UNIVERSITÉ DE GENÈVE

Archive ouverte UNIGE
https://archive-ouverte.unige.ch

Thèse 2005

Open Access

This version of the publication is provided by the author(s) and made available in accordance with the copyright holder(s).

Evolution des fractures du genou chez l'adulte au Sultanat d'Oman : revue à long terme de 30 cas

Sharawy, Ayman el

How to cite

SHARAWY, Ayman el. Evolution des fractures du genou chez l'adulte au Sultanat d'Oman : revue à long terme de 30 cas. Doctoral Thesis, 2005. doi: 10.13097/archive-ouverte/unige:365

This publication URL: https://archive-ouverte.unige.ch/unige:365
Publication DOI: 10.13097/archive-ouverte/unige:365

© This document is protected by copyright. Please refer to copyright holder(s) for terms of use.

Thèse rédigée sous la direction du Professeur Robin PETER

Evolution des fractures du genou chez l'adulte au Sultanat d'Oman

Revue à long terme de 30 cas

THESE

Présentée à la faculté de Médecine
de l'Université de Genève
pour obtenir le grade de Docteur en médecine

par

Ayman EL SHARAWY

Du Caire / Egypte

Thèse n° 10443

Genève

2005

UNIVERSITE DE GENEVE **FACULTE DE MEDECINE**

Département de Chirurgie
Service de Chirurgie Orthopédique et Traumatologie de l'Appareil moteur

---

Thèse rédigée sous la direction du Professeur Robin PETER

Evolution des fractures du genou chez l'adulte au Sultanat d'Oman

Revue à long terme de 30 cas

THESE

Présentée à la faculté de Médecine
de l'Université de Genève
pour obtenir le grade de Docteur en médecine

par

Ayman EL SHARAWY

Du Caire / Egypte

Thèse n° 10443

Genève

2005

UNIVERSITÉ DE GENÈVE

FACULTÉ DE MÉDECINE

DOCTORAT EN MEDECINE

Thèse de:

Monsieur Ayman EL SHARAWY
originaire du Caire (Egypte)

Intitulée

EVOLUTION DES FRACTURES DU GENOU CHEZ L'ADULTE AU SULTANAT D'OMAN REVUE A LONG TERME DE 30 CAS

La Faculté de médecine, sur le préavis de Monsieur Robin PETER, professeur adjoint au Département de chirurgie, autorise l'impression de la présente thèse, sans prétendre par là émettre d'opinion sur les propositions qui y sont énoncées.

Genève, le 7 octobre 2005

Thèse n° **10443**

Jean-Louis Carpentier
Doyen

ACKNOWLEDGEMENT

I would like to dedicate this thesis to my wife Ammal and my sons Omar & Ali and to my Parents.

I would like to express my sincere and deep gratitude to Prof. Robin Peter, Chief of Trauma, in Geneva University for his faithful supervision, constructive guidance and real interest in the progress of this work.

I thank sincerely Dr. Jean Marc Meyer for his great care, support and full time encouragement and finally I would like to thank Dr. Wahid Al Kharusi, Chief of Trauma, Orthopaedic and Rehabilitation in Khoula Hospital in Oman for his sincere advice, support and guideness through all the process of this work.
I would like as well to thank Geneva University and the orthopaedic department of Geneva University for giving me the chance to present this work.

CONTENTS

RESUME

Les fractures du genou chez l'adulte représentent 2% de toutes les fractures, mais en raison de notre mode de vie moderne et de l'augmentation de la rapidité des moyens de transport, la fréquence de ces lésions augmente. Les fractures du genou se présentent souvent comme des lésions complexes susceptibles de nombreuses complications. C'est la raison pour laquelle la prise en charge de telles lésions est encore sujette à discussion.

Autrefois ces fractures étaient en général prises en charge par des rebouteux, ou par les chirurgiens généraux. Ils utilisaient divers types d'extension pendant des durées variables suivis de l'application d'appareils plâtrés et immobilisation de toute sorte. Ces traitements étaient grevés de nombreuses complications telle que retard de consolidation, pseudarthrose, déformations, raccourcissement etc. En raison de ces complications de nombreuses méthodes de fixation interne ont été proposées.

Le but de cette étude est de décrire l'évolution des protocoles de traitement des fractures du genou survenues ces 30 dernières années à Oman et de présenter la situation actuelle avec les techniques modernes utilisées aujourd'hui dans ce pays. Nos résultats ont été obtenus suivant l'application de ces techniques.

Jusqu'en 1970, il n'existait pas de système de santé contrôlé par l'état à Oman. Le secteur médical était composé de 3 hôpitaux répartis dans le pays et d'un 4^{e} rallié à l' « American Missionary Hospital » construit au début des années 50. Les patients avaient accès à la médecine occidentale à l'hôpital américain situé dans la vieille ville de Muscat. Pour la médecine traditionnelle et Islamique. Elle consistait pour l'essentiel è cautériser les zones douloureuses par des pointes de feu « WASAM » et à appliquer de ventouses « HEGAMA ». Les fractures étaient traitées localement par des rebouteux qui les manipulaient et les réduisaient puis les contenaient par des mélanges de farine et d'œufs. La contention par feuilles de bananes était également fréquemment employée.

En 1970, sous le règne de Sa majesté le Sultan, le premier hôpital fut crée avec son service ambulatoire à 300 km. de la capitale. A ce jour le pays compte 14 hôpitaux et de très nombreux services ambulatoires. Le système de santé a été conçu pour permettre à chaque omanais de pouvoir atteindre un service de santé dans les 10 minutes.

Du point de vue anatomique, le genou se compose de l'extrémité distale du fémur, de la rotule et de la tête tibiale. Les pièces osseuses sont reliées entre elles par 5 ligaments principaux qui stabilisent cette articulation. A Oman, les fractures de la rotule sont rares.

Nous avons réalisé l' étude de 30 patients victimes de fractures comminutives de l'extrémité distale intra articulaire du fémur et des plateaux tibiaux présentant un déplacement supérieur à 5 mm ou avec une angulation dépassant 10 degrés associées à une ouverture cutanée avec d'importantes lésions des tissus mous.

Tous les patients ont suivi le protocole suivant :

1- Radiographies standard de face et de profil
2- CT Scan pour planning préopératoire
3- Prise en charge chirurgicale avec débridement et parage des lésions cutanées dans les 5 heures suivant l'admission
4- Ostéosynthèse des fractures chez les polytraumatisés aussitôt que l'état général le permettait
5- Mobilisation passive pendant les 3 à 5 jours postopératoires
6- Décharge par plâtre cruro-pédieux pendant 3 à 5 semaines dépendant du psychisme du patient.
7- Charge partielle en fonction des signes cliniques et radiologiques de consolidation
8- La durée des contrôles médicaux était décidée en fonction des observations cliniques et radiologiques

23 patients étaient de sexe masculin (76,7%) et 7 de sexe féminin (23,3%). 18 patients présentaient une fracture du fémur distal (60%) et 12 patients présentaient une fracture des plateaux tibiaux. (40%). 21 patients ont été victimes d'accidents de la circulation

(70%), 9 (30%) ont été l'objet de chutes d'une hauteur plus ou moins importante. Le côté droit a été atteint chez 16 patients (53,3%) et le gauche chez 13 patients (43,3%). Un patient a présenté une fracture du tibia droit et du fémur gauche (3,4%). La série comporte 8 polytraumatisés (26,7%). Une fracture du rachis a été observée chez 2 sujets (6,6%) et un traumatisme cranio-cérébral dans 3 cas (10%).

Les 30 patients ont été contrôlés cliniquement et radiologiquement dans une moyenne de 30 mois après l'accident (18 à 51 mois). La consolidation avait été obtenue chez tous les patients au moment du contrôle. Le matériel a été retiré chez 6 d'entre eux entre le 24^{e} et le 36^{e} mois après l'accident.

La moyenne d'âge était de 39 ans (21 à 63 ans) et la durée moyenne du séjour hospitalier a été de 21 jours (3 à 82 jours). Un patient a présenté un démontage de l'ostéosynthèse suite à une charge prématurée et a du être réopéré. En général nous avons constaté que les fractures des plateaux tibiaux présentaient des résultats bons ou excellents malgré des images radiologiques et une réduction moyennes.

Dans le cas de fractures inter condyliennes, les résultats n'ont pas été aussi satisfaisants même avec une image bonne radiologique et une réduction opératoire anatomique de la fracture. 23 patients n'ont pas présenté de complications post opératoires immédiates (76,7%). Une infection s'est développée chez 3 patients (10%). Une neurapraxie a été observée dans un cas (3,3%). 3 patients ont présenté une TVP (10%).

Nous avons utilisé plusieurs types d'implants. Pour les plateaux tibiaux notre choix s'est porté sur un vissage percutané par vis d'Asnis chez 2 patients (16,7%) dans le cas de fractures peu déplacées, ne disposant pas de vis perforées. De même dans des fractures intra articulaires uni condyliennes du fémur distal, 2 patients ont bénéficié du même traitement, les vis ayant été insérées perpendiculairement au trait de fracture dans un but de neutralisation (11,1%). Des plaques en L ou en T ont été utilisées chez 10 patients (83,3%) en cas de fractures des plateaux tibiaux. Pour le plateau tibial externe, nous

avons recouru à une voie antéro-extene para rotulienne et pour le plateau tibial interne le choix s'est porté sur la voie antéro-interne para rotulienne . En cas de fracture bi condylienne la voie d'abord a été antérieure longitudinale ou comme dans 3 cas l'incision en coupe de champagne (25%) sans complication liée au lambeau cutané.

Bien que les fractures du genou soient très difficiles et représentent un défi pour le chirurgien, avec une bonne planification opératoire et une bonne technique, le résultat du traitement chirurgical reste nettement supérieur à tout autre type de traitement avec de bons ou excellents résultats et des complications dans une moindre mesure.

Grâce a l'utilisation de nouvelles technique développées par le groupe AO il est désormais acquis qu'une amélioration globale des résultats peut être obtenue. Il reste quelques incertitudes quant au meilleur type de fixation interne ou externe. Le type de fixation, le moment de l'opération et l'emploi de greffes est encore en discussion et fait l'objet de recherches.

Dans notre étude, le mode de vie des Omanais a un excellent effet sut la récupération de l'amplitude articulaire résultant de l'habitude de s'asseoir sur les talons et de la position du genou en flexion maximale pendant la prière. La tolérance à la douleur est excellente chez les patients de l'ancienne génération en raison de leur mode de vie. Récemment des techniques plus biologiques telles que la plaque de Liss et l'enclouage fémoral distal ont amélioré les résultats. A Oman nous sommes entrain d'adapter ces nouvelles techniques dans le but d' améliorer l'évolution de nos patients.

Nos résultats ont étés rassemblés et analysés dans un but de contrôle de qualité et d'enseignement. En conclusion la mise en œuvre des techniques modernes de réduction chirurgicale et fixation interne des fractures du genou dans le cadre du système de santé omanais ont amélioré les résultats de ces graves lésions parmi les habitants de ce pays.

INTRODUCTION

Fractures around the knee in adults account for only 2% of all the fractures. But because of our modern life styles and high velocity means of transportation, these injuries are being seen with increasing frequency. Fractures around the knee are often complex injuries that present to the surgeon with numerous potential complications, the management of these fractures remains controversial.

In the past, this injury was treated by the General Surgeons who used to apply skeletal traction for variable duration, followed by some form of cast or brace immobilization. Complications associated with closed management of those fractures have led to the proposal of a number of alternative methods of internal fixation.

Although early attempts of internal fixation for distal femur fractures frequently gave unacceptably high rates of malunion, nonunion and infection, improved techniques of internal fixation have yielded results far superior to those achieved with nonsurgical management. Meticulous internal fixation has been shown to yield good to excellent results in 60% to 80% of cases and allows immediate mobilization of the patient and the extremity, minimizing the cardiopulmonary and other multisystem sequelae of long-term immobility (50).

Our goal of this study is to give a description of the tremendous evolution in the treatment protocols for fractures around the knee, which occurred during the past 30 years in Oman, and to describe the state of the art with modern techniques which are now days used in Oman and our results achieved using these modern techniques.

HISTORICAL

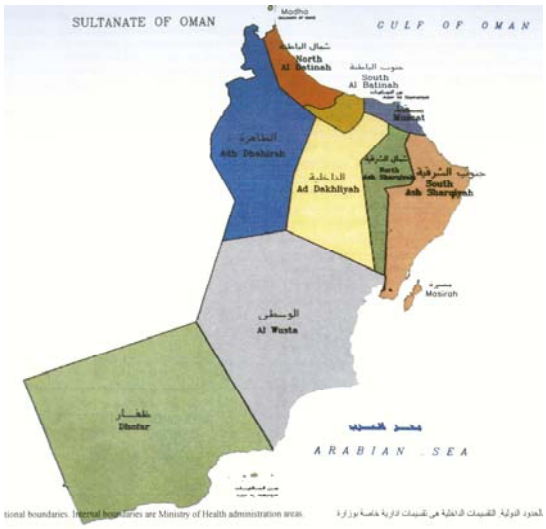
Up to 1970 there was no updated system of the government in Oman. Everything was through the palace, the medical sector was formed of 3 palace clinics around the whole country and one American Missionary Hospital built in the early 50' s. For western type of medicine, people used to come to the old city for the American Hospital. Otherwise Local Omani medicine and Islamic medicine in the form of "Wasam" cautery by hot iron rod and "Hegama" negative suction by hot cups were used.

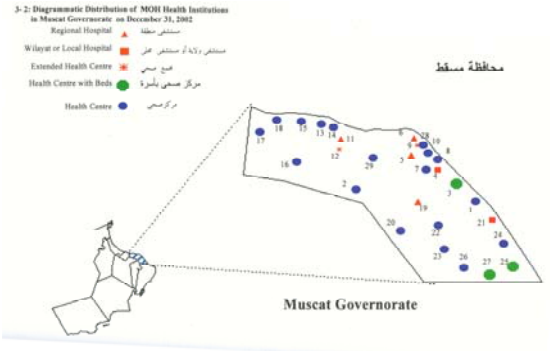
Healed Wasam

Fresh Wasam

Fractures were treated by the local osteopath who used to manipulate the fractures and fix them with local ingredients as flour and eggs using banana leaves. Till 1970, osteopath, except in the American Hospital, treated all the fractures. From 1970 the utilization of osteopath slowly eliminated and starting from 1982, more hospitals were opened and the people of Oman came to know and accept modern type of medicine. By then, most trauma cases were treated in the main referral hospitals.

In 1970 under the instructions of His Majesty The Sultan, the first ever governmental hospital, 300 km from the capital, Muscat, together with the clinics were launched. In 1974, 4 hospitals were built, now we have 14 regional hospitals and many health centers. The health system was founded to allow any patient in Oman to reach a health institute within 10 minutes.





Khoula hospital was built in late 1970 by the Petroleum Development of Oman Company (PDO) and was donated to the government to be a surgical and maternity hospital. In 1982, the Orthopaedic department started with only 3 beds. In 1984, 54 beds were set for trauma with specialized pediatric ward. Two years later, Khoula became a trauma center with 200 beds for all types of trauma.

Today Khoula hospital has developed to be the first trauma center of the country with total number of 425 beds, 200 beds for the orthopaedic department, 4 inpatient wards, and 8 rooms outpatient clinic and 45 staff members; 75 beds for the neuro surgery, 75 beds for plastic surgery and 75 beds for the obstetric and gynecology departments.

Also, the presence of supportive teams of general surgery, radiological team with CT Scan and MRI facilities, physiotherapy team, acupuncture, orthotic and prosthetic workshop, occupational therapy teams, with the 45 orthopaedic doctors from different grades, forms a holistic approach to trauma management.

The orthopaedic department was recognized by the Royal College of Edinburgh since 1983.

In 1988, sub specialties were developed in Khoula hospital in the orthopaedic department, every consultant and his team deal with trauma and with his specialty; pediatric, joint replacement, sports medicine and spinal. We performed the first THR (Total Hip Replacement), TKR (Total Knee Replacement) and diagnostic arthroscopy. Meanwhile, during this time regional hospitals started to have their own orthopaedic teams.

All units were managed and supervised by the Chief of trauma & rehabilitation, Dr. Wahid Al-Kharusi, Founder of the department, a position developed for him in 1984.

In 1998, an additional orthopaedic ward was added with another 36 beds and Khoula hospital was declared level one trauma center.

In 2003, super specialties were developed in the form of Ilizarov and limb reconstruction, shoulder, hand, pelvis and acetabulