO classification	69
15	Comparison of blood loss, operative time and union rate between different studies	73
16	Comparison of functional outcomes with different rating scales	74

LIST OF GRAPHS

GRAPH NO.	DESCRIPTION	PAGE NO.
1	Gender distribution	55
2	Age distribution	56
3	Nature of trauma	58
4	AO type of fracture	59
5	Duration of surgery	61
6	Blood loss during the surgery	62
7	Complications	64
8	Outcome: Sanders 40 point functional evaluation scale	65
9	Assessment of outcome according to AO type of fractures	66

LIST OF FIGURES

FIGURE NO.	FIGURES	PAGE NO.
1	Schematic drawing of distal femur	11
2	Distal femur (Viewed from below)	11
3	Anatomy of the distal femur	12
4	Anatomy of the distal femur (Axial view)	14
5	Alignment of the lower extremity	14
6	Blood supply around the knee	16
7	Lateral view of knee showing muscle attachments and deforming forces	18
8	AO / OTA classfication of supracondylar and intercondylar fractures of femur	22
9	Entry point of the supracondylar nail	46

LIST OF PHOTOGRAPHS

PHOTO NO.	FIGURES	PAGE NO.
1	Instruments	102
2	Instruments	102
3	Nail jig assembly	102
4	GSH nail	102
5	Positioning and draping	102
6	Incision	102
7	Entry point	103
8	Entry point	103
9	Guide wire insertion	103
10	Guide wire insertion	103
11	Reaming	103
12	Nail Insertion with jig assembly	103
13	Distal locking	104
14	Distal locking	104
15	Proximal locking	104
16	Proximal locking	104
17	Skin Closure	104
18	Sterile dressing	104
19	Mobilization on CPM	105
20	Excellent results: Preoperative	105
21	Post operative	105
22	Four weeks post operative	105
23	Six months follow-up	105

PHOTO NO.	FIGURES	PAGE NO.
24	Excellent Results: Surgical scar and traumatic scar	106
25	Active extension	106
26	Full weight bearing	106
27	Sitting cross legged	106
28	Fair Results: Preoperative	107
29	Three months post operative	107
30	Six months follow up	107
31	Knee stiffness at six months	107
32	Knee stiffness at six months	107

INTRODUCTION

Supracondylar and intercondylar femur fractures are fractures that involve the distal 15 cm of the femur including the distal femoral metaphysis (supracondylar) and the articular surface of the distal femur (intercondylar). The distal femur is funnel shaped and the area where the stronger diaphyseal bone meets the thinner and weaker metaphyseal bone is prone to fracture with direct or indirect trauma.[1]

There is a bimodal distribution of fractures based on age and gender. Most high-energy fractures occur in males between 15 and 50 years, while most low-energy fractures occur in osteoporotic women more than 50 years. The incidence is highest in females over the age of 75 years and in males between the ages of 15 and 24 years.[2,3]

These fractures occur at approximately one-tenth the rate of proximal femur fractures and make up six percent of all femur fractures. The most common high-energy mechanism of injury is a road traffic accident (53%) and the most common low-energy mechanism is a fall at home (33%).[1]

High-energy injury leads to severe comminution. Long-term disability can occur in patients with extensive articular cartilage damage and severe soft tissue injury. Because of the proximity of these fractures to the knee joint, regaining full knee motion may be difficult. The incidences of malunion, nonunion and infection are relatively high in many reported series.[3,4,5] Supracondylar femur fractures that occur after total knee replacement are also more difficult to treat

adequately because the knee replacement prosthesis can interfere with fixation implants.[6]

Thus, complications are commonly seen in these fractures and can be devastating.

Despite the advances in techniques and the improvements in surgical implants, treatment of distal femoral fractures remains a challenge in many situations. The significant forces applied to this area, even during restricted patient activities, require a strong implant. However, fixation is difficult because of the wide canal, thin cortex, and relatively poor bone quality of the distal femur. For best results, the device chosen must provide fixation rigid enough for early motion.[1,7]

The goal in treating supracondylar and intercondylar femur fractures, as with any periarticular fracture in a weight bearing bone, is restoration of a stable limb for functional, pain-free ambulation.Maintaining anatomic alignment, length and preventing stiffness restore function of knee joint.[1,4]

Earlier a nonsurgical approach was recommended for supracondylar fractures. Early conversion to cast bracing after a period of traction was later introduced,claiming to offer better functional outcomes compared with prolonged casting across the knee. The number of complications were unacceptably high.[2]

Since late 1970s to early 1990s open reduction and internal fixation by means of plate and screw osteosynthesis (condylar blade plate and dynamic condylar screw) has emerged as the gold standard of operative treatment.[2] The

advantages of internal fixation (early mobilization) can be offset, however, by the required access route, leading to iatrogenic soft tissue trauma and periosteal stripping of the bone. Additionally revision surgery due to pseudoarthrosis and infection is common. Rigid fixation is often difficult to achieve particularly in osteoporotic bone because of the degree of comminution and poor holding power of the bone.[8]

Flexible intramedullary nailing, modified antegrade nailing, and external fixation allowed fracture fixation with minimal exposure of the fracture site. However, axial and rotational stability of these implants are inferior in distal femur and early mobilisation of the limb could result in loss of reduction.[2]

To counter these problems, retrograde supracondylar nailing with cannulated stainless steel GSH nail was developed for stable interlocked nailing in 1988. The retrograde supracondylar nail was initially designed for the elderly and for the treatment of low femur shaft fractures. However, results were so good in the elderly that it has been used in younger patients with the same good results.[9]

The advantages of the supracondylar nail include a reduction in operating time and blood loss with reduction of devascularization of fracture fragments. In cases with severe metaphyseal comminution, supracondylar nailing offers a more biological method of fixation with less devitalisation of soft tissue. Fixation of intercondylar fractures is also possible with additional compression screws to stabilise the intra-articular fragments. Metaphyseal fragments are left undisturbed, which limits the need for bone grafting. It is especially useful in

obese patients and in fractures occurring below hip implants or above total knee implants that have an open notch design. It provides good axial and rotational stability for treating both open and closed fractures resulting in early mobilization. Furthermore, small incision area results in early recovery with minimal morbidity for the patient.[6,10,11]

In view of the above context the present study is undertaken to evaluate and explore supracondylar nailing in supracondylar and intercondylar fractures of femur with emphasis on a stable fixation with minimal exposure, early mobilization, less complications and a better quality of life.

OBJECTIVES

The objectives of the present study were;

1. To study the functional outcome in terms of pain, knee stability and mobility.
2. To assess the complications of retrograde nailing in distal femoral fractures.

REVIEW OF LITERATURE

Historical Review

Supracondylar and intercondylar fractures of the distal femur historically have been difficult to treat. These serious injuries often are unstable and comminuted and have the potential to produce significant long-term disability.[2]

These fractures usually occur in elderly patients with multiple comorbidities and osteoporotic bone thus, a high rate of complications exists. The elderly patient may present with a fracture resulting from trivial trauma, such as falling on the flexed knee. Furthermore, in older patients, treatment may be complicated by previous joint arthroplasty.[1,2,12]

Among young patients, this injury is usually a component of multiple trauma due to high-velocity, high-energy incidents, such as motor vehicle accidents or falls from a height. In particular, motorcycle accidents are a prime cause for these fractures in the 17 to 30-year-old patient.[1]

Supracondylar and intercondylar distal femur fractures require anatomically stable internal fixation for best results, which usually necessitates surgical treatment. Over the past 30 years, implants and techniques have improved. It is now recognized by most orthopaedic surgeons that distal femoral fractures are best treated with reduction and surgical stabilization.[2,12]

In the 1960s, nonoperative treatment methods, such as traction and cast bracing produced better results than operative treatment because of the lack of

adequate internal fixation devices. In 1966, the Campbell Clinic retrospectively reviewed 213 supracondylar and intercondylar femoral fractures. Delayed union or nonunion occurred in 9.7% of fractures treated with closed methods and in 29% of fractures treated operatively. Two-pin traction was recommended as the treatment of choice.[13]

Studies done in the 1970s, AO principles and the use of the angled blade plate revolutionized the treatment of these injuries. It gained wide acceptance for treatment of fractures of the distal femur. Although it provided stable fixation of most fractures, the technique was technically demanding, and early problems included infection and inadequate fixation in osteoporotic bone and refracture after plate removal.[3,5,14]

In 1972, a study reported 93% satisfactory results in patients treated with blade plates; however, 25% developed infections.[14] In 1979 a prospective study found only 50% fractures of the distal femur adequately fixed. In those, just 21% of fractures had good or excellent results.[3]

In 1980, a randomized trial evaluated 84 fractures treated operatively and nonoperatively. The incidence of nonunion was 17%, and average active range of motion was only 91 degrees. The importance of initiating range-of-motion exercises early was emphasized. Traction followed by cast bracing was recommended for supracondylar fractures (AO type A); almost all intercondylar fractures (AO types B and C) were treated operatively.[5]

As experience with AO plating techniques increased and the use of perioperative antibiotics became routine, the results reported with these devices

improved. In 1982, good or excellent results in 76% of 68 fractures of the distal femur treated with AO techniques (most with blade plates) were seen in a study. Bone grafting was performed in 87% of patients.[12]

Dynamic Condylar Screw Fixation

A less technically demanding alternative to the blade plate is the dynamic condylar screw fixation. Whereas the blade plate requires accurate insertion in three planes simultaneously, the dynamic condylar screw allows freedom in the flexion-extension plane.[15,16] Authors have reported the results of distal femoral fractures treated with the dynamic condylar screw. Nonunion occurred in zero to 5.7%, infection in zero to 5.3%, and malunion in 5.3% to 11%. Bone grafting was used in about a third of the fractures. Overall, results were similar to those obtained with blade plates.[15]

In a prospective study, indirect reduction techniques were applied to distal femoral fractures treated with dynamic condylar screws. Excellent or satisfactory results were obtained in 87% of patients. All poor results occurred in elderly, osteopenic patients with comminuted intraarticular fractures, and the authors suggested that this technique may not be suitable for osteoporotic patients.[16]

Blade plates and condylar screws are unsuitable for use in fractures with less than three to four cm of intact femoral condylar bone and in fractures with a large amount of articular comminution. For these fractures, the condylar buttress plate is the commonly used implant.[17,16] The multiple holes in the distal end of the plate allow multiple screws to be directed into comminuted fragments. The condylar buttress plate, however, does not provide as rigid fixation as a blade

plate or condylar screw.[17] Methylmethacrylate has been used by some to improve screw purchase in osteopenic bone.

The less-invasive stabilization system (LISS) plate, which uses locked screws and percutaneous fixation, also has been introduced recently. A study compared the biomechanical properties of this fixation device with those of the dynamic compression screw and condylar buttress plate. The LISS allowed higher elastic deformation than the other systems, placing it between rigid fixation and intramedullary nailing.[18] Initial experience with this method has been encouraging; however, clinical efficacy has yet to be demonstrated.

An Indian prospective study have analysed the results of various surgical techniques in 25 patients. 68% good or excellent results were seen which was significantly better than with conservative treatment. They concluded that early open reduction and internal fixation using AO technique gave good results in the hands of experienced surgeon, in patients of any age group, if it is followed by an early active, controlled rehabilitation programme.[19]

Intramedullary nailing

Intramedullary nailing recently has received increased attention for the treatment of supracondylar and intercondylar femur fractures. These devices obtain more "biological fixation" than plates because they are load-sharing rather than load-sparing implants. They offer greater soft tissue preservation and bone grafting is required less often.[20,21] This was shown in a prospective study which used antegrade interlocked intramedullary nailing in extraarticular fractures of the distal femur caused by gunshot wounds. All fractures healed without bone

grafting, no hardware failures occurred, 95% had good or excellent results, and knee flexion averaged 120 degrees. Eight fractures (21%) healed in a malaligned position, but only three had more than five degrees of angulation.[20]

Results of 57 supracondylar and intercondylar fractures of the femur treated with antegrade interlocking nailing were evaluated. These included 8 AO type A2, 13 type A3, 8 type C1, 25 type C2, and 3 type C3 fractures; 44% of the fractures were open. All fractures united and range of motion averaged 115 degrees. Poor results occurred in all three AO type C3 fractures. The authors concluded that preoperative roentgenograms must be scrutinized carefully for the presence of coronal fracture lines in intercondylar femoral fractures.[21]

Few authors have studied the use of anteroposterior and medial lateral blocking screws to aid in the reduction of supracondylar fractures and have concluded that these blocking screws can increase the primary stability of these fractures.[22,23]

Although antegrade nailing has been considered a relatively benign procedure, it has been shown that it is associated with trochanteric pain, thigh pain, stiffness, abductor weakness, limp, reduced walking distance, and difficulty with stair climbing. Trochanteric pain is the most common complaint (40%).[24]

ANATOMICAL ASPECTS OF DISTAL FEMUR AND CONTRIBUTING FACTORS

The supracondylar area of the femur is defined as the zone between the femoral condyles and the junction of the metaphysis with the femoral shaft. This area comprises the distal nine to 15 cm of the femur.[25]

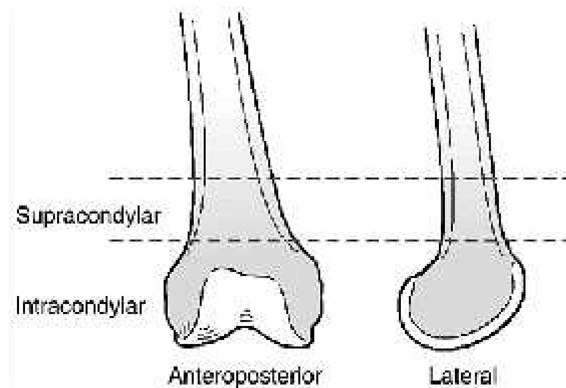


Figure No. 1: Schematic drawing of distal femur

Bone

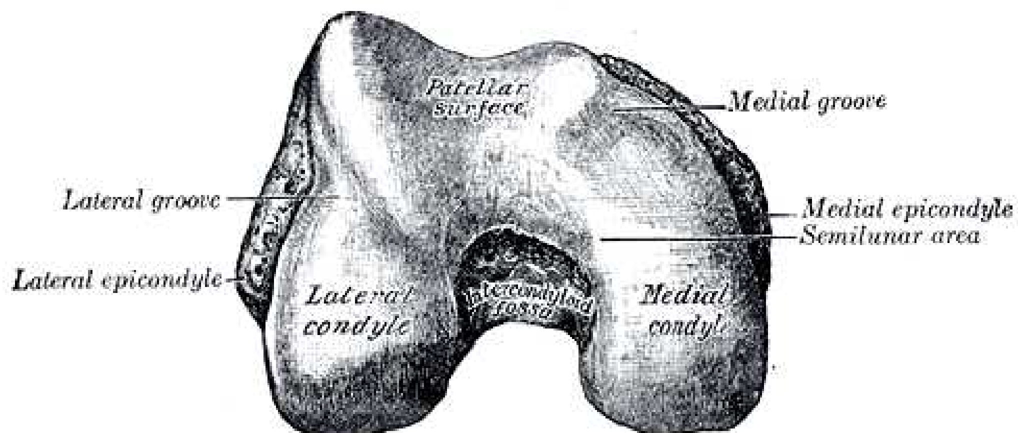


Figure No. 2: Distal femur (Viewed from below)

The lower end, larger than the upper, is somewhat cuboid in form, but its transverse diameter is greater than its antero-posterior; it consists of two oblong eminences known as the condyles. They are separated from one another by a smooth shallow articular depression called the patellar surface; behind, they project considerably, and the interval between them forms a deep notch, the intercondyloid fossa. The lateral condyle is more prominent and broader, the medial condyle is the longer and, when the femur is held with its body perpendicular, projects to a lower level. When, however, the femur is in its natural oblique position the lower surfaces of the two condyles lie in the same horizontal plane. Their opposed surfaces form the walls of the intercondyloid fossa.[26] The posterior cruciate ligament of the knee-joint is attached to the lower and front part of the medial wall of the fossa and the anterior cruciate ligament to an impression on the upper and back part of its lateral wall.

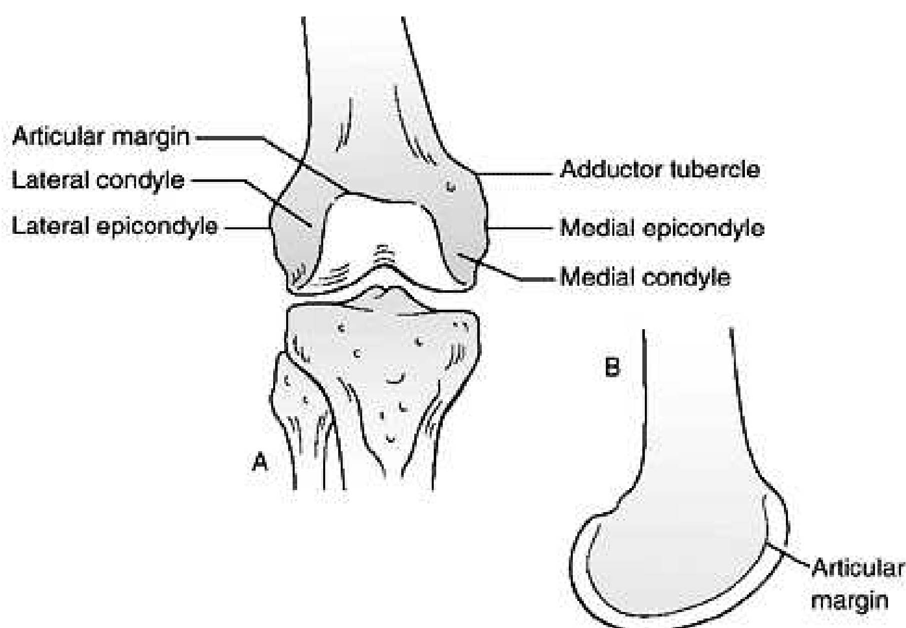


Figure No. 3: Anatomy of the distal femur:

A – Anterior view; B – Lateral view

Each condyle is surmounted by an elevation, the epicondyle. The medial epicondyle is a large convex eminence to which the tibial collateral ligament of the knee-joint is attached. At its upper part is the adductor tubercle, and behind it is a rough impression which gives origin to the medial head of the gastrocnemius. The lateral epicondyle, smaller and less prominent than the medial, gives attachment to the fibular collateral ligament of the knee-joint. Above and behind the lateral epicondyle is an area for the origin of the lateral head of the gastrocnemius.[26]

The articular surface of the lower end of the femur occupies the anterior, inferior, and posterior surfaces of the condyles. Its front part is named the patellar surface and articulates with the patella. The lower and posterior parts of the articular surface constitute the tibial surfaces for articulation with the corresponding condyles of the tibia and menisci.

When viewing the lateral surface of the distal femoral shaft and lateral condyle, it is observed that the shaft is aligned with the anterior half of the lateral condyle. When viewing the distal surface of both condyles, it can be seen that the condyles are wider posteriorly. The highest bone strength is found at the posterior aspects of the condyles, with the central area being relatively weak.

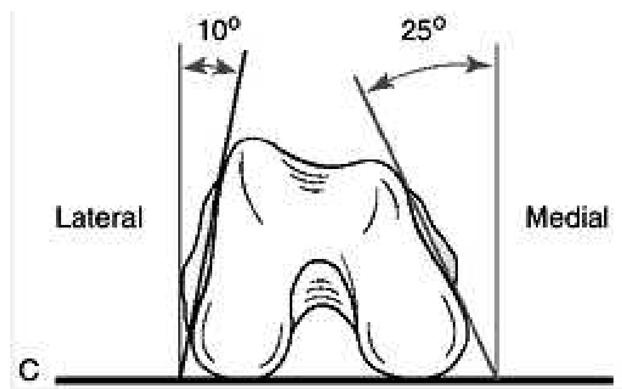


Figure No. 4: Anatomy of the distal femur (Axial view)

The distal femur is trapezoidal. The anterior surface slopes downward from lateral to medial, the lateral wall inclines 10 degrees, and the medial wall inclines 25 degrees.[27]

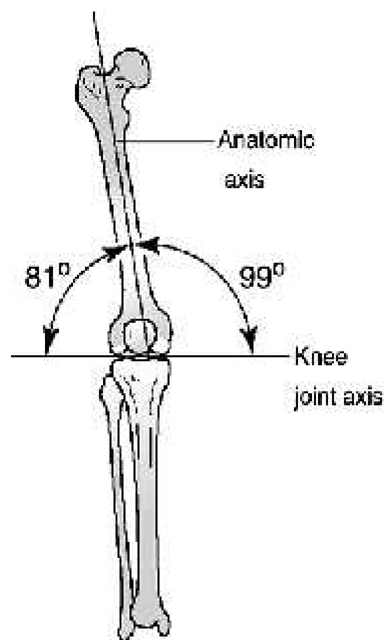


Figure No. 5: Alignment of the lower extremity

The parallel femoral condylar surfaces are created by the mechanical axis configuration of the lower extremity. The mechanical axis configuration is a straight line from the center of the femoral head that intersects the center of the knee and ankle joints. The distal femoral joint line forms a six degree angle to the long axis of the femoral shaft creating physiological valgus of the distal femoral joint line.[27]

Soft Tissues

Anterior to the femur is the quadriceps femoris muscle, consisting of four heads (the rectus femoris, the vastus medialis, the vastus intermedius, and the vastus lateralis). The quadricepses are separated from the muscles of the posterior compartment of the thigh by the lateral and medial intermuscular septa. The medial and lateral gastrocnemius muscles originate from a point of attachment proximal and adjacent to the posterior articular margins of the medial and lateral condyles, respectively.[1]

The femoral artery passes into the popliteal fossa approximately 10 cm above the knee joint. It passes through the adductor magnus muscle proximal to the insertion of that muscle into the adductor tubercle.[2]

Blood Supply[28]

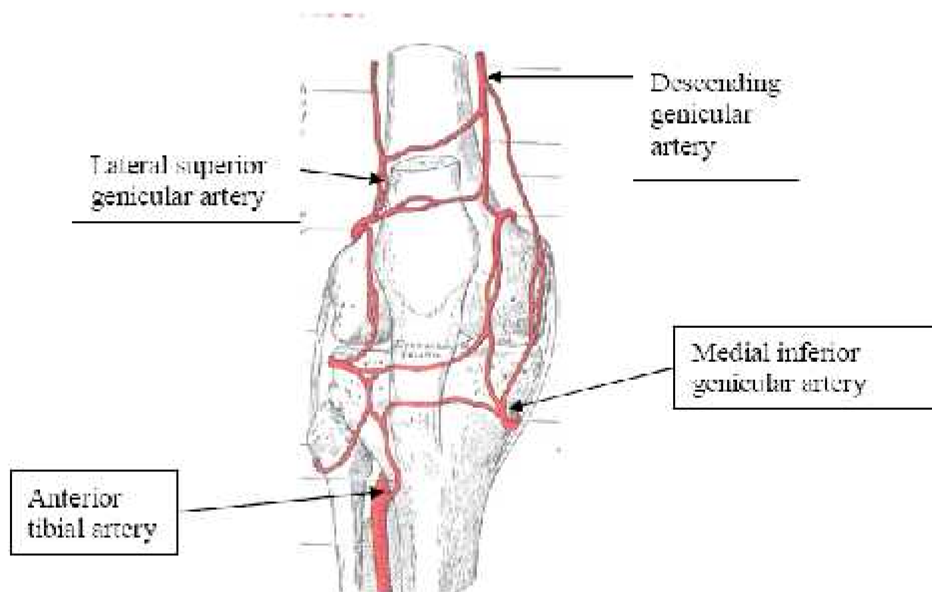


Figure No. 6: Blood supply around the knee

It is mainly supplied by the profunda femoris, usually there is only one nutrient artery (maximum of two) which is a branch of the second perforating artery. After penetrating the posterior cortex the nutrient artery arborizes proximally and distally to provide endosteal circulation to the shaft. The periosteal vessels also enter the bone along the linea aspera and supply the outer one-fourth of the cortex. They align themselves perpendicular to the cortical surface with few traversing along the periosteum longitudinally.

Proliferation of the periosteal vessels is the key vascular response to the fracture and is the primary source for bone healing. These periosteal vessels supply the outer half of the cortex. Medullary blood supply is eventually restored late in the healing process.The genicular circulation is responsible for virtually all structures about the knee. This genicular anastomosis is formed by

1. Descending genicular artery, a branch of femoral artery.
2. Medial and lateral superior genicular arteries, branches of the popliteal artery
3. Middle genicular artery, a branch of popliteal artery.
4. Branches of the anterior tibial recurrent arteries.

The lateral femoral circumflex and the recurrent tibialis anterior arteries are additional sources of this anastamotic ring.

Significance of the Inner Architecture of the Distal Femur[29]

By mathematical analysis it has been "shown that in every part of the femur there is a remarkable adaptation of the inner structure of the bone to the mechanical requirements. The various parts of the femur are well-adapted for the efficient transmission of the loads from the acetabulum to the tibia.

As the distal end of the femur is approached the shaft gradually becomes thinner until the articular surface is reached, where there remains only a thin shell of compact bone. With the gradual thinning of the compact bone of the shaft, there is a simultaneous increase in the amount of the spongy bone and a gradual flaring of the femur which gives this portion a gross area of cross-section. The function of the lower end of the femur is to transmit through a hinged joint the loads carried by the femur. For stability the width of the bearing on which the hinge action occurs should be relatively large.

There is a greatly increased stability produced by the expansion of the lower femur from a hollow shaft of compact bone to a structure of much larger cross-section almost entirely composed of spongy bone.

The most efficient manner in which stresses are transmitted is by the arrangement of the resisting material in lines parallel to the direction in which the stresses occur. Theoretically the most efficient manner to attain these objects would be to prolong the innermost filaments of the bone as straight lines parallel to the longitudinal axis of the bone, and gradually to flare the outer shell of compact bone outward.

Epiphyseal center of distal aspect of femur is present at birth in newborns, & it expands rapidly to fill both condylar regions.,Distal femur physis is largest & fastest growing physis in the body.It contributes to approximately 70 % length of femur (37 % of length of entire limb) and 1.0 cm of growth/year.[30]

MECHANISM OF INJURY

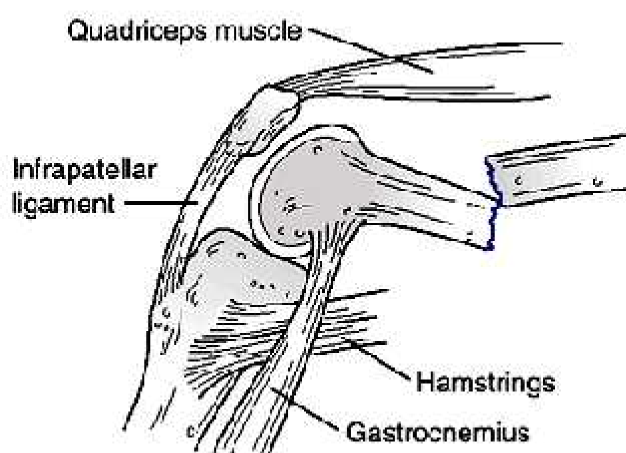


Figure No. 7: Lateral view of knee showing muscle attachments and deforming forces

Most supracondylar fractures are the result of a severe axial load with a varus, valgus or rotational force. In young patients, this amount of force is typically the result of high-energy trauma such as motor vehicle collisions and falls from height. In elderly patients, the force from a minor slip and fall on a flexed knee may be sufficient to produce these fractures.

After fracture, the deformities observed are usually those of femoral shortening, apex posterior angulation, and posterior displacement of the distal fragment. These deforming forces are produced by the quadriceps, hamstring and gastrocnemius muscles. Varus deformity may result from the pull of the adductor muscles. With an intercondylar fracture, there will often be rotational malalignment of the condyles (with resulting joint incongruity) because of the separate attachments of the gastrocnemius muscles to each condyle.[27]

Classification of Supracondylar and intercondylar fractures

There is no universally accepted method of classification for these fractures. A good classification system should:[1]

1. Distinguish among the many possible injuries to this area, including extraarticular, intra-articular and isolated condylar lesions.
2. Allow different surgeons consistently and reliably to grade a fracture pattern into one of the classification groups.
3. Assist in deciding the optimal method of treatment for the injury.
4. Correlate with the findings of outcome analysis to allow estimation of prognosis for each injury pattern.

Many classification systems have been used:

1. Stewart, Sisk, and Wallace (1966): Based on location and fracture line.[13]
2. Neer's classification (1967): Based on the relationship of the condyles to the proximal fragment and does not take into account associated intra-articular fractures or joint incongruity.[4]
3. Schatzker and Lambert classification (1974): Based on extent.[3]
4. Seinsheimer classification (1980): Four basic groups with nine subtypes, which addressed the problem of articular disruption. Although cumbersome, this allows the surgeon to analyze results based on a specific fracture group or subtype.[5]
5. Muller's classification (1979):[31]

The most widely accepted classification of supracondylar and intercondylar fractures is that developed by Muller,[31] updated by the AO group, and adopted by the Orthopedic Trauma Association (OTA).[32] This system separates supracondylar fractures of the femur into three general types that are further subdivided into three groups. The severity of the fracture (which is inversely related to the prognosis) progressively increases from one type or subgroup to the next. A coherent treatment plan can be described that applies to most fractures within each group.

Type	Description
A	Extraarticular
A1	Simple (two-part)
A2	Metaphyseal wedge
A3	Metaphyseal complex (comminuted)
B	Partial articular (unicondylar)
B1	Lateral condyle (fracture in the sagittal plane)
B2	Medial condyle (fracture in the sagittal plane)
B3	Frontal (fracture in the coronal plane)
C	Complete articular (bicondylar)
C1	Articular simple and metaphyseal simple (a T or Y fracture pattern)
C2	Articular simple and metaphyseal multifragmentary
C3	Multifragmentary articular

.

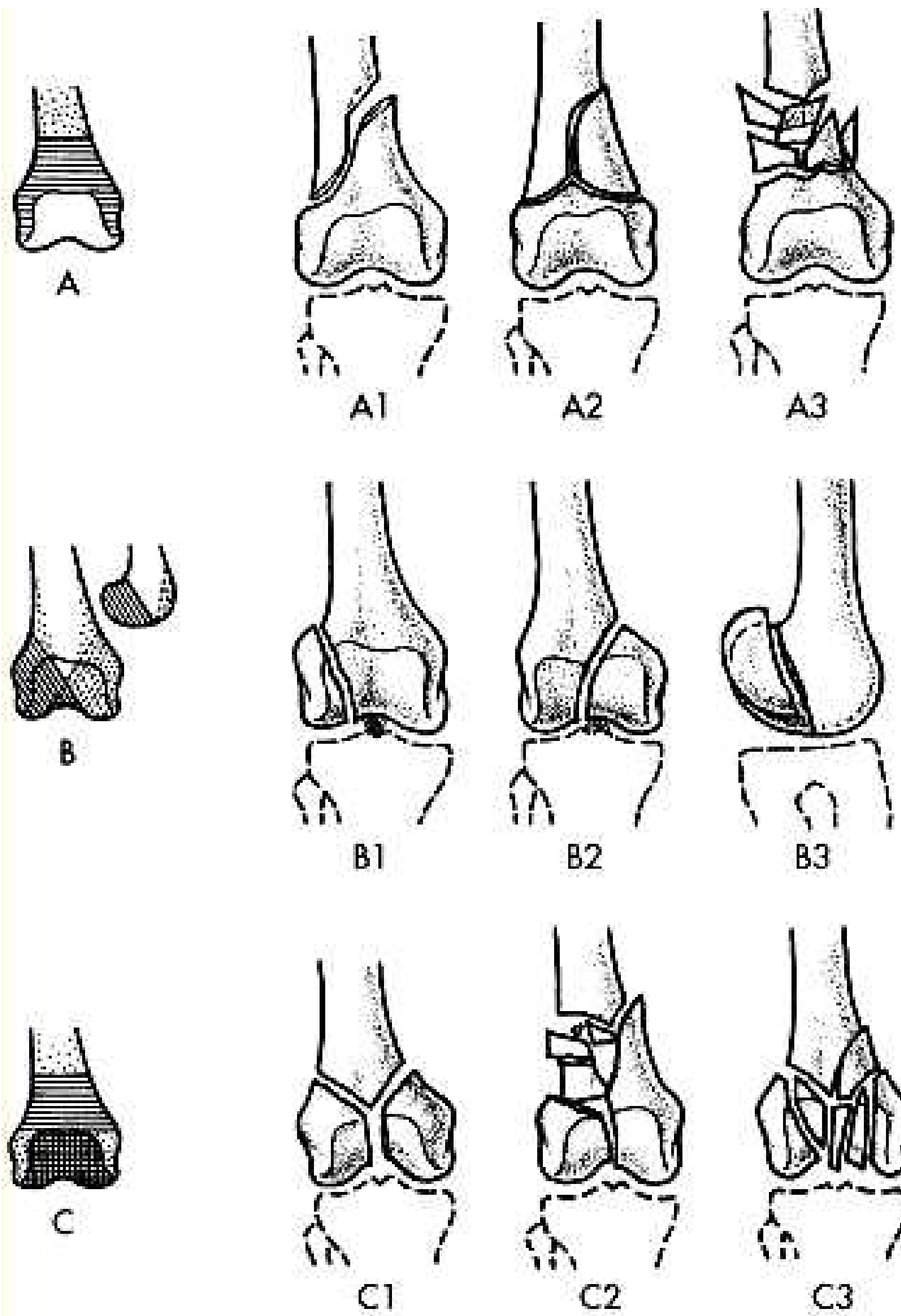


Figure No. 8: AO / OTA classfication of supracondylar and intercondylar fractures of femur

ASSOCIATED INJURIES AND COMPLICATIONS

Physical examination and x-ray assessment must assess the possible presence of a fracture to the acetabulum, the femoral neck, and the femoral shaft. An associated ligament injury to the knee has been reported in up to 20% of cases. Fractures of the tibial plateau or shaft may be produced.[33] Open fractures occur in five to 10% of all supracondylar and intercondylar fractures. The most common site for the open wound is over the anterior thigh proximal to the patella. Patients frequently have some damage to the distal quadriceps muscle or tendon.[1]

The femoral and popliteal arteries are at risk of injury because of their close proximity to the site of fracture. The incidence of associated injury to these vessels is low.[34]

SUPRACONDYLAR NAILING

First popularized in the 1990's, supracondylar/retrograde intramedullary nailing of supracondylar femur fractures remains a standard form of treatment for these fractures today. While not suited to every distal femur fracture, supracondylar nailing offers certain advantages which maintain its position in the armamentarium of treatment options for these challenging fractures.[22,35,36]

Since antegrade nailing has been so successful in treating femur fractures, there has been some resistance to accepting newer techniques. In 1950, a form of retrograde femoral nailing was introduced to treat subtrochanteric and intertrochanteric femur fractures. A curved nail was introduced through the medial femoral condyle and passed up through the fracture site.[37] Some authors

began treating ipsilateral femoral neck and shaft fractures by stabilizing the femoral neck with multiple cancellous screws, followed by retrograde nailing of the shaft fracture. In this series, the retrograde nails were inserted extra-articularly from a medial femoral condylar starting point. The disadvantage of the medial condylar starting point was that it required the use of a flexible femoral nail or a reversed tibial nail. The tibial nail has no anterior bow and caused varus malalignment in distal femur fractures.[38]

Subsequently, an intercondylar starting point was developed for retrograde nailing of femoral shaft fractures in order to avoid the varus malalignment.[35,36] A study first reported on this intercondylar approach after the procedure being performed in 14 patients.[36]

Supracondylar intramedullary nailing offers the most truly percutaneous, minimally invasive fracture fixation, without disruption of the periosteal blood supply or fracture hematoma. *Insertion is through a small, two cm arthrotomy, with an ideal starting point anterior to the posterior cruciate ligament attachment, and just medial to the intercondylar groove, having minimal impact on patellofemoral contact area.* Unlike more rigid constructs, intramedullary devices offer relative stability, leading to secondary bone healing through callus formation. Implant design allows for multiple targeted screws in the metaphyseal region, interference fit in the diaphysis, and freehand proximal locking to maintain length and rotation.[22,39]

Supracondylar intramedullary nailing is best suited to supracondylar femur fractures in the metadiaphyseal region (AO/OTA type A), those with shaft

extension or simple intra-articular extension (AO/OTA type C1). It has become a popular method of treating AO types A and B and less comminuted intercondylar (AO type C1 and C2) fractures.[23,39]

As shown in a prospective study, overall assessment of clinical outcome based on the criteria of Schatzker and Lambert was graded excellent in six patients, good in three patients, fair in three patients, and one graded as a failure. Supracondylar nailing for fixation of supracondylar AO type A and less comminuted intercondylar (AO type C1 and C2) fractures is recommended by the authors.[40]

Selected type C fractures are an indication for supracondylar nailing. Supracondylar nailing was used to treat 26 distal femoral fractures, six of which were AO type C. Twenty-five of the 26 fractures healed within 12 weeks. There was no malunion or non union.[41]

Supracondylar femoral nailing was used for the treatment of distal femoral and femoral shaft fractures in 40 patients. The mean age of patients was 63.7 years and seven percent presented with ipsilateral local pathologies or associated entities. Patients (70%) were evaluated with a mean follow-up period of 20.4 months using the functional score of Lysholm and the activity score of Tegner (Lysholm – mean: 87.7 pts shaft. vs. 80.1 pts. distal) (Tegner-mean: 5.2 pts. shaft vs. 3.9 pts. Distal) Despite a high age of patients (average 63.7 years) and many local co-morbitities, supracondylar nailing resulted in the majority (95.1%) reliable osseous healing. The authors concluded that supracondylar

retrograde nailing represents a reliable fixation method for extra-articular (A1-3) and simple intra-articular (C1-2) fractures of the supracondylar area.[42]

Like antegrade nails, these supracondylar nails have the theoretical advantages of being load-sharing rather then load bearing devices. These devices require little soft tissue dissection, and infrequently need bone grafting.[22,39] Thus the importance in elderly patients cannot be overemphasized. A retrospective study in elderly patients with average age of 75 years found supracondylar femoral nailing a reliable procedure .All patients were assessed with regard to operative time, blood loss, and postoperative complications. There were no cases of implant or fixation failure.[43]

Specific operative advantages[39] include decreased set-up time in the operating room, decreased operative time in certain situations, less blood loss when compared to the dynamic condylar screw (DCS).[44] Supracondylar nails have also been shown to resist varus deformation as well as an angled blade plate.[17] It was found that the supracondylar nail with a grouped screw configuration absorbed more energy during axial loading. One such study found the 95-degree plate to be stiffer in valgus bending and torsion but found no significant difference between the plate and GSH nail in varus bending or flexion.[17]

Twenty-two patients with 23 supracondylar femur fractures were randomized to receive either a retrograde intramedullary nail fixation (IM group, 12 fractures) or a fixed-angle blade plate fixation (11 fractures). There was no statistically significant difference in the scores for any of the SF-36 domains.[45]

With the rigid fixation of the distal femoral fractures, bone grafting is frequently needed. Biological osteosynthesis using retrograde intramedullary supracondylar nail (RIMSN) preserve the blood supply and limit the need for bone grafting.[39,46]

From September 2002 to December 2004, 68 closed fractures of the distal femur were treated by bridge plate osteosynthesis using DCS in 31 and RIMSN in 37. The patients were allocated to one of the two groups randomly and followed for 24-36 months.

The blood loss was significantly more in the DCS group (p=0.000). There were no significant differences in terms of cumulative rate of union (p=0.855), range of motion of the knee (p=0.727), overall results (p=0.925) and complications (p=0.927) between the two groups. The Conclusion was that no implant or surgical technique is superior to any other under all circumstances for distal femoral fracture and supracondylar intramedullary nailing is a very good alternative for the treatment of distal femoral fractures.[46]

Simultaneous treatment of bilateral lower extremity injuries , effective treatment of ipsilateral femoral shaft and femoral neck fractures allowing the hip fracture to be stabilized with a separate device,are added advantages for the patient.[39,35,36]

Ipsilateral fractures of the femur and tibia (floating knee) can be operated with a single incision using a technique of retrograde insertion of a femoral nail and unreamed insertion of an interlocking tibial nail.[35] The advantage of this method of treatment is a single medial parapatellar incision. Functional results

were good or excellent in 13 of the 20 patients (65%) at the average follow-up of 20 months in a prospective study. Authors concluded that retrograde technique is expedient and allows other procedures to be performed simultaneously in severely injured patients.[47]

Supracondylar nailing of distal femoral fractures is preferable to antegrade nailing in many situations. No risk of pudendal nerve palsy (which is as high as 17% in antegrade femoral nailing on a fracture table) with no position-induced well-leg compartment syndrome are seen.[48,49] There is rapid access to the intended starting portal in patients with traumatic arthrotomies to the knee and the ability to treat thoracic and/or abdominal injuries and orthopaedic injuries simultaneously or sequentially.[36]

In a prospective,multicenter series of 359 femur fractures, 175 fractures were treated with antegrade femoral nailing and 166 managed using a retrograde technique.The conclusion was that both antegrade and retrograde nailing can lead to excellent fracture reduction and alignment for femoral midshaft fractures. However, supracondylar nailing proved to be superior in the reduction and alignment of distal femoral fractures when compared to antegrade nailing.[50]

In another comparative prospective study between antegrade femoral nailing and retrograde technique, supracondylar retrograde nailing group showed significantly earlier union rate (p=0.032). It was found that supracondylar nailing does not give rise to a higher rate of knee complications. Therefore, this approach was strongly recommended as it is technically less demanding.[51]

Several authors have advocated supracondylar femoral nailing to treat bilateral femur fractures. Both fractures can be nailed simultaneously, thus minimizing operative time and blood loss.[16,39,35]

Obese patients can be operated on more efficiently and with greater ease using a retrograde technique.[16] Patients with poor skin quality in the region of antegrade starting points should also be considered candidates for retrograde femoral nailing.[52]

Since there is no direct radiation to the pelvic region during retrograde femoral technique, pregnant patients may benefit from this technique.[52] Patients with distorted proximal femoral anatomy, such as patients with Paget's disease or with previous proximal femoral fractures, can present a formidable challenge with an antegrade technique. Therefore, retrograde insertion of a femoral nail may be an attractive alternative. Paget's disease tends to distort the proximal femoral anatomy much more than its distal anatomy.[53]

Head-injured patients may also benefit from retrograde femoral nailing.[54] An antegrade approach in a patient with a head injury can lead to significant heterotopic ossification in the region of the hip joint. The presence of heterotopic ossification in the hip region preoperatively made an antegrade starting portal almost impossible. The authors proceeded with supracondylar femoral nailing and obtained good results.[39]

Distal femoral fractures below hip implants or above total knee implants with an open notch design also can be effectively treated with supracondylar nailing. Fractures above total knee arthroplasties require special attention. The

notch in most cruciate retaining prostheses is of sufficient width to permit nail placement.[6,55,56]

In a prospective study supracondylar nailing in patients who suffered distal femoral fractures above total knee arthroplasty was carried out. The average age of patients was 68 (42-92) years. There were no wound infection, loss of reduction or implant failure. All patients had regained their previous range of movement of the knee joint at an average follow up of 20 months.[6] In comparison with the LISS plate, retrograde intramedullary nailing provide greater stability in these periprosthetic fractures.[56]

There has always been a concern for potential patellofemoral arthritis with an intra-articular starting portal.[22,57]

To date, there has not been enough long-term follow-up to determine whether this should truly be a concern. Some authors have argued that supracondylar nailing probably does not lead to significant posttraumatic arthritis because the intercondylar starting point is not in a weight-bearing area and is brought into contact with the patella only in extreme flexion.[22]

In one series one third of patients complained of continued knee pain postoperatively. Arthroscopy was performed in three of these patients approximately six months after femoral fixation. Arthroscopy revealed no abnormalities except for some scarring in a patient who had a history of an ipsilateral patellar dislocation. During exchange nailing, inspection of the joint once again revealed no pathologic changes. The intercondylar entry portal was

actually covered by fibrous tissue. Biopsy of this tissue revealed that it was fibrocartilage.[39]

Postoperative knee stiffness is another potential concern with supracondylar femoral nailing. However, several studies[39,50,58] have shown that knee range of motion is not adversely affected by this technique .The risk of intra-articular infection and metallosis has also been mentioned in the literature as a potential problem.[59] Ironically, the alternative fixation used for supracondylar femur fractures such as a 95 degree blade plate or a condylar buttress plate is also in an intra-articular location. Therefore, it can be hypothesized that a supracondylar nail does not have an increased risk of infection or metallosis when compared to traditional supracondylar femoral fracture fixation.

The issue of quadriceps atrophy and weakness is another potential pitfall of supracondylar nailing. But in a recent series, only two of 31 ambulatory patients demonstrated mild quadriceps weakness. One of the two patients had a limp with prolonged walking. Although loss of quadriceps strength is a concern, the literature reveals that it is usually mild and responsive to exercise therapy. Overall, patients treated with a retrograde technique have a low incidence of limping and pain.[39]

Technically, it is usually more difficult to judge rotational alignment and achieve proper length during supracondylar femoral nailing.[23] Therefore, the surgeon needs to be cognizant of this potential problem. The proximal screw locking in supracondylar femoral nails can be challenging because of the amount

of soft tissue in the region of the proximal thigh. Loss of the screw in the thigh can be a technical nightmare.[23]

The surgeon must demonstrate sound judgment in interpreting the fracture pattern and must possess a basic understanding of the principles of operative fracture management as well as knowledge of the mechanics of the implants.170 patients with distal femoral fractures were operated by 10 different orthopaedic surgeons using retrograde intramedullary nail and dynamic condylar screw. 25 poor results each in both groups were in the absolute control of the operating surgeon .13 (34%) poor results were not in the control of the operating surgeon.[60]

The proximal tip of the nail generally lies in the mid or distal femoral shaft, creating a stress riser in this area. The shorter lengths of some nail designs do not allow fixation of fractures that extend above the distal femoral metaphysis.[52]

Also, fractures with intra-articular extension must be reduced and clamped prior to reaming and nail insertion. Independent lag screws anterior and posterior to the nail provide additional fixation. The mismatch in canal dimensions relative to nail in the metaphysis can lend to instability and mal-reduction in the coronal plane. The use of Poller (blocking) screws are helpful in this situation.[17,61]

Earlier designs of some supracondylar nails, specifically the GSH nail for supracondylar femur fractures, had some biomechanical shortcomings. The original GSH nail came in 11 and 12-mm diameters with 6.4-mm interlocking screw holes .A series with a earlier supracondylar GSH nail had five delayed

unions and four nonunions.[61] The GSH nail has been subsequently modified with five mm interlocking screws to decrease the incidence of this complication. The GSH nail's modification has increased its fatigue life by a factor of five in laboratory tests.[62] Only one fatigue failure has occurred since the nail's modification. However, since there was one failure despite the previous modification, further changes have been made, specifically the elimination of the intermediate screw holes in the central portion of the nail. This technological advancement should eradicate concerns over the biomechanical strength of these supracondylar rods.[10,17,62]

Recently no hardware failures were reported with the newer nails that use five mm locking screws. A 95% union rate using the new GSH nail was reported.Early knee range of motion was started using continuous passive motion and knee motion averaged 109 degrees. This study emphasized knee mobilization for optimum results.[11]

A study expanded upon reported biomechanical properties of a retrograde intramedullary supracondylar nail (GSH) and a fixed angle screw side plate device (10 hole, 95^0) in a matched pair human femur fracture model .Findings were consistent regarding the greater torsional stiffness of fixed angle screw side plates. However, the results differ from previous reports that this study found no significant stiffness difference in axial loading. This study used cadaver bones of elderly patients, who are at most risk for fracture fixation failure.[17]

A prospective study evaluated the results of unreamed supracondylar nailing for distal third femoral fractures. A consecutive series of 27 patients (with

28 fractures) were prospectively evaluated. Outcome measures were union time, initiation of weight bearing, deformity, shortening and modified Knee Society Knee Score. In these patients 26 (93%) of the 28 fractures achieved union,the mean union time for the other 21 fractures was 4.4 months. By the end of one year, excellent or good scores for pain and function were recorded in 77% patients. The study concluded that supracondylar nailing is a reliable alternative in the management of selected complicated fractures of the distal femur.[42]

24 patients with 26 supracondylar femoral fractures with significant number of associated injuries were treated with a supracondylar intramedullary nail. Sanders 40 point functional evaluation rating scale was used to evaluate function. There were four excellent, 16 good, two fair, and two poor results. The inference was that supracondylar nail provides similar functional outcomes to lateral fixation devices with significantly less soft tissue dissection.[10]

In 2003, the management and outcome of distal femur fracture treated with a retrograde fixation in 47 patients was investigated. Seven complication were noted, three related to severity of injury and four related to operation. There were no relevant difference between type A and type C fractures in functional, clinical or radiographic outcomes.[63]

In a retrospective study forty operations were performed for fresh fractures and five as reoperations because of non-union and breakage of condylar screw and plate (DCS). Nine of the cases were due to a high energy trauma. Seven of the fractures were periprostetic and four were open fractures. The outcome (ROM of the knee joint, pain, radiological results, union time), and per-

and postoperative complications were studied. There were three (6%) superficial wound infections without an effect on the final radiological result. End results suggested that supracondylar nailing is a reliable fixation modality of peri prosthetic, open and high-energy fractures.[41]

METHODOLOGY

The present study was conducted in the department of Orthopaedics, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients with supracondylar and intercondylar fractures of the femur during the period of one year from December 2007 to November 2008.

Study design

One year prospective study

Source of data

Patients operated by supracondylar intramedullary nailing for supracondylar and intercondylar fractures of the femur in department of orthopedics, KLES Dr. Prabhakar Kore Hospital and Medical Research Center, Belgaum, Karnataka were selected as study population.

Sample Size

Fifteen male and female patients with supracondylar and intercondylar fractures of the femur who were undergoing supracondylar intramedullary nailing were selected for the study.

Sampling procedure

The sample size was calculated considering 80% of average cases with supracondylar and intercondylar fractures of the femur at KLES Dr. Prabhakar

Kore Hospital and Medical Research Centre, Belgaum Karnataka over a period of last three years.

Selection criteria

Inclusion criteria

- All patients with age group above 18 yrs having supracondylar and intercondylar fractures of femur with an indication for surgical management.
- Multiple fracture in patients.
- Fractures occurring below hip implants or above knee implants with open notch design.

Exclusion criteria

- Patients who are bedridden or non-ambulatory.
- Patients with severe life-threatening or other medical problems.
- Articular comminution.
- Fracture extension into isthmus.

Procedure

The study was approved by the Ethical and Research Committee of Jawaharlal Nehru Medical College, Belgaum. After finding the suitability as per inclusion and exclusion criteria ,patients were selected for the study and briefed about the nature of the study, the interventions used and written ,informed consent was obtained (Annexure–I). The consented patients were enrolled in the

present study. Further, descriptive data of the participants like name, age, sex, detailed history, were obtained by interviewing the participants and clinical examination and necessary investigations were recorded on predesigned and pretested proforma (Annexure II).

Pre operative evaluation

- History
- Clinical examination
- Laboratory investigations
- Radiological assessement

  Detailed history and proper clinical examination was carried out to find:

- Nature of trauma.
- Mechanism of injury and duration since injury.
- Significant past and family history.
- Presence of associated injury.
- General physical examination.
- Local examination- Inspection usually shows swelling and deformity around the distal femur and knee. The presence of an open wound in the case of compound fractures should be identified. Manipulation of the injured limb demonstrates abnormal mobility and crepitus. The vascular supply to the limb should be assessed by examining for the presence of a pulse at the popliteal, dorsalis pedis and posterior tibial arteries. Motor and sensory function to the leg and foot must be assessed.[1]

Laboratory investigations

- Complete blood count
- Mini-renal, Blood sugar level
- Urine analysis
- HIV, HBsAg
- Chest X-ray
- Electrocardiogram

Radio logical assessment[1]

X-rays of the distal femur and knee joints (anteroposterior and lateral): Classification of fracture, type and amount of displacement and degree of comminution. Complex intraarticular fractures of the supracondylar area are visualized better with additional 45^0 oblique x-rays. Anteroposterior and lateral radiographs of the uninjured femur may help to plan fracture fixation, determine alignment, and preoperatively determine nail length. Additional x-rays of associated injuries, the pelvis, the ipsilateral hip, and the complete ipsilateral femoral shaft are assessed.

Special tests

- ABG analysis.
- Three dimensional CT scan (if required).
- Arteriography: When suspected vascular injury.

Principles of Surgical Treatment[64]

The goals of operative treatment of supracondylar and intercondylar femoral fractures are:

a) Anatomical reduction of distal femoral articular surface.
b) Stable internal fixation with restoration of axial alignment.
c) Bone grafting of any defects.
d) Minimal soft tissue stripping.
e) Early active mobilization.

Indications for Surgery[39,35,36,65]

1. Supracondylar and intercondylar fractures of femur.
2. Polytrauma patients.
3. Bilateral femur fractures: Both fractures can be nailed simultaneously, thus minimizing operative time and blood loss.
4. Obese patients: Operated more easily by this technique, as getting entry point via antegrade technique is difficult.
5. Floating knee: Both supracondylar and tibial shaft fracture can be treated by a single incision.
6. Ipsilateral femoral neck and distal femur fractures.
7. Supracondylar fractures with shaft extension.
8. Fracture around a total knee replacement.
9. Major associated knee ligament injuries.
10. Pathological fractures.
11. Pregnant female:There is no direct radiation to pelvic region.

Contraindications[65]

1. Active infection.
2. Massive comminution or bone loss.
3. Inadequate facilities.

Timing of Surgery

Timing of surgery depends greatly on general condition of the patient, concomitant injuries, local soft tissue status, the circulatory and neurological situation, the logistic conditions of the hospital and the skills of the surgeon. In isolated closed, displaced supracondylar fractures that require surgery, internal fixation should be performed within the first 48 hours. If surgery is delayed for more than eight hours, the patient should be placed in tibial pin traction. Closed fractures in patients with multiple injuries should be stabilized during thoracic, abdominal, vascular, or neurosurgical procedures whenever possible.[1,2]

Preoperative planning

The surgery is performed on tracing paper before being carried out in the operating room. The fracture and its subsequent reduction, size (length and diameter) of implants and the exact position of screws can be sketched .Executed properly, this surgical tactic shortens operative time, minimizes intraoperative decision-making and improves results. Often radiographs of the uninjured extremity will prove helpful to assess length and alignment.[2]

Instruments and implants used

1. Supracondylar curved jig
    a. This consists of a short transverse drill guide, to which a long vertical curved guide bar with multiple holes is attached by a guide bar bolt. The guide bar of the jig should be lateral to the thigh of the patient while passing the nail retrogradely and the bend (curve) should face anterior to patient.
    b. The advantage of this instrument is nail can be locked both proximally and distally with the same jig and this can be used for both left and right sides by turning the guide bar upside down.
2. Hexagonal bolt (nail bolt): connects IMSC to jig.
3. Straight bone awl: used to make entry point.
4. Long guide wire: ball tipped and plain.
5. Spanner.
6. Flexible intramedullary reamers with pneumatic system.
7. Rigid cannulated reamers.
8. Protection sleeve.
9. Long drill bit (3.2mm).
10. Depth gauge; Tap; Hexagonal screw driver.
11. Extraction rod(ram): introducing and extracting nail.
12. General instruments: Retractors, Reduction clamps, Mallet, etc.

Implant description[10]

Intramedullary supracondylar nail is a closed section fully cannulated stainless steel condylocephalic nail. Some nails have five degree distal anterior bend for ease of insertion. Anterior bend is located 3.8 cm proximal from the driving end. (eight degree antecurvature begin at 50 mm from the distal end, with a second bend three degree curve at 120 mm). Each nail has five mm diameter holes for locking in medial lateral direction. It is available in diameters of 10, 11, 12 mm and length varying from 15 to 25 cm. They are basically available in two design types:

Multiple hole design: Has multiple holes ranging from seven to 12 depending on the length of the nail along the entire length of the nail with 20mm intervals in between the adjacent holes.

Five hole design: Has three holes at the distal end and two holes at the proximal end. The two proximal holes are positioned at 40.5 mm from the proximal end of the nail.

Locking Screw: The screws are manufactured from the high tensile stainless steel alloy 316L. They have a thread diameter of five mm, core diameter of four mm and pitch of 1.3 mm. It has self-tapping thread, which extends along the entire length of locking screw.

Initially 6.4 mm locking bolts were used. After initial experience of fatigue fracture with 6.4 mm locking bolts, universally five mm locking bolts are being used.[11,64]

GSH nail[11]

The Green-Seligson-Henry (GSH) nail developed by Green, Seligson, and Henry, is a cannulated, single-piece, stainless steel implant that is available in 10, 11 and 12 mm diameters. The supracondylar nail (GSH nail) has a maximum length of 300 mm with a lateral targeting device that is effective up to 250 mm. It is a retrograde intramedullary nail designed to be inserted through the intercondylar notch,medial or lateral condyles. The nail is then anchored to the condyles with large compression screws.

The nail size used depends on the size of the patient and the extent of distal femoral comminution. In the case of Y or T condylar fractures, the condyles must be reduced and fixed with lag screws before the insertion of the nails.

Operative procedure

Patients were operated under epidural/spinal / general anaesthesia. Patient was placed in supine position over a radiolucent operating table. Pneumatic tourniquet was applied. Then the limb was cleaned with detergent and cetrimide, scrubbed with povidine iodine (7.5%), painted with povidine (five percent) and draping done.

The injured leg was positioned freely, with knee flexed 90^0 either by taking the leg by the edge of operating table or by breaking the table at knee to relax the gastrosoleus muscle and allow traction by gravity. Knee flexion allows proper access to the entry portal, as well as reduction and fixation of

intercondylar fractures.The uninjured leg was positioned to allow free movement of image intensifier from antero-posterior to lateral plane for fractured limb.[2]

Tourniquet pressure was raised to twice the systolic blood pressure after three to four minutes of elevation or exsanguination. Tourniquet was inflated and time noted. Sterile gloves were applied to the foot and steri-drape was applied over the thigh from knee to hip joint.

Surgical technique[2]

Fluoroscopic control was used throughout the procedure. Fracture was reduced either with a tibial traction pin or with manual traction. Rotational alignment was obtained by aligning the iliac crest, patella, and first web space of the foot in comparison with the uninjured leg.

The nail was inserted with either an open or percutaneous technique. An open technique is necessary for accurate reduction of displaced intercondylar fractures. The knee joint was entered through a standard midline incision or medial parapatellar capsular incision.[35]

For the percutaneous technique, a five cm vertical incision was centered over the patellar tendon, extending from the inferior pole of the patella to 1 cm above the tibial tubercle, incising the center of the patellar tendon vertically in the direction of the longitudinal fibers.[39]

Intercondylar fractures were anatomically reduced and stabilized with Kirschner wires. A large tenaculum clamp aids in maintaining reduction. The medial and lateral femoral condyles are lagged together with 6.5 mm partially

threaded cancellous screws placed in a lateral to medial direction in the anterior and posterior segments of the condyles at least 1.5 mm apart. Preoperative radiographs and CT scans should be scrutinized for tangential posterior fractures of the condyles. These fractures (Hoffa's fracture) require screw osteosynthesis in an anteroposterior direction.[52]

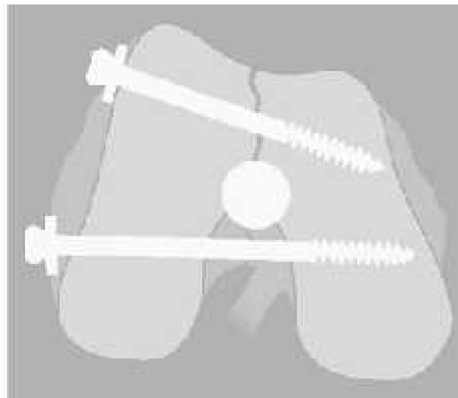


Figure No. 9: Entry point of the supracondylar nail

Entry point was made in the center of the intercondylar notch, just anterior to the origin of the posterior cruciate ligament or approximately five mm anterior to the posterior cortex. Either a Kuntscher awl or a cannulated step reamer over a guide pin was used to make the entry portal. The portal was aligned with reference to the condyles, not the femoral shaft.[36]

***Reaming*[52]**

After creation of the entry portal, awl was removed and replaced with a ball-tipped guide wire. This guide wire was advanced across the fracture into the diaphysis under fluoroscopic control. There are several ways to achieve a reduction. The most simple is manual traction and the application of correctional

forces. If difficulty is encountered with the reduction, drill sleeve was passed which can be used to "joystick" the distal fragment into place. If this maneuver fails, a femoral distractor may be used.

An eight mm end-cutting reamer was used to enlarge the condylar portal and then progressively reamed in 0.5 mm increments to one to 1.5 mm larger than the diameter of the selected nail. The shaft was reamed to a point slightly proximal to the expected tip of the nail. The entry point was reamed 1.5 mm larger than the selected nail to avoid displacing the condyle when the nail is inserted.

Nail Selection

The size of the implant was based on the location and extent of the fracture. It was ensured that the size chosen will enable the nail to be locked securely into the proximal non-fractured zone.

Nail Insertion [36,52]

A nail of the proper length and diameter was connected with the alignment rod placed through the guide bar. The apex at the distal end of the nail usually was directed dorsally and guide bar positioned laterally. The nail was advanced over the guide wire into the distal condyles and then across the fracture site, into the diaphysis. The nail was advanced until the distal end was countersunk two to five mm below the surface of the intercondylar notch and guide wire was removed. Failure to countersink the nail may adequately lead to

patellar impingement. Anterior to posterior or lateral to medial blocking screws can be used to help align the nail and prevent malreduction at this point.

Screws placement[36,52]

These supracondylar nails should be statically locked with at least two distal and two proximal screws. One proximal screw may be used if the nail has at least 10 cm of secure intramedullary purchase.

The distal interlocking screws usually were placed first. A stab incision was made through the fascia to the cortex through the most distal hole in the drill guide. The eight mm (gold) and four mm (green) drill sleeve were advanced through the drill guide to the cortex and four mm drill bit was used to penetrate both cortices. For proper screw selection, depth measurements were taken by reading the calibration off the four mm drill bit.

To place the five mm interlocking screw, the gold sleeve was withdrawn and the appropriate length screw and screwdriver was assembled. Screwdriver was placed through the green sleeve and screw advanced through both cortices. Second distal locking screw was placed in the same manner.

Two screws usually are used for proximal interlocking. The more distal screw is placed first. Stab incision is made and green and gold drill sleeves are passed to the femoral cortex .Under fluoroscopy, hole was drilled, screw length measured, and screw was placed. A second proximal locking screw was placed in a similar manner. Alternatively, proximal- locking screws were inserted with a

freehand technique or radiolucent drill. The wounds were irrigated copiously and closed in layers with a romovac drain in situ.

Compound/Open fractures[1]

Compound fractures constitute five percent to 10% of all supracondylar and intercondylar femoral fractures. Thorough irrigation and debridement of the fracture is single most important step in the prevention of infection. The major disadvantage of immediate internal fixation is the increased risk of infection due to interference with local blood supply.

In patients with type I, II and IIIA open supracondylar fractures, experienced fracture surgeons favor definitive internal fixation after debridement of the traumatic wounds. However, most grade IIIB and IIIC open supracondylar fractures are managed with external fixation across the knee or with delayed internal fixation. But this delay, increases the technical difficulty of the procedure and contributes to patient morbidity.

Post operative care

Immediate

- Limb elevation over two pillows.
- Check X-ray of the operated femur (full length) including knee in both antero-posterior and lateral views.
- Intravenous antibiotics for three days postoperatively.
- Romovac Drain removed on the second or third post-operative day and wound inspection done.

- To switch over to oral antibiotics by fifth post operative day. Analgesics if required given.

Post operative management

- Postoperative rehabilitation depends on the stability of fixation and the fracture pattern and was individualized for each patient.[66]
- All patients initially placed in a knee immobilizer or lockable hinged knee brace.
- Hinged knee braces usually used to protect fractures with stable fixation.
- Patients with stable fixation, started on a continuous passive motion program in the first 24 to 48 hours after surgery. [67]
- Fractures with less secure fixation were given temporary slab immobilization.
- Initially only touch-down weight-bearing was allowed for extra-articular (AO type A) fractures and was progressed as callus formation increased over the next four to six weeks.
- Patients with intra-articular (AO type B and C) fractures were strictly advised, supervised and guarded full weight-bearing over six to 12 weeks.

COMPLICATIONS[20,39]

Almost all of complications of these fractures are actually perioperative in origin. Therefore, the problem areas of retrograde nailing are best grouped into preoperative, intraoperative, and postoperative categories.

Preoperative Complications

- Inappropriate initial patient selection is one of the main causes of later fixation failure and infection.
- The need to assess the intercondylar notch region to ensure that intra articular fracture lines and comminution have not irreparably compromised the retrograde entry portal area. Computed tomography can provide this information.

Intraoperative Complications

- Injury to the knee joint, resulting in pain or instability, is the most common complication.
- It is important to place the retrograde entry portal in the proper location. This minimizes risk of injury to the posterior cruciate ligament, and facilitates proper axial fracture alignment after nail insertion.[39] An anterior, medial or lateral malposition will encroach on the distal femoral articular surface or the patellofemoral joint.
- The potential for damage to the under surface of the patella also exists during the insertion of these reamers.
- Another potential problem of intramedullary reaming is reaming debris left in the knee joint. It makes sense to thoroughly irrigate the knee after completion of the procedure.
- Leaving the end of the nail sticking in the knee joint is a poor technique; however, the greatest risk of nail protrusion is not from an intraoperative error but from subsequent distal nail migration.
- Bleeding or neurological complications are very rare.

Postoperative Complications

- *Knee Pain:* The most common cause is an over-long distal locking screw protruding into the medial soft tissues. Symptoms are relieved by screw removal after the fracture heals.[57]

Knee Stiffness[68]

Postoperative physical therapy with range-of-motion exercises may be helpful in maintaining motion in patients. Knee stiffness may be addressed successfully by manipulation or arthroscopy with lysis of adhesions.

Delayed union and non union:

If healing is delayed, nail dynamization should be considered. Nonunion should be treated by exchange nailing with reaming.[39]

Infection: Knee joint sepsis following supracondylar nailing is very rare.[39]

Knee sepsis should be treated using standard joint drainage techniques with the addition of implant removal.

Patello-femoral arthritis[57]

Quadriceps atrophy[39]

Synovial metallosis[59]

Heterotopic ossification[68]

Method of Evaluation

Clinical assessment

- Sanders 40 point Functional evaluation scale (Annexure II).[10]
- Radiological Union:[1]
    - Radiological examination was performed in two planes and assessed for callus formation and varus – valgus and flexion – extension deformities. "Union" was defined as the appearance of bridging callus and trabeculations extending across the fracture site. "Nonunion" was defined as no evidence of fracture union progression in six months of follow up.
    - "Delayed union" was defined as the appearance of the signs of fracture union, but the progress of union to consolidation is delayed than is otherwise expected. "Malunion" was defined as varus-valgus angulations greater than five degrees, apex anterior-posterior angulations greater than 10 degrees and rotational mal-alignment greater than 15 degrees.

Sanders 40 point Functional evaluation scale[10]

The patient was evaluated by:

- Range of motion**,** Extension; Deformation; Shortening (cm); Pain; Walking Ability; Stair climbing and return to work.
- The patient was given specific points at each follow up.

- The results are: excellent for 36-40 points; good for 26-35 points; fair for 16-25 points and poor for 0-15 points.

Follow up

The cases were followed at four weeks, three months and sixth month by assessing Sanders 40 point functional evaluation scale.[10]

Statistical analysis

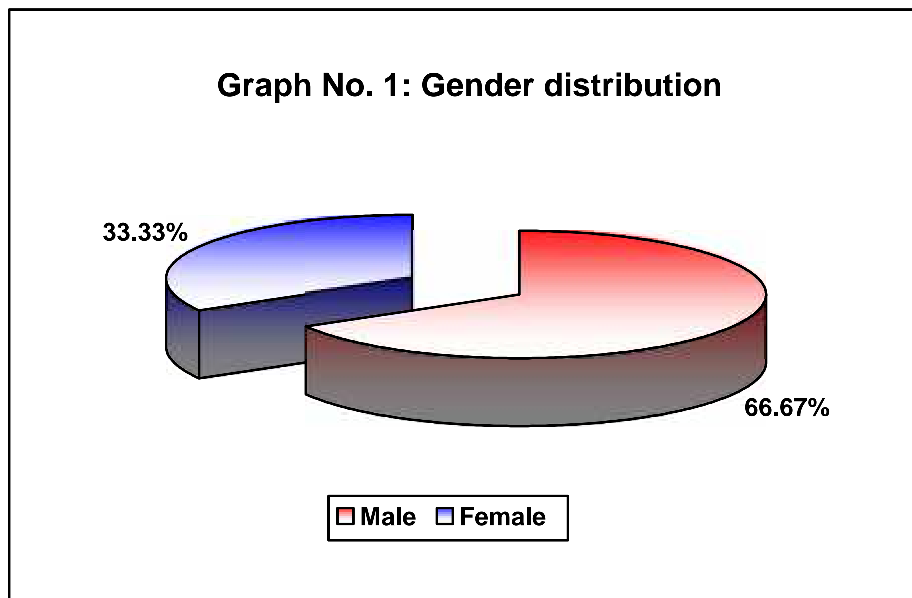
The data analysis was done for a period of three months as per Sanders 40 point Functional Evaluation Scale[10] using rates, ratios and percentages of different outcomes which were computed and compiled.

RESULTS

This series consisted of 15 cases of supracondylar and intercondylar fractures of the femur treated surgically by internal fixation with supracondylar intramedullary interlocking nail. Following observations were made from the data collected.

Table No. 1: Gender distribution

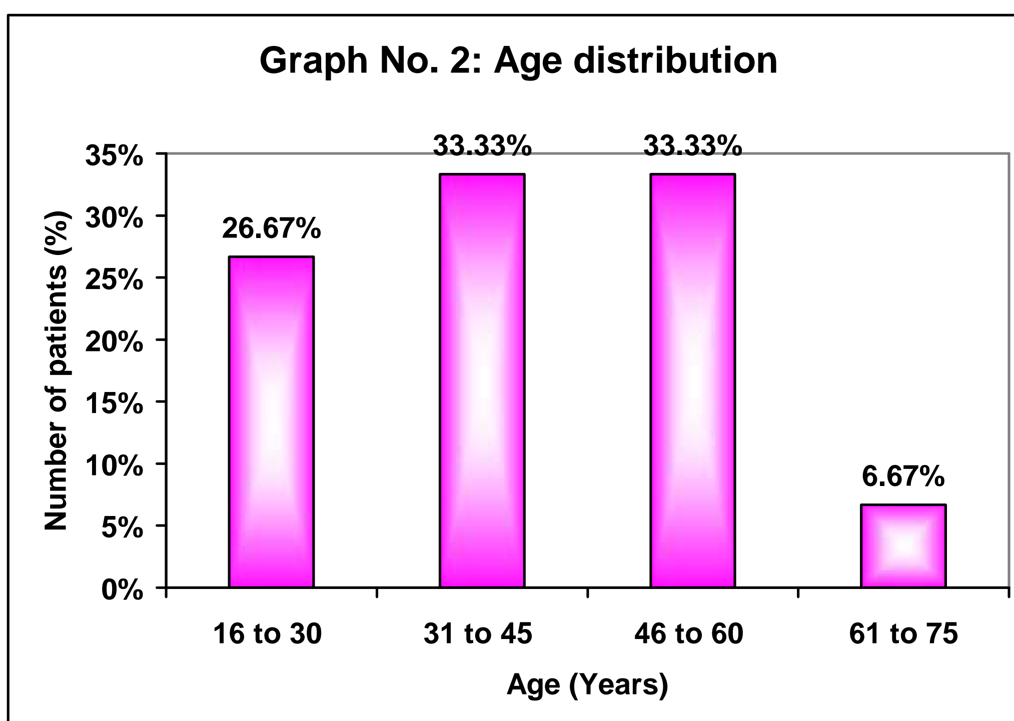
Gender	Number	Percentage
Male	10	66.67%
Female	05	33.33%
Total	15	100%



In the present study, out of the 15 patients there were 10 males accounting to 66.67% and five females making up the remaining 33.33%. Male to female ratio was 2:1.

Table No. 2: Age distribution

Age (Years)	Number	Percentage
16 to 30	04	26.67%
31 to 45	05	33.33%
46 to 60	05	33.33%
61 to 75	01	6.67%
Total	15	100%



Age of the patients ranged from 21 to 74 years with an average of 46 years. Majority (66.66%) of the patients were in the age group of 31 to 45 and 46 to 60 years. Four patients (26.67%) were in the age group of 16 to 30 years. There was one patient (6.67%) in the age group of 61 to 75 years.

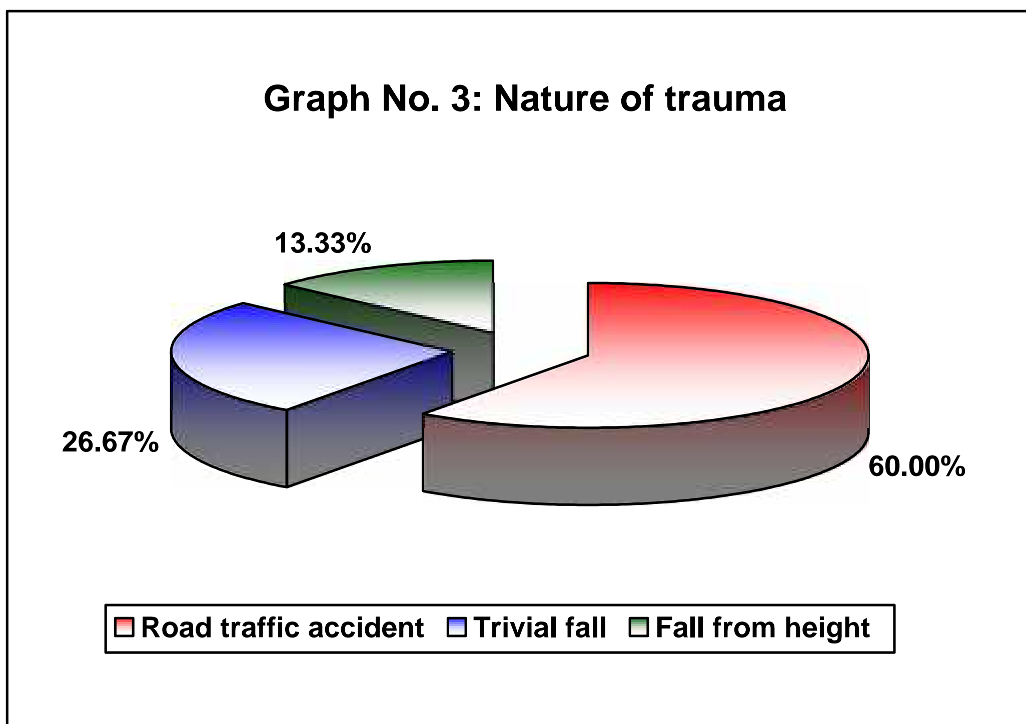
Table No. 3: Side of injury

Side	Number	Percentage
Right	09	60%
Left	06	40%
Total	15	100%

Right side was involved more commonly than the left in this study group. Right side was involved in nine patients making up for 60% of the fractures and the left was involved in six patients accounting for 40% of the fractures. None of the patients had bilateral fractures.

Table No. 4: Nature of trauma

Nature of trauma	Number	Percentage
Road traffic accident	09	60.00%
Trivial fall	04	26.67%
Fall from height	02	13.33%
Total	15	100%

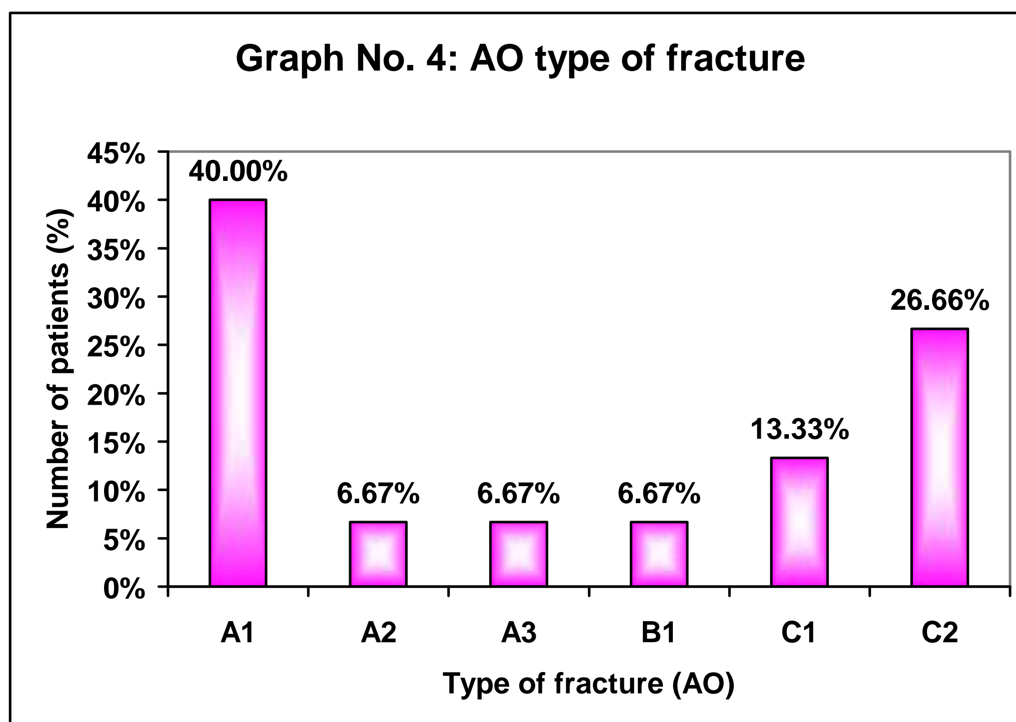


Majority of the fractures occurred due to road traffic accidents that is, 60%. Other causes included trivial fall (26.67%) and fall from height (13.33%).

Table No. 5: Type of fracture

a. AO type

AO Type	Number	Percentage
A1	06	40.00%
A2	01	6.67%
A3	01	6.67%
B1	01	6.67%
C1	02	13.33%
C2	04	26.66%
Total	15	100%



Out of the 15 fractures, majority were extra-articular fractures. The extraarticular fractures constituted 53.34% of the fractures. Among them 40%

were A1, 6.67% each were A2 and A3 fractures. 46.66% were intra-articular fractures. Among them majority (26.66%) were C2 fractures followed by 13.33% C1 fractures and 6.67% B1 fractures.

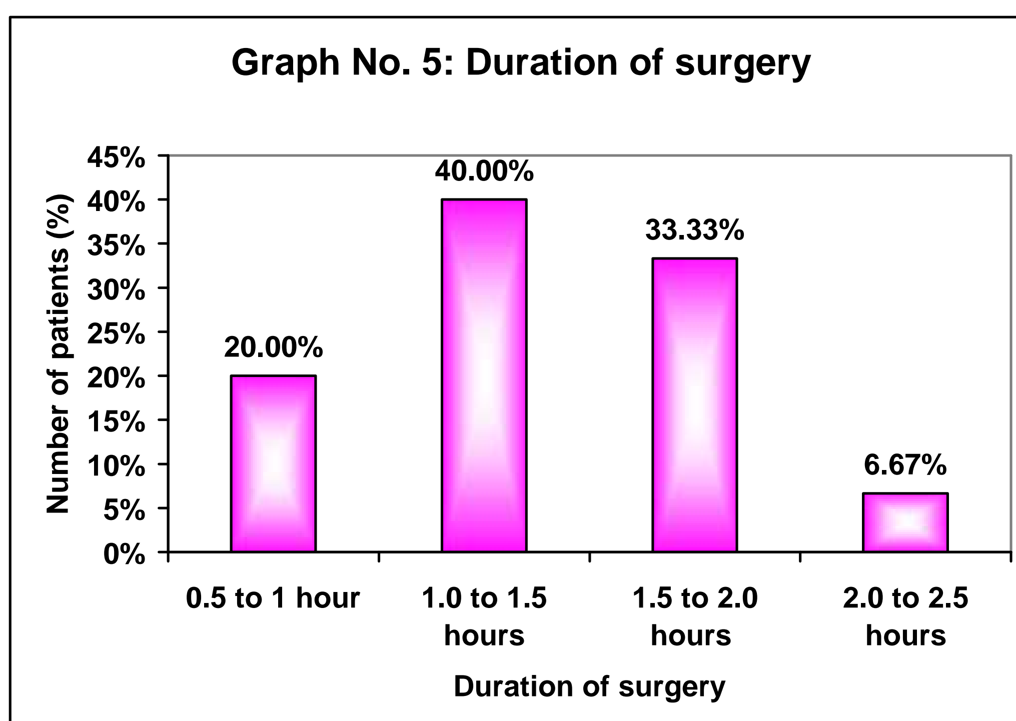
b. Closed or Compound fractures.

Type	Number	Percentage
Closed	13	86.67%
Compound	02	13.33%
Total	15	100%

In the present study majority (13 patients, 86.67%) were closed fractures and two (13.33%) were compound fractures. Among the compound fracture one was Gustilo type IIIA and other was type IIIB.

Table No. 6: Duration of surgery.

Duration	Number	Percentage
0.5 to 1 hour	03	20.00%
1 to 1.5 hours	06	40.00%
1.5 to 2.0 hours	05	33.33%
2.0 to 2.5 hours	01	6.67%
Total	15	100%

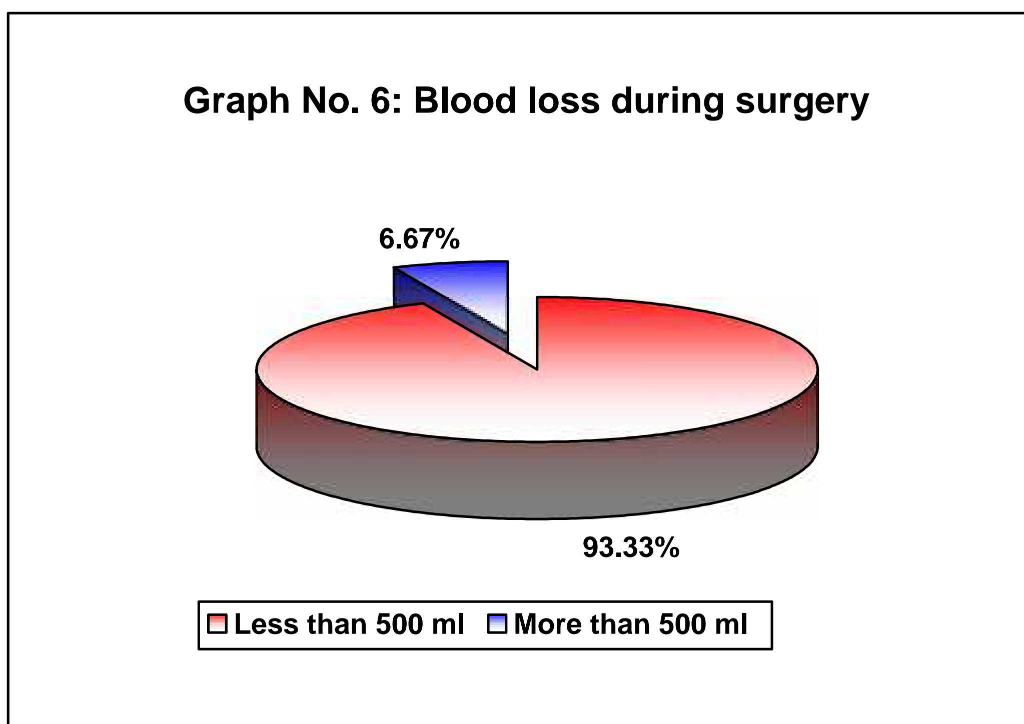


In three cases (20%) the duration was less than one hour, in six cases (40%) the duration was 1.0 to 1.5 hours and in five cases (33.33%) it was 1.5 to 2.0 hours. In one case (6.67%) the duration of surgery exceeded two hours.

Operative time averaged 100 minutes for all fractures, 90 minutes for extra-articular fractures and 110 minutes for intra-articular fractures.

Table No. 7: Blood loss during the surgery

Blood loss	Number	Percentage
Less than 500 ml	14	93.33%
More than 500 ml	01	6.67%
Total	15	100%



In 14 (93.33%) cases, blood loss was less than 500 ml and in one (6.67%) case it was more than 500 ml. Average estimated blood loss was 120 ml. None of the patients required blood transfusion.

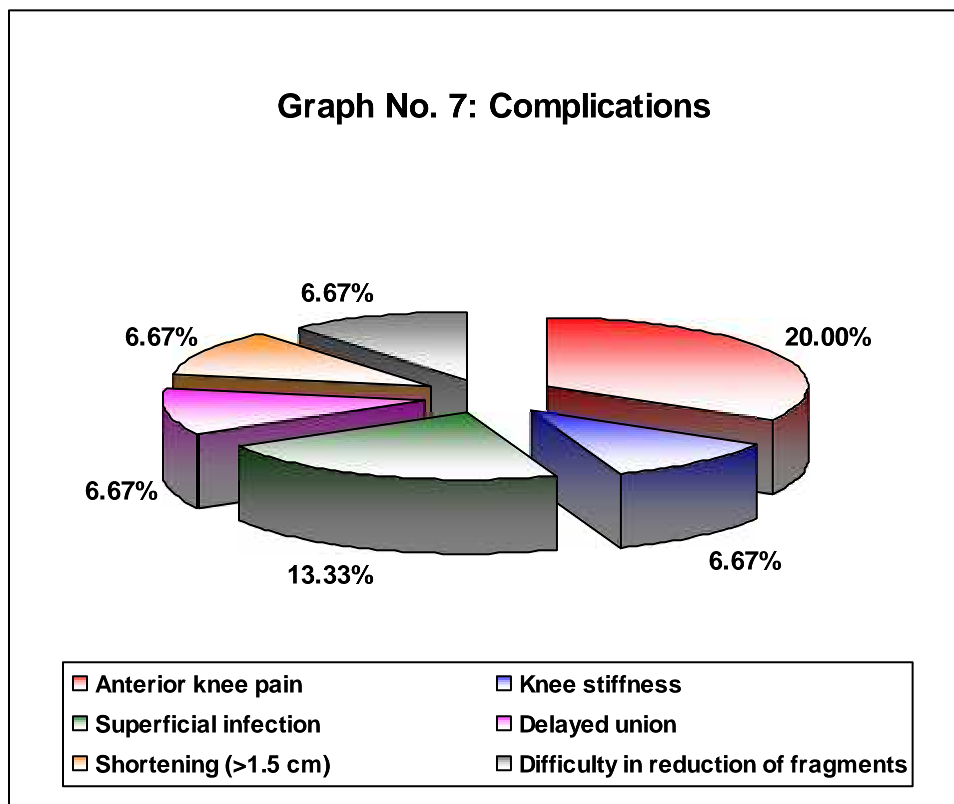
Table No. 8: Time to radiological union

Time (Weeks)	Number	Percentage
10 to 12	07	46.66%
12 to 14	06	40.00%
14 to 16	01	6.67%
16 to 18	01	6.67%
Total	15	100%

Average time to fracture union was 14 weeks (ranging from 10 to 18 weeks). Seven cases(46.66%) took 10 to 12 weeks time to radiological union.Six cases(40%) took between 12 to 14 weeks time to radiological union . There were two delayed unions(6.67%). None of the patients required bone grafting.

Table No. 9: Complications

Complications	Number	Percentage
Anterior knee pain	03	20.00%
Knee stiffness	01	6.67%
Superficial infection	01	6.67%
Delayed union	02	13.33%
Shortening (more than 1.5 cm)	01	6.67%
Difficulty in reduction of fragments	01	6.67%

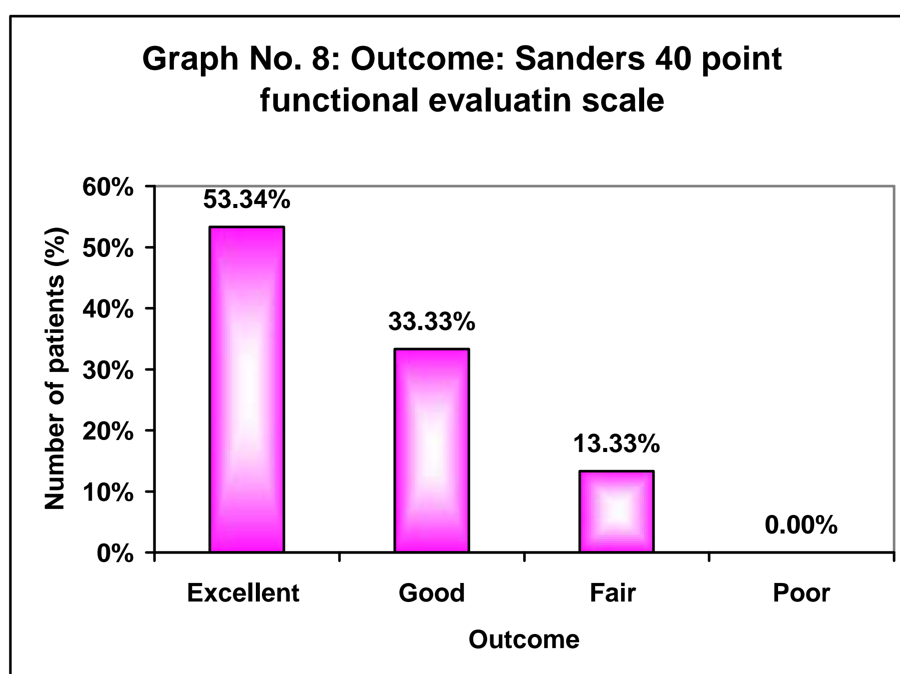


In the present study complications included anterior knee pain in three patients (20%). In these three patients, one patient had associated delayed union

and shortening (>1.5cm). One patient had knee stiffness, delayed union and intraoperative difficulty in reduction of fragments. Superficial infection was observed in one patient. There were no non union and implant failures.

Table No. 10: Outcome: Sanders 40 point functional evaluation scale

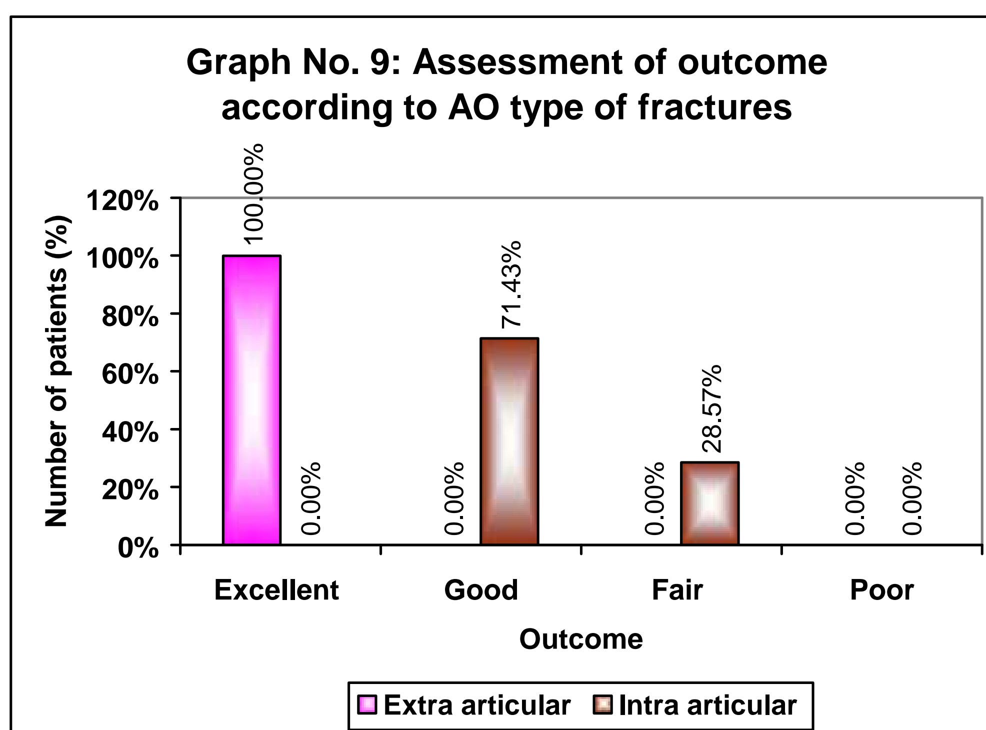
Outcome	Number	Percentage
Excellent	08	53.34%
Good	05	33.33%
Fair	02	13.33%
Poor	00	00%



Sander's 40 point scale was used to evaluate the functional results. Using this rating scale at sixth month, there were eight (53.33%) excellent results, five (33.33%) good results and two (13.33%) fair results. There were no patients reported with poor outcome.

Table No. 11: Assessment of outcome according to AO type of fractures

Outcome	Extra articular (Type A)		Intra articular (Type B and C)	
	Number	**Percentage**	**Number**	**Percentage**
Excellent	08	100%	00	00%
Good	00	00%	05	71.43%
Fair	00	00%	02	28.57%
Poor	00	00%	00	00%
Total	08	100%	07	100%



On further critical analysis, it was found that all type A extra-articular fractures had (100%) excellent results as compared to type C intra-articular fractures, which had 71.43% good and 28.57% fair results.

DISCUSSION

There has been no uniform reporting of the results of treatment of supracondylar and intercondylar femur fractures. It is difficult to compare the results of different reported series in literature, because of differences in demographic characteristics and differing fracture characteristics and is further complicated by the use of different classification systems and functional rating systems. Infact in an editorial comment on comparative results of the supracondylar fractures of the femur, there was proposed some minimum standards on classifying fractures and reporting results.[69] It was suggested that the results for different fracture groups should be separately analyzed, lest "mix" of fractures may alter results, like:

- Comminuted fractures versus non-comminuted fractures.
- Osteoporotic versus non-osteoporotic bones.
- Fractures with versus those without penetration of quadriceps by bone.
- Isolated fractures with concomitant ipsilateral injuries of the same knee versus multiple injuries not involving the ipsilateral knee.
- Simple versus compound fractures.
- Articular versus non-articular fractures.

Table No. 12: Comparison of demographic profile with other studies

Study	Age group (Years)	Average age	Males	Females
Seifert J et al[63]	17-92	44	29	19
Gellman RE[10]	24-84	50	13	09
Lucas ST[11]	15-69	39	17	08
Present study	21-74	46	10	05

The demographic profile of this study was comparable with that of few previous studies.[10,11,63]

The average age was 46 years and majority of fractures (ten) were seen in males. The present study validates the view that supracondylar and intercondylar femoral fractures are most commonly seen in adult male population.[1]

Table No. 13: Comparison of mechanism of injury and fracture characteristics

Study	Total	RTA (%)	Compound	Simple	Type A	Type B & C
Seifert J et al[63]	48	66%	6(12%)	42 (88%)	37 (77%)	11 (23%)
Gellman RE[10]	24	61%	8 (33%)	16 (67%)	13 (57%)	11 (43%)
Lucas ST[11]	25	72%	6 (24%)	19 (76%)	6 (24%)	19 (76%)
Present study	15	60%	2 (13.3%)	13 (86.67%)	8 (53.34%)	7 (46.66%)

Mechanism of injury and fracture characteristics of the present study were comparable with that of few previous studies.[10,11,63] Most high energy fractures

occurs in males. RTA is the major cause of morbidity.[2,10,11] The present study had nine (60%) cases .

Percentage of compound fractures were comparable with studies of few authors.[11,63] There were two cases (13.33%) in the present study. One was Gustilo type IIIA and other was type IIIB. Thorough irrigation and debridement was carried out for these two cases. After debridement, immediate definitive internal fixation with supracondylar nailing was done. According to experienced fracture surgeons any delay in fixation increases the technical difficulty of the procedure and contributes to patient morbidity.[1]

Table No. 14: Comparison of AO classification

Series	A1	A2	A3	B1	C1	C2	C3
Gellman RE[10]	9(41%)	2(8%)	2(8%)	-	2(08%)	5(24%)	4(11%)
Present study	6(40%)	1(6.67%)	1(6.67%)	1(6.67%)	2(13.33%)	4(26.66%)	-

Percentage of intra-articular fractures were more or less similar to that of Gellman et al respectively. This study had 46.66% of intra-articular fractures (type B and C) while there were 53.34% extra-articular (type A) fractures. There was no type C3 fractures included in the present study.[10]

The concept of retrograde supracondylar intramedullary nailing in distal femur fractures was developed in an attempt to over come the limitations of antegrade nailing in multiple system injuries (necessity of extension table) or in distal fracture type and to ensure the advantages of minimal invasive technique in contrast to plate osteosynthesis.[39] While supracondylar nailing is an accepted

minimal invasive procedure for osteosynthesis of femoral fractures, it also is recommended for type A and C distal femur fractures.[40,42]

Biomechanical analysis of various supracondylar nailing systems compared with the plate systems predominantly have shown a lower torsional and axial stiffness but similar bending stiffness, particularly for physiologic and critical modes of varus loading.[17,52,62,70,71] In 1991 it was reported “by virtue of intramedullary position”, the GSH nail has a biomechanical advantage over laterally placed conventional devices. The intramedullary position decreases the lever arm, reducing varus or valgus moment on the fracture.[11]

If reconstruction of the condylar region during supracondylar nailing is necessary, an optimal overview of the joint planes can be achieved easily using a parapatellar enlargement of the access route. This is necessary for type C intra-articular fractures that need open reconstruction and screw osteosynthesis of the condyles followed by intramedullary supracondylar nailing with no contact to the metaphyseal region. In effect it provides biological osteosynthesis of the distal femur fractures.[63]

In only two patients, open reconstruction of the intercondylar fracture was carried out.Both were type C2 intra-articular fractures. In rest of the 13 patients, percutaneous methods were sufficient enough to identify the entry point and to reconstruct the intercondylar fracture.

The correct choice of supracondylar nail insertion site is mandatory to restore the physiological rotation and mechanical alignment. The actual intercondylar location of this entry point has been variously described as dictated

by the clinical experience of various surgeons.[10,22,23,39,35] Examples of these descriptions are:

- Approximately one cm anterior to the attachment of the posterior cruciate ligament (fluoroscopic control), in line with the femoral shaft in both the anteroposterior and the lateral planes.

- In non-articular portion of the distal femur, at the junction of the cartilage with the synovial reflection in the notch close to the center of the femoral canal.

Despite the variability in these descriptions, clinical consensus indicates that one of the most important factors in entry-portal placement is alignment with the center of the femoral shaft on both the anteroposterior and lateral fluoroscopic views.

In the vast majority of femurs, the optimal entry portal for supracondylar femoral nailing is located in the expected safe position, anterior to the posterior cruciate ligament insertion and slightly medial to center of the intercondylar groove.[22] The potential compromise of the patellofemoral contact area by the retrograde entry portal can be recognized before nailing during the initial intraoperative fluoroscopic imaging of the fracture. In this way, the surgeon has the option, based on the individual clinical situation, to proceed with supracondylar nailing using a sub optimal entry-portal location.[22]

The present study gave stress on proper operative technique of supracondylar nailing. This included, identifying proper entry point for nail under

fluoroscopy, ideal nail size with thorough preoperative evaluation and anatomic reduction of fragments .Only one case (6.67%) had intra-operative difficulty in reduction of fragments. This case was a type C2 fracture and open reduction was used.

There are very few accounts in the literature that detail operative time or blood loss associated with internally fixing supracondylar fractures using lateral fixation devices. These devices are associated with substantial blood loss because of soft tissue dissection involved. In one study, an estimated blood loss of 500 ml and operative time of two hours was reported using a compression screw device.[72] The operative time and blood loss become important issues in the multiple injured patients and in elderly patients with significant medical problems.

Table No. 15: Comparison of blood loss, operative time and union rate between different studies

Series	Average Blood loss (ml)	Average Operative time (min)	Average Union rate (weeks)	Comment
Seifert J et al[63]	-	-	12.6	All fractures healed; 1 open reduction
Gellman RE[10]	110	154	12	All healed; one bone graft
Lucas ST[11]	170	156	14	All healed; one open reduction
Present study	120	100	14	All healed; 2 Open reduction

Comparing the present data with the previous series,[10,11,63] similar results were found regarding time to union rates.

The present study depicts that supracondylar nail has markedly decreased blood loss and operative time associated with treatment of supracondylar and intercondylar femoral fractures. Average estimated blood loss was 120 ml. In 14 (93.33%) cases, blood loss was less than 500 ml and in one (6.67%) case it was more than 500 ml. This case had associated severe hypertension and diabetes mellitus. None of the patients required blood transfusion.

Furthurmore, average operative time is lesser as compared to similar studies.[10,11] In one case (6.67%), the duration of surgery exceeded two hours. There was associated compound (open) type IIIB fracture with this case which

required thorough debridement. Operative time averaged 100 minutes for all fractures.

Table No. 16: Comparison of functional outcomes with different rating scales

Series	Functional results	Complications
Seifert J et al[63]	Leung score: A: 16 % fair; 16% good; 16% excellent C: 18 % fair; 73% good; 19% excellent	2 shortening; 1 insufficient fracture reposition; 1 spiral fracture.
Gellman RE[10]	Sanders 40 point evaluation scale : 30% excellent;54% good; 8% fair;8% poor	1 malunion; 3 shortening; 1 nail impingement.
Lucas ST[11]	A: ROM 92^0; Average flexion 98^0 C: ROM 103^0; Average flexion 106^0	4 knee pain; 1 malunion; 1 shortening; 2 posttraumatic arthritis; 1 bent nail; 1 late infection.
Present study	Sanders 40 point evaluation scale: 53.34% excellent; 33.33% good;13.33% fair Type A 100% excellent Type C 71.43% good; 28.57% fair	3 anterior knee pain; 2 delayed union; 1 knee stiffness; 1 shortening and 1 difficulty in reduction of fragments.

Numerous rating scales have been used to determine the functional outcomes after surgical treatment of supracondylar and intercondylar fractures of femur.[3,4,14] However no rating scale is validated to be superior to other.

Sanders 40 point functional evaluation scale[10] has been used in this study because it emphasizes on important patient outcome variables such as pain, functions as related to activities of daily living, range of motion, extension, deformation, shortening, pain, walking ability, stair climbing and return to work.[10] This scale was evaluated for patients at each follow up of four weeks, three months and sixth month. The results at the final follow up of six months were taken into consideration.

Using this scale, there were 100% excellent results in type A extra-articular fractures.The excellent results of type A fractures can be attributed to simple, stable fracture configuration, no intra-articular involvement and vigorous post operative rehabilitation. This study compared to a previous study[10] (using same scale) showed better scores. The previous study included type C3 fractures. These fractures were excluded from this study.

Thus, supracondylar retrograde nailing represents a reliable fixation method for extra-articular (A1-3) and simple intra-articular (C1-2) fractures of the supracondylar area as shown in previous studies.[42] However in all B, in low transcondylar (some C2) and most comminuted condylar (C3) fractures, one should not compromise anatomic and stable reconstructions of articular surface to use a retrograde nail device.[42] Rather in these specific complex fractures of the condyles, one should use standard open reduction and internal fixation of the

condyles with lag screws and plate fixation with indirect reduction of the shaft to the condyles.

C2 and C3 fractures are still regarded as domains for plate fixation by some investigators. But some investigators have performed retrograde nailing in all C type fractures including C3 fractures.[23] This study had lower scores in patients with type C fractures especially type C2 and agrees with the former studies.[42] There were 71.43% good with 28.57% fair results in type B, C1 and C2 intra-articular fractures in this study. There were no excellent results but no poor results were observed either in the present study.

All the fractures in the present study healed at an average of 14 weeks. Previous studies with lateral fixation devices report similar time to union, however 25 to 40% of these patients underwent bone grafting primarily with reports of delayed union and nonunion.[3,72] In fact, a study recommended bone grafting in all comminuted supracondylar fractures.[3] Dreaded complications of non union and malunion were avoided in this study. Also, following correct operative technique[2] resulted in avoiding these complications. Earlier studies had malunion as an associated complication.[10,11]

Data from this present study suggest that supracondylar nailing leads to rapid healing without need for bone grafting inspite of comminution and bone loss. The decreased need for bone grafting may be attributed to decreased periosteal stripping and intramedullary reaming.

In the present study, majority of patients had their fractures healed in excellent alignment without shortening. The 1.8cm shortening that occurred in

one patient (6.67%) did affect the final functional outcome .This patient had a type C2 fracture and had fair results at the final follow up of six months.The patient could do well with shoe raise. Shortening as a complication has been discussed previously in many studies.[10,11,63] According to these studies, communition with bone loss in these complex fractures decrease the final true length of the lower limb.

Of great concern than the loss of alignment is the problem of nail impingement. Three patients in this study had occasional anterior knee pain. These patients had to use rail while climbing stairs. This is acknowledged as technical error of proper nail countersinking, nail migration or because of poor original instrumentation. The patients were comfortable with mild analgesics. Meticulous attention to every technical detail can avoid the complication and such minor mishaps.[16,22,39]

Infection rates are low (0% to 8%), with current principles of irrigation, debridement and antibiotic prophylaxis in the series using lateral fixation devices.[15,16,18] In this study, there was one case of superficial wound infection, which subsided after debridement and intravenous antibiotics. This case had associated open degloving injury due to trauma. Compound fractures did not alter the functional results in this study. The present study had no delayed or deep infection as compared to a previous study where supracondylar nailing was used.[11] Greater numbers are needed to determine if the infection rate can be decreased further with the retrograde supracondylar nail.

Two cases (13.33%) took longer then the expected time to heal (16 and 18 weeks) and resulted in delayed union. Both cases were intra articular (C2) fractures and had associated injuries (fracture of femur in one case and SAH with brachial plexus injury in other case) involved. In these two cases, one (6.67%) had associated knee stiffness with flexion restricted to less then 90^0. This patient could carry out activities of daily living with difficulty and had fair results at sixth month follow up. Thus, the importance of intraarticular fractures with associated injuries on normal time to radiological union has been emphasized in the present study. These results are in concordance with previous studies.[12,64]

Knee joint sepsis following supracondylar nailing is very rare.[39] There was no knee joint infection in this study. No cases in present study were lost to follow up.

Some studies have shown a less satisfactory outcome in elderly patients, presumably because of poorer quality bone stock.[3,5] The lack of elderly population base in this study makes it impossible to address this question.

One common confounding variable in the present study that was not evaluated properly was pre-existing arthritic condition, which can lower the score. This limitation is acknowledged in this study.

CONCLUSION

Supracondylar intramedullary nailing in supracondylar and intercondylar femoral fractures makes “biological osteosynthesis” possible in these difficult and complex fractures with less operative time, minimal soft tissue stripping, minimal blood loss, decreased need for bone grafting and reasonably rigid fixation in osteoporotic bones.

It provides predictably reproducible good functional results with low morbidity and good healing rates as well as satisfactory mobility in AO type A, type B and C distal femoral fractures. This safe, successful, effective and reliable technique should find a place in the armamentarium of every orthopedic surgeon dealing with distal femoral fractures that initially requires attention to details of operative technique.

A word of caution is that, effects of the supracondylar nailing on the knee in long-term clinical outcome studies are awaited.

SUMMARY

This present study comprised of supracondylar intramedullary nailing of supracondylar and intercondylar femoral fractures in 15 patients. The results are summarized as follows;

- Majority (66.6%) of the patients were in the age group of 31 to 60 yrs.
- Males (66.67%) were most commonly affected.
- Predominantly right side (60%) was involved.
- Road traffic accidents (60%) were the most common mode of injury.
- Two (13.33%) were compound fractures. Among them one (50%) was Gustilo type IIIA and the other (50%) was Gustilo type IIIB fracture.
- In only two patients, open reconstruction of the intercondylar fracture followed by nailing was required. These two patients had type C (intra-articular) fractures. In rest of the 13 patients percutaneous methods were sufficient enough to identify the entry point, to achieve reduction, to do nailing and to reconstruct the intercondylar fracture.
- In all cases except one, the surgery was performed within two hours. There was associated compound (open) type IIIB fracture with this case which required thorough debridement. The average duration of surgery was 100 minutes.
- Average estimated blood loss was 120 ml.

- All fractures united at an average of 14 weeks (10 to 18 weeks), with two cases of delayed union. No cases of nonunion or malunion were noted.

- Using Sanders 40 point evaluation scale, there was a final functional outcome of 86% good to excellent results in this study.

- All type A fractures (extra-articular) had 100% excellent results.

- There were good (71.43%) to fair (28.57%) results in all type C fractures (intra-articular). There were no excellent results for type C fractures but no poor results either.

- Three patients complained of occasional anterior knee pain, more on climbing stairs. These patients got pain relief with mild analgesics.

- Two patients (13.33%) with delayed union were seen in this study. No bone grafting was required for these two patients.

- One patient (6.67%) with knee stiffness carried routine activities of daily living with slight difficulty. There was shortening of limb (1.8 cm) in one (6.67%) patient, which could be managed with shoe raise. These patients had fair results at the final follow up of sixth month.

BIBLIOGRAPHY

1. Bucholz RW, Heckman JD. Rockwood and Greens fractures in adults. 6th Ed. London: Lippincott Williams and Wilkins; 2005.

2. Canale ST. Campbell's operative orthopedics. 10th Ed. St. Louis: Mosby; 2003.

3. Schatzker J, Lambert DC. Supracondylar fractures of the femur. Clin Orthop 1979; 138: 77.

4. Neer CS, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur: a study of one hundred and ten cases, J Bone Joint Surg 1967; 49A: 591.

5. Seinsheimer F. Fractures of the distal femur. Clin Orthop 1980; 153: 169.

6. Gliatis J, Megas P, Panagiotopoulos E, Lambiris E. Midterm results of treatment with a retrograde nail for supracondylar periprosthetic fractures of the femur following total knee arthroplasty. J Orthop Trauma 2005; 19(3): 164-70.

7. Rabin SI, Carlson D, Rabin SL. Complications of Supracondylar Femur Fractures. Loyola U Orthopaedic J 1995; 4: 30-8.

8. Koval KJ, Seligson D, Rosen H, Fee K. Distal femoral nonunion: treatment with a retrograde inserted locked intramedullary nail. J Orthop Trauma. 1995; 9(4):285-91.

9. Green SA. Distal intramedullary fixation of supracondylar fractures of femur. Tech Orthop 1988; 3: 71-6.

10. Gellman GD, Paiement HD, Green, Coughlin RR. Treatment of Supracondylar Femoral Fractures With a Retrograde Intramedullary nail. Clin Orthop Relat Res 1996; 332: 90-7.

11. Lucas SM, Henry SL, Seligson D. Management of supracondylar fractures of the femur with the GSH supracondylar nail: The percutaneous technique. Tech Orthop 1995; 9: 189.

12. Mize RD, Bucholz RW, Grogan DP: Surgical treatment of displaced, comminuted fractures of the distal end of the femur: an extensile approach, J Bone Joint Surg 1982; 64A: 871.

13. Stewart MJ, Sisk TD, Wallace SL. Fractures of distal third of femur. J Bone Joint Surg (Am) 1966; 48: 784-807.

14. Olerud S. Operative treatment of supracondylar-condylar fractures of the femur: Technique and results in fifteen cases, J Bone Joint Surg 1964; 54A: 1015.

15. Sanders R, Regazzoni P, Rüedi TP. Treatment of supracondylar-intracondylar fractures of the femur using the dynamic condylar screw. J Orthop Trauma 1989; 3: 214.

16. Ostrum RF, Geel C. Indirect reduction and internal fixation of supracondylar femur fractures without bone graft. J Orthop Trauma 1995; 9: 278.

17. Firoozbakhsh K, Behzadi K, DeCoster TA, Moneim MS, Naraghi FF. Mechanics of retrograde nail versus plate fixation for supracondylar femur fractures. J Orthop Trauma. 1995; 9(2): 152-7.

18. Marti A, Fankhauser C, Frenk A, Cordey J, Gasser B. Biomechanical evaluation of the less invasive stabilization system for the internal fixation of distal femur fractures. J Orthop Trauma 15:482, 2001.

19. Sudheer U, Sreejith TG, Marthya A, Gopinath P, Raveendran MK. A Prospective Study On The Functional Outcome Following Open Reduction And Internal Fixation In Supracondylar Intercondylar Fracture Femur. J. Orthopaedics 2007;4(2): e30.

20. Tornetta P, Tiburzi D. The treatment of femoral shaft fractures using intramedullary interlocked nails with and without intramedullary reaming: a preliminary report. J Orthop Trauma 1997; 11: 89.

21. Whittle APW, Russell TA, Taylor JC, Tagert B. Treatment of supracondylar and intercondylar fractures of the femur with antegrade interlocking intramedullary nails, Orthop Trans 1995; 18: 103-23.

22. Carmack DB, Moed BR, Kingston C, Zmurko M, Watson JT, Richardson M. Identification of the optimal intercondylar starting point for retrograde femoral nailing: an anatomic study. J Trauma. 2003; 55(4): 692-5.

23. Krettek C, Rudolf J, Schandelmaier P, Guy P, Konemann B, Tscherne H. Unreamed intramedullary nailing of femoral shaft fractures: operative technique and early clinical experience with the standard locking option. Injury. 1996; 27(4): 233-54.

24. Bain G, Zacest A, Paterson D, Middleton J, Pohl AP. Abduction strength following intramedullary nailing of the femur. J Orthop Trauma 1997; 11: 93-7.

25. Wiss D. Master techniques in orthopaedic surgery. Philadelphia: Lippincott-Raven; 1998.

26. Wiss D, Watson JT, Johnson EE. Fractures of the knee. In: Rockwood CA, Green DP, Bucholz RW, et al., eds. Fractures in adults, 4th ed. Philadelphia: Lippincott-Raven; 1996

27. Browner BD, Levine AM, Jupiter JB. Skeletal trauma: fractures, dislocations, ligamentous injuries, 2nd ed. Philadelphia: WB Saunders; 1997.

28. Lipshutz, BB. Studies on the Blood Vascular Tree. Anat Rec 1995; 9: 285-91.

29. Koch JC. The Laws of Bone Architecture, Am. Jour. Anat., 1917, xxi.

30. Bardeen CR. Development and Variation, of the Inferior Extremity. Am J Anat 1907; vi.

31. Muller KH, Strosche H, Scheuer I. Plate osteosynthesis in posttraumatic deformities of the femoral shaft. Arch Orthop Trauma Surg 1984; 103: 303.

32. Orthopaedic Trauma Association Committee for Coding and Classification. Fracture and dislocation compendium. J Orthop Trauma 1996; 10(Suppl 1): 41-5.

33. Walling AK, Seradge H, Speigel PG. Injuries to the knee ligaments with fractures of the femur. J Bone Joint Surg Am 1982; 64: 1324-7.

34. Green NE, Allen FL. Vascular injuries associated with dislocation of the knee. J Bone Joint Surg Am 1977; 59: 236-9.

35. Herscovici D, Whiteman KW. Retrograde nailing of the femur using an intercondylar approach. Clin Orthop 1996; 332: 98-104.

36. Patterson B, Routt M, Benirshke S, Hansen S. Retrograde nailing of femoral shaft fractures. J Trauma 1995; 38: 38-43.

37. Lezius A. Intramedullary nailing of intratrochanteric and subtrochanteric fractures with a curved nail. J Int College Surg 1950; 13: 569-72.

38. Swiontkowski MF, Hansen ST, Kellam J. Ipsilateral fractures of femoral neck and shaft. A treatment protocol. J Bone Joint Surg 1984; 66A: 260-8.

39. Moed BR, Watson JT. Retrograde intramedullary nailing, without reaming, of fractures of the femoral shaft in multiply injured patients. J Bone Joint Surg 1995; 77A: 1520-7.

40. Saw A, Lau CP. Supracondylar nailing for difficult distal femur fractures. J Orthop Surg 2003: 11(2): 141–7.

41. Handolin L, Pajarinen J, Lindahl J, Hirvensalo E. Retrograde Intramedullary Nailing in Supracondylar Femoral Fractures – The Töölö Hospital Experience. Eero Hirvensalo Société d'Orthopédie et de Traumatologie 2002; 25:

42. Neubauer TH, Ritter E, Potschka TH, Karlbauer A, Wagner M. Retrograde Nailing of Femoral Fractures. Acta Chirurgiae Orthopaedicae Et Traumatologiae echosl 2008; 75: 158-66.

43. El-Kawy S, Ansara S, Moftah A, Shalaby H, Varughese V. Retrograde femoral nailing in elderly patients with supracondylar fracture femur; is it the answer for a clinical problem? Intern Orthop (SICOT) 2007; 31: 83-6.

44. Christodoulou A, Terzidis I, Ploumis A, Metsovitis S, Koukoulidis A, Toptsis C. Supracondylar femoral fractures in elderly patients treated with the dynamic condylar screw and the retrograde intramedullary nail: a comparative study of the two methods. Arch Orthop Trauma Surg. 2005; 125(2): 73-9.

45. Hartin L, Harris M, Hazratwala L. Retrograde nailing versus fixed-angle blade plating for supracondylar femoral fractures: a randomized controlled trial. ANZ J Surg 2006; 76(5): 290-4.

46. Halwai MA, Travma U, Derg CA. Bridge plate osteosynthesis using dynamic condylar screw (DCS) or retrograde intramedullary

supracondylar nail (RIMSN) in the treatment of distal femoral fractures: comparison of two methodsin a prospective randomized study. Turk J Trauma Emerg Surg 2009; 15(2): 148-53.

47. Gregory P, DiCicco J, Karpik K, DiPasquale T, Herscovici D, Sanders R. Ipsilateral fractures of the femur and tibia: Treatment with retrograde femoral nailing and unreamed tibial nailing. J OrthopTrauma 1996; 10: 309-16.

48. Brumback RJ, Ellison TS, Molligan H, Molligan DJ, Mahaffey S, Schmidhauser C. Pudendal nerve palsy complicating intramedullary nailing of the femur. J Bone Joint Surg 1992; 74A: 1450-5.

49. Kao JT, Burton D, Comstock C, McClellan RT. Pudendal nerve palsy after femoral intramedullary nailing. Orthop Trans 1991; 15: 836.

50. Ricci WM, Bellabarba C, O'Boyle M. Retrograde vs. antegrade nailing of femoral shaft fractures. Vancouver, British Columbia, Canada: Presented at the Orthopaedic Trauma Association Annual Meeting 1998; 1998.

51. Yu CK, Singh VA, Mariapan S, Chong ST. Antegrade Versus Retrograde Locked Intramedullary Nailing for Femoral Fractures: Which Is Better? Eur J Trauma Emerg Surg 2007; 33: 135-40.

52. DeLong WG, Bennett FS. The Science and Practice of Intramedullary Nailing: The GSH supracondylar nail. 2nd Ed. Media, PA: Williams and Wilkins; 1997.

53. Sinha AK, Mani GV. Retrograde nailing for distal femoral fractures in Paget's disease. Injury 1996; 27: 514-5.

54. Brumback R, Wells D, Lakatoss R, Poka A, Bathon GH, Burgess AR. Heterotopic ossification about the hip after intramedullary rodding for fractures of the femur. J Bone Joint Surg 1990; 72A: 1067-73.

55. Parvizi J, Jain N, Schmidt AH. Periprosthetic knee fractures. J Orthop Trauma. 2008; 22(9): 663-71.

56. Bong MR, Egol KA, Koval KJ, Kummer FJ, Su ET, Iesaka K, Bayer J, et al. Comparison of the LISS and a retrograde-inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty. J Arthroplasty 2002; 17(7): 876-81.

57. Morgan E, Ostrum RF, DiCicco J, Mc Elroy J, Poka A. Effects of retrogradefemoral intramedullary nailing on the patellofemoral articulation. J Orthop Trauma 1999; 13 (1): 13-6.

58. Steinberg G, Hubbard C. Heterotopic ossification after intramedullary rodding. J Orthop Trauma 1993; 7: 536-42.

59. Johnson E, Marroquin C, Kossovosky N. Synovial metalllosis resulting from intraarticular intramedullary nailing of a distal femoral nonunion. J Orthop Trauma 1993; 7: 320-4.

60. Nabi DG, Rashid TS, Ahmed KK, Ahmed HM. Radiologically Visible Surgical Error and Poor Outcome of Internal Fixation in Distal Femoral Fractures. Orrttopediia Traumatologia Rehabilitacja 2008; 4(6) 10: 362-6.

61. Iannacone WM, Bennette FS, Delong G, Born CT. Initial experience with the treatment of supracondylar femoral fractures using the supracondylar intramedullary nail: a preliminary report. J Orthop Trauma 1994; 8(4): 322-7.

62. Smith & Nephew Richards, Inc.: Fatigue testing of the supracondylar nail. Memphis, TN: Technical Report; 92-122.

63. Seifert J, Stengal D, Matthes G, Hinz P, Ekkernkamp A, Ostermann, PAW et al. Retrograde Fixation of Distal Femoral Fractures: Results Using a New Nail System. J Orthop Trauma 2003; 17 (7): 488-95.

64. Helfet DL, Lorich DG. Retrograde intramedullary nailing of supracondylar femoral fractures. Clin Orthop 1988; 350: 80-4.

65. Johnson KD, Hicken G. Distal femur fractures. Orthop Clin 1987; 18 (1): 115-32.

66. Ganz SB. Physical therapy of the knee. In: Insall JN (ed). Surgery of the Knee. New York: Churchill Livingstone; 1993.

67. Salter RB, Simmons DF, The biological effect of continuous passive motion on healing of full thickness defects in articular cartilage. J Bone Joint 1980; 62A: 1232-51.

68. Horne LT, Blue BA. Intraarticular heterotopic ossification on the knee following intramedullary nailing of the fractured femur using a retrograde method (case reports). J Orthop Trauma 1999; 13(5): 385-8.

69. Laros GS. Supracondylar fractures of the femur. Editorial comment and comparative results. Clin Orthop 1979; 138: 9-12.

70. Hora NM, David C, Haynes A, Grimm MJ. Biomechanical analysis of supracondylar femoral fractures fixed with modern retrograde intramedullary nails. J Orthop Trauma 1999; 13 (8): 539-44.

71. Ito K, Grass R, Zwipp H. Internal fixation of supracondylar femoral fractures: Comparative biomechanical performances of 95 degree blade plate and two retrograde nails. J Orthop Trauma 1998; 12: 259-66.

72. Pritchett JW. Supracondylar fractures of the femur. Clin Orthop. 1984; (184): 173-7.

ANNEXURE I

CONSENT FORM

TITLE OF THE STUDY: "TO EVALUATE SUPRACONDYLAR INTRAMEDULLARY NAILING IN SUPRACONDYLAR AND INTER-CONDYLAR FRACTURE OF FEMUR IN ADULTS - A HOSPITAL BASED PROSPECTIVE STUDY".

PRINCIPAL INVESTIGATOR: Dr Abhinav Thakur

Introduction and purpose

The Retrograde Supracondylar nail has been used successfully in treating both open and closed supracondylar fractures of femur. This is an improved modality of treatment resulting in good post operative rehabilitation and excellent patient compliance.

Procedure

In this study you will be asked about the manner in which you got the injury, the present and past history and then after detailed clinical examination and investigations you will be taken for required procedure with GSH retrograde supracondylar nail would be used. The nail would be can be inserted with either an open or percutaneous technique. Patient would be followed up with post-operative X-rays and regular physiotherapy. The patients will be followed up at fourth week, third month and sixth month. Roentgenograms will be taken in AP and Lateral views to look for signs of radiological union. At every follow up

clinical examination would be done. Clinical union would be there if fracture site becomes stable and pain free. The time taken for radiological and clinical union would be noted down.You will also be observed for any kind of complication and if present will be treated.

Benefits

1. You will be getting an upcoming modality of treatment as part of the internationally accepted standards.
2. The results of the study may improve the treatment guidelines thereby benefiting other patients.

Risks:

1. Difficulty in reduction
2. Infection
3. Knee stiffness and knee sepsis
4. Patellar impingement of the nail
5. Malalignment

Alternatives

If the patient is not ready to act as a participant, he/she will be provided with conventional modality of treatment.

Voluntary participation/ withdrawal

Taking part in this study is voluntary. I may choose not to take part in this study, or if I decide to take part I can later change my mind and withdraw from

the study. My decision will not change the present or future health care or other services that I receive. The study doctor or the sponsor may stop my participation in this study. I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study I will receive the standard treatment for patients with my condition.

Costs

The cost to the patient of the supracondylar nail, would come to around 3000/- and would be explained to the patient.

Compensation

In the event of any injury related to this study treatment will be available through KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum but there would be no compensation for such medical treatment by law.

Confidentiality

All information collected about you during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify you in this research record. Information from this study may be published but your identity will be confidential in any publication. The results of this study would only be useful in patient care. You will be given a copy of this form for your information.

Question

If any enquiries in the future or in case of research related injury illness, you may contact following person.

Dr. Shailesh.V. Udapudi,
Guide
Professor,
Department of Orthopaedics,
Belgaum.
J. N. Medical College, Belgaum.
Ph No. 0831-2473777.
Ext. 1312, 1779

Dr. Abhinav Thakur
Post-Graduate Student,
Department of Orthopaedics,
J. N. Medical College,

Ph.0831-2473777
Ext. 1312, 1779

Consent to participate in research study

I voluntarily agree to take part in this study by signing on the line below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form.

Signature of the Participant or legally authorized representative.

Participant's Name : ....

Signature : ....

Name of the legally authorized representative : ....

Signature : ....

Witness's Name : ....

Signature : ....

Investigators name and Signature : ....

Date and Place : ....

ANNEXURE II

PROFORMA

1) NAME :

2) AGE :

3) SEX :

4) ADDRESS :

5) OCCUPATION :

6) DATE OF INJURY :

7) DATE OF ADMISSION :

8) DATE OF SURGERY :

9) DATE OF DISCHARGE :

10) NATURE OF TRAUMA :

a) RTA Yes/No b) Sports injuries Yes/No

c) Fall from height Yes/No d) Assault Yes/No

e) Trivial injuries Yes/No f) Other injuries Yes/No

11) Mechanism of injury

a) Direct Yes/No b) Indirect Yes/No

12) Duration since injury

a) < 1 week b) > 1 week

13) SIGNIFICANT PAST HISTORY:

a) History of	Diabetes	Yes/No
	Hypertension	Yes/No
	Asthma	Yes/No
	Epilepsy	Yes/No
	Other conditions	Yes/No
b) Previous history of fractures		Yes/No

14) SIGNIFICANT FAMILY HISTORY:

15) GENERAL PHYSICAL EXAMINATION:

a) Pulse rate

b) Blood Pressure

c) SPO_2

d) Respiratory Rate

e) Pallor Yes/No

f) Cyanosis Yes/No

g) Icterus Yes/No

h) Lymphadenopathy Yes/No

i) RS examination:

j) CVS examination:

k) PA examination:

l) CNS examination:

m) Presence of associated injury: Yes/No If yes, specify

16) LOCAL EXAMINATION

17) RELEVANT INVESTIGATIONS: Yes/No

- Roentgenogram of the distal femur and knee joints AP and LAT Yes/No
- Additional x-rays of associated injuries Yes/No
- Routine blood investigations like Hb, TLC, DLC, ESR Yes/No
- Renal profile Yes/No
- HIV, HbsAg Yes/No
- Chest X-ray, ECG Yes/No

18) DIAGNOSIS:

19) TREATMENT:

Yes/No

First Aid: a) Immobilisation of the limb

b) Thomas Splint/POP slab

c) Analgesics

Definitive Treatment:

a) Relevant investigations and medical fitness for surgery. Yes/No

b) Anaesthesia Spinal/General

c) Retrograde supracondylar nail

d) Antibiotic therapy- preop and postop Yes/No

e)Analgesics Yes/No

20) COMPLICATIONS:

Intraoperative: a) Difficulty in reduction of fragments Yes/No

b) Excessive Bleeding Yes/No

c) Wrong placement of implant Yes/No

d) Other complications Yes/No

Postoperative: A) Immediate:

a) Bleeding Yes/No

b) Infection Yes/No

B) Delayed:

a) Chronic Infection Yes/No

b) Knee Stiffness Yes/No

c) Patellar Impingement of the nail Yes/No

d) Malalignment Yes/No

e) Knee Sepsis Yes/No

21) FOLLOW UP:

Date:

Serial No. of Follow Up :

Time since Surgery :

Clinical Union :

Pain at fracture site Yes/No

Abnormal Mobility Yes/No

Transmission of Movements Yes/No

Radiological Union:X-Ray Yes/No

SANDERS 40 POINT FUNCTIONAL EVALUATION SCALE

Function	Result	Points
Range of motion of the knee (^{0})		
Flexion		
>125	Excellent	6
100-124	Good	4
90-99	Fair	2
<90	Poor	0
Extension		
0	Excellent	3
≤5	Good	2
6-10	Fair	1
>10	Poor	0
Deformation		
Angulation (^{0})		
0	Excellent	3
<10	Good	2
10-15	Fair	1
>15	Poor	0
Shortening (cm)		
0	Excellent	3
<1.5	Good	2
1.5-2.5	Fair	1
>2.5	Poor	0
Pain		
None	Excellent	3
Occasional or with changes in weather or both	Good	2
With fatigue	Fair	1
Constant	Poor	0

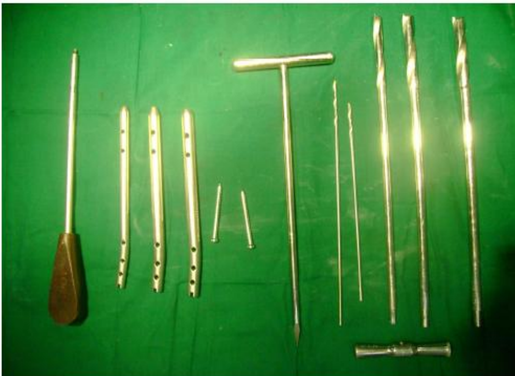
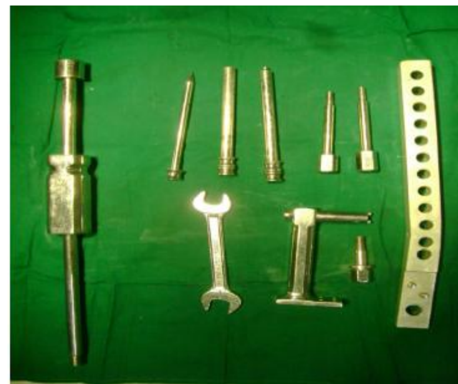
Walking Ability

Function	**Result**	**Points**
Walking		
Unrestricted	Excellent	6
>30 minutes to <60 minutes	Good	4
<30 minutes	Fair	2
Walks at home, is confined to wheelchair or is bedridden	Poor	0
Stair climbing		
No limitation	Excellent	3
Holds rail	Good	2
One stair at a time	Fair	1
Elevator only	Poor	0
Return to work (A or B)		
A. Employed before injury		
Returned to preinjury job	Excellent	6
Returned to preinjury job with difficulty	Good	4
Altered full time job	Fair	2
Part time job or unemployed	Poor	0
B. Retired before injury		
Returned to preinjury life style	Excellent	6
Needs occasional help	Good	4
Needs assistance at home with activities of daily living	Fair	2
Moved in with family or nursing home	Poor	0

Excellent = 36.40 points : Good = 26-35 points : Fair = 16-25 points
Poor = 0-15 points

ANNEXURE III

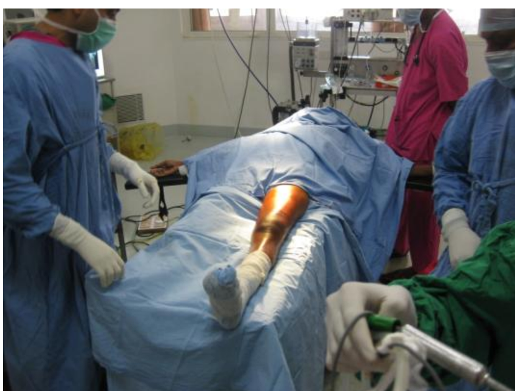
PHOTOGRAPHS

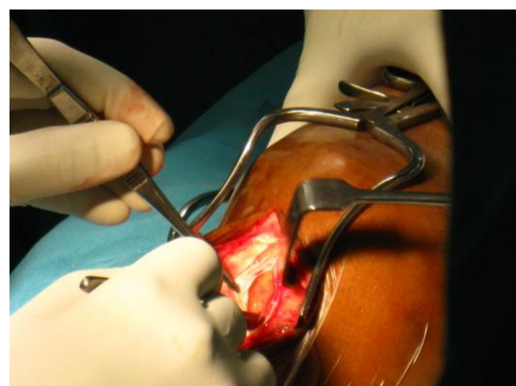
Photograph 1 and 2: Instruments

Photograph 3: Nail jig assembly

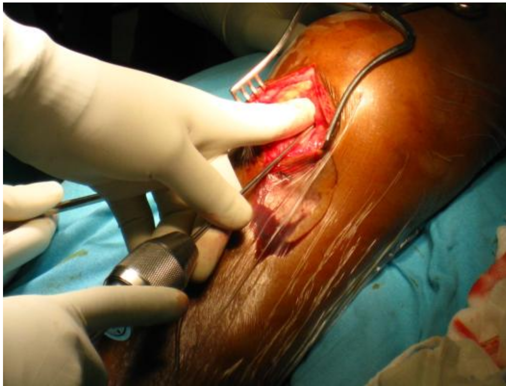
Photograph 4: GSH nail

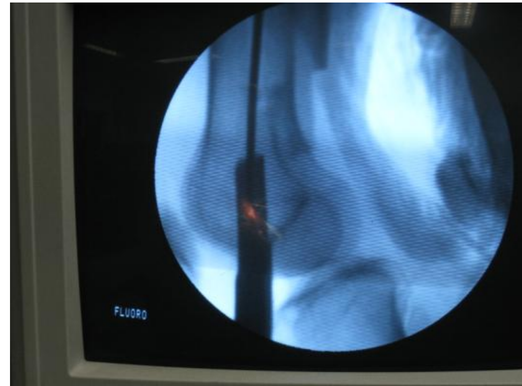


Photograph 5:Positioning and draping

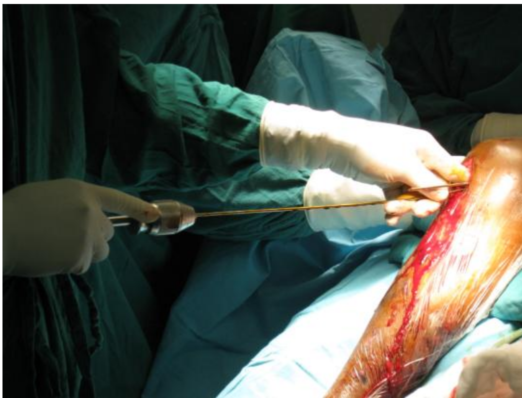


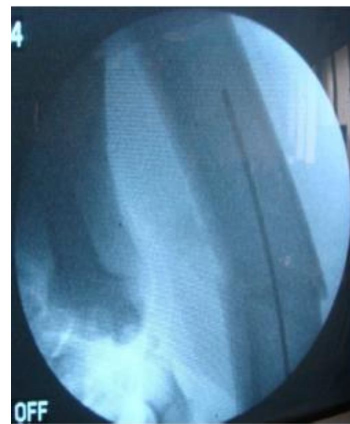
Photograph 6:Incision



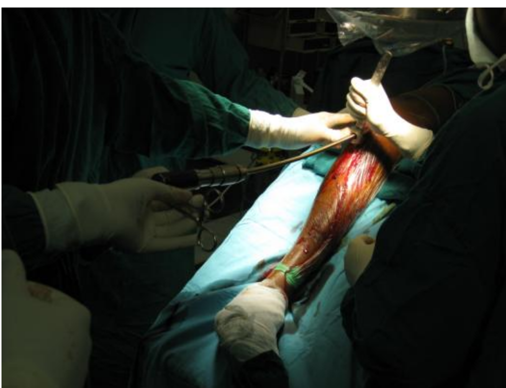


Photograph 7 and 8: Entry point

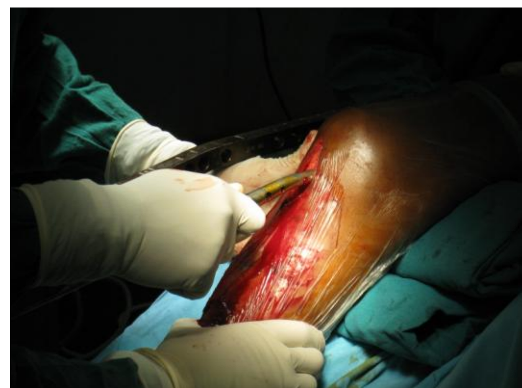




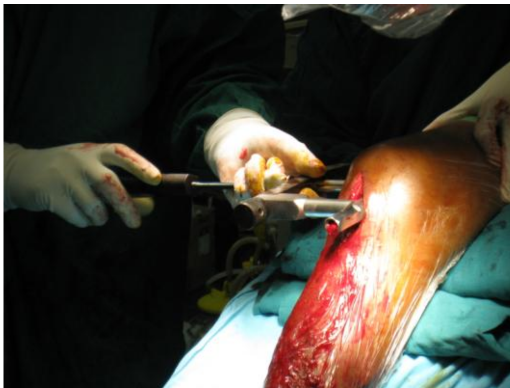
Photograph 9 and 10: Guide wire insertion



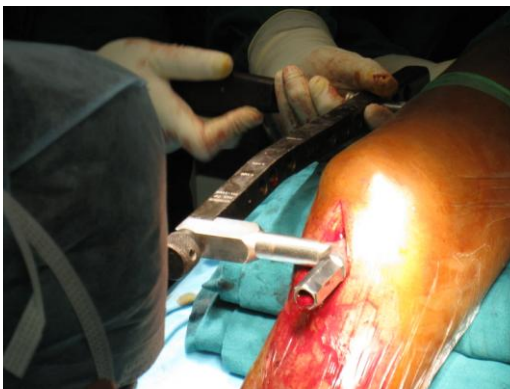
Photograph 11: Reaming

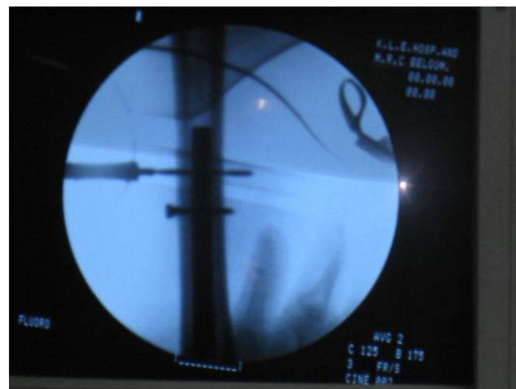


Photograph 12: Nail Insertion with jig assembly

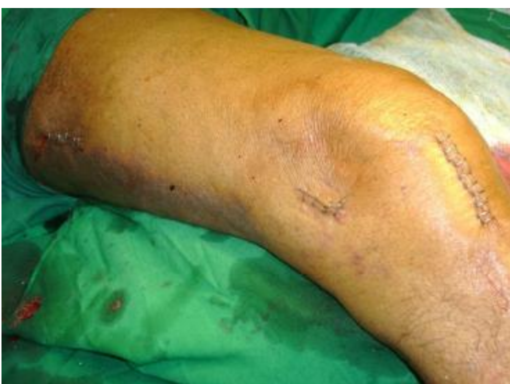


Photograph 13 and 14: Distal locking

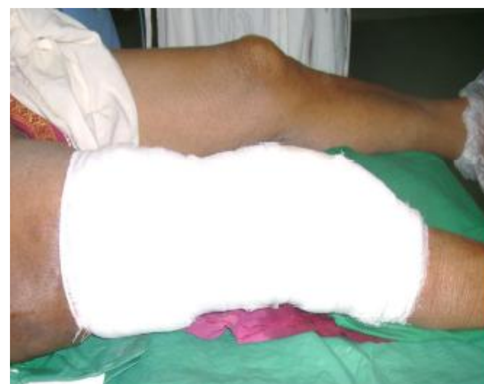




Photograph 15 and 16: Proximal locking



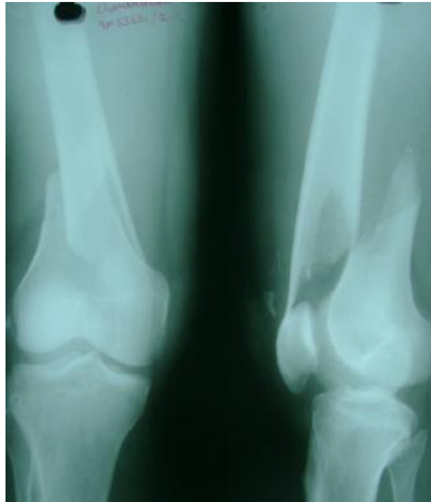
Photograph 17: Skin Closure



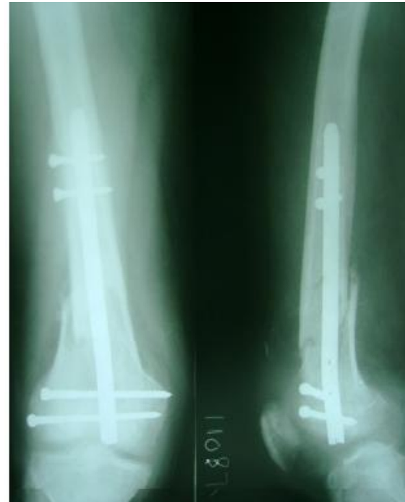
Photograph 18: Sterile dressing

Photograph 19: Mobilization on CPM

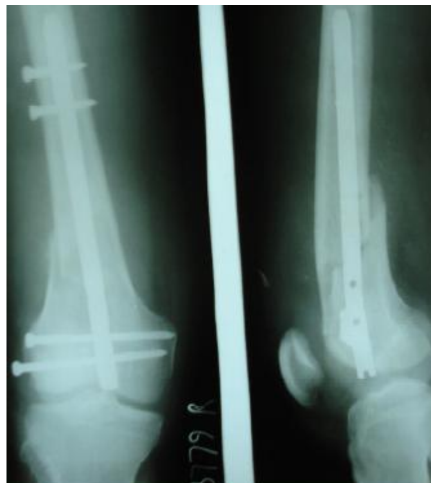
EXCELLENT RESULTS



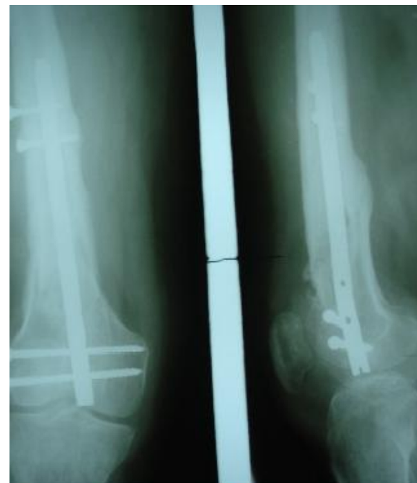
Photograph 20: Preoperative



Photograph 21: Post operative

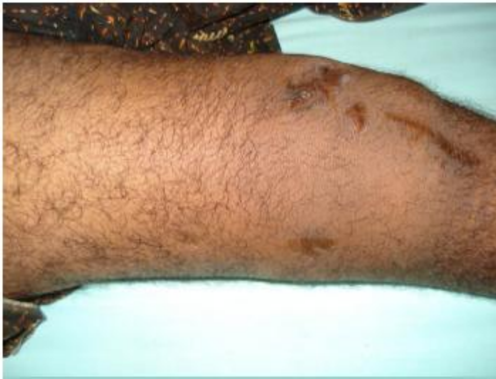


Photograph 22: Four weeks post operative



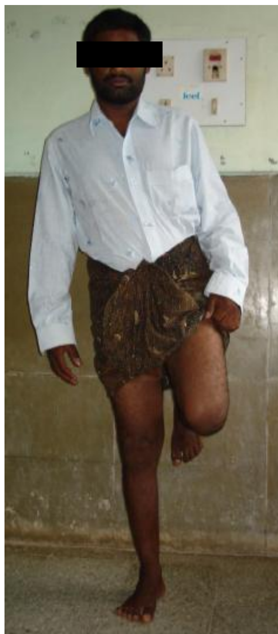
Photograph 23: Six months follow-up

EXCELLENT RESULTS

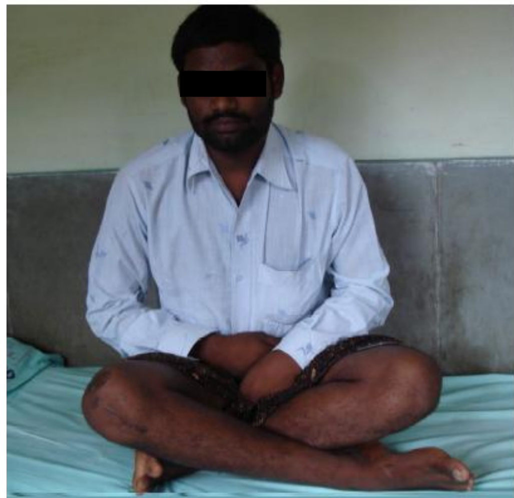


Photograph 24: Surgical scar and traumatic scar

Photograph 25: Active extension

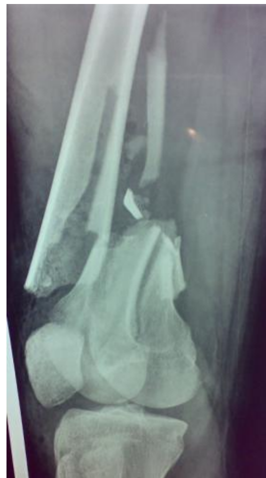


Photograph 26: Full weight bearing

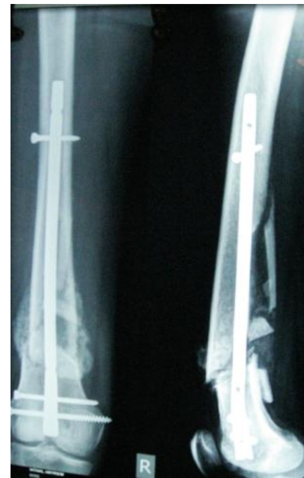


Photograph 27: Sitting cross legged

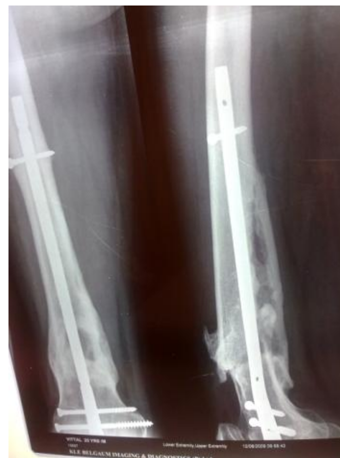
FAIR RESULTS



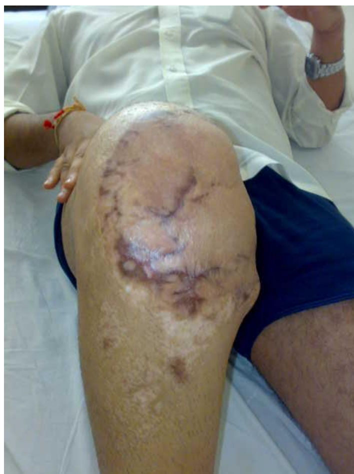
Photograph 28: Preoperative

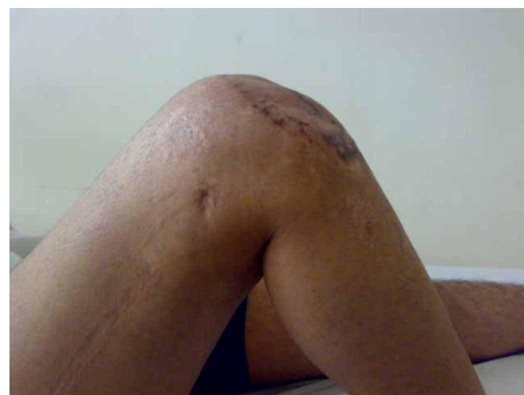


Photograph 29: Three months post operative



Photograph 29: Six months follow up





Photograph 31 and 32: Knee stiffness at six months

ANNEXURE IV - MASTER CHART

													Treatment			Complications		Outcome			
										Type									SFES		
Sl. No.	IP No.	Gender	Age (Years)	Date of admission	Date of Surgery	Date of discharge	Nature of trauma	Past History	Associated injuries	AO Classification	Simple/ Compound	Side	Nail size (mm/cm)	Operative time (Minutes)	Blood Loss (ml)	Intra Operative	Post operative	Time to radiological Union (Weeks)	4 weeks	3 months	6 months
1	251070	M	52	02.12.07	06.12.07	16.12.07	FFH	AST	NAD	C1	S	L	10/26	90	100	-	-	12	FR	GD	GD
2	255344	F	74	17.12.07	18.12.07	26.12.07	TF	DM, HTN LHMPL	NAD	A1	S	L	10/24	75	120	-	-	13	GD	EX	EX
3	266741	M	40	24.01.08	29.01.08	29.02.08	RTA	N	FMFL	C2	S	L	10/26	100	100	DIF RED FRG	KN STFF,DU	18	FR	FR	FR
4	266786	M	25	29.01.08	30.01.08	18.02.08	RTA	N	DGIJ	C2	C IIIB	R	11/26	150	110	-	SUPF INF	12	FR	GD	GD
5	267664	F	47	01.04.08	09.04.08	20.04.08	TF	DM, HTN	NAD	A1	S	R	10/26	90	90	-	-	12	GD	EX	EX
6	267800	F	25	02.04.08	02.04.08	14.04.08	RTA	N	NAD	A1	S	R	10/24	100	80	-	-	11	GD	GD	EX
7	267801	M	40	02.04.08	14.04.08	25.04.08	RTA	DM	FRMLRB, PN	A3	S	R	10/26	100	250	-	-	14	GD	GD	EX
8	267802	F	60	02.04.08	04.04.08	15.05.08	RTA	N	FRHM	A1	S	R	10/24	75	90	-	ANT KN PAIN	13	GD	GD	EX
9	276501	M	44	12.06.08	12.06.08	24.06.08	RTA	N	NAD	B1	S	R	10/26	110	80			11	GD	GD	GD
10	277612	M	21	02.07.08	12.07.08	06.08.08	RTA	N	SAH, FRRPT	C2	C IIIA	R	10/26	120	110	-	SHRT, ANT KN PAIN,DU	16	FR	FR	FR
11	284502	M	60	12.08.08	14.08.08	27.08.08	TF	DM, HTN PATFR	NAD	A1	S	R	11/28	90	600	-	-	11	GD	GD	EX
12	285392	M	42	20.08.08	02.09.08	13.09.08	RTA	HTN, PATFR	FRLHM	C1	S	L	10/26	120	120			13	FR	GD	GD
13	285694	M	46	24.08.08	26.08.08	08.09.08	RTA	N	NAD	C2	S	L	11/24	60	150	-	ANT KN PAIN	14	FR	GD	GD
14	292710	M	22	17.10.08	17.10.08	28.10.08	FFH	N	NAD	A2	S	R	10/28	60	80	-	-	11	GD	EX	EX
15	297078	F	42	11.11.08	15.11.08	25.11.08	TF	N	NAD	A1	S	L	10/24	60	120	-	-	12	FR	EX	EX

ANNEXURE IV

KEY TO MASTER CHART

ANT KN PAIN	-	Anterior knee pain
AST	-	Asthma
C	-	Compound
Cm	-	Centimeter
DGIJ	-	Degloving injury of right thigh
DIFF RED FRG	-	Difficulty in reduction of fragments
DM	-	Diabetes mellitus
DU	-	Delayed union
EX	-	Excellent
FFH	-	Fall from height
FMFL	-	Fracture left shaft of femur
FR	-	Fair
FRHLM	-	Fracture shaft left humerus
FRHM	-	Fracture of right humerus
FRMLRB	-	Fracture of multiple ribs
FRRPT	-	Right brachial plexus injury
GD	-	Good
HTN	-	Hypertension
IP No.	-	Inpatient Number
KN STFF	-	Knee stiffness
L	-	Left

LHMPL	-	Left hemiplegia
mm	-	Millimeter
ml	-	Milli Litre
PATFR	-	Patella fracture
PN	-	Pneumothorax
R	-	Right
RTA	-	Road traffic accidents
S	-	Simple
SAH	-	Subarachnoid haemorrhage
SFES	-	Sander's 40 point functional evaluation scale
SHRT	-	Shortening
Sl No.	-	Serial Number
SUPF INF	-	Superficial infection
TF	-	Trivial fall

										Type			Treatment			Complications		Outcome			
																			SFES		
Sl. No.	IP No.	Gender	Age (Years)	Date of admission	Date of Surgery	Date of discharge	Nature of trauma	Past History	Associated injuries	AO Classification	Simple/ Compound	Side	Nail size (mm/cm)	Operative time (Minutes)	Blood Loss (ml)	Intra Operative	Post operative	Time to radiological Union (Weeks)	4 weeks	3 months	6 months
1	251070	M	52	02.12.07	06.12.07	16.12.07	FFH	AST	NAD	C1	S	L	10/26	90	100	-	-	12	FR	GD	GD
2	255344	F	74	17.12.07	18.12.07	26.12.07	TF	DM, HTN LHMPL	NAD	A1	S	L	10/24	75	120	-	-	13	GD	EX	EX
3	266741	M	40	24.01.08	29.01.08	29.02.08	RTA	N	FMFL	C2	S	L	10/26	100	100	DIF RED FRG	KN STFF,DU	18	FR	FR	FR
4	266786	M	25	29.01.08	30.01.08	18.02.08	RTA	N	DGIJ	C2	C IIIB	R	11/26	150	110	-	SUPF INF	12	FR	GD	GD
5	267664	F	47	01.04.08	09.04.08	20.04.08	TF	DM, HTN	NAD	A1	S	R	10/26	90	90	-	-	12	GD	EX	EX
6	267800	F	25	02.04.08	02.04.08	14.04.08	RTA	N	NAD	A1	S	R	10/24	100	80	-	-	11	GD	GD	EX
7	267801	M	40	02.04.08	14.04.08	25.04.08	RTA	DM	FRMLRB, PN	A3	S	R	10/26	100	250	-	-	14	GD	GD	EX
8	267802	F	60	02.04.08	04.04.08	15.05.08	RTA	N	FRHM	A1	S	R	10/24	75	90	-	ANT KN PAIN	13	GD	GD	EX
9	276501	M	44	12.06.08	12.06.08	24.06.08	RTA	N	NAD	B1	S	R	10/26	110	80			11	GD	GD	GD
10	277612	M	21	02.07.08	12.07.08	06.08.08	RTA	N	SAH, FRRPT	C2	C IIIA	R	10/26	120	110	-	SHRT, ANT KN PAIN,DU	16	FR	FR	FR
11	284502	M	60	12.08.08	14.08.08	27.08.08	TF	DM, HTN PATFR	NAD	A1	S	R	11/28	90	600	-	-	11	GD	GD	EX
12	285392	M	42	20.08.08	02.09.08	13.09.08	RTA	HTN, PATFR	FRLHM	C1	S	L	10/26	120	120			13	FR	GD	GD
13	285694	M	46	24.08.08	26.08.08	08.09.08	RTA	N	NAD	C2	S	L	11/24	60	150	-	ANT KN PAIN	14	FR	GD	GD
14	292710	M	22	17.10.08	17.10.08	28.10.08	FFH	N	NAD	A2	S	R	10/28	60	80	-	-	11	GD	EX	EX
15	297078	F	42	11.11.08	15.11.08	25.11.08	TF	N	NAD	A1	S	L	10/24	60	120	-	-	12	FR	EX	EX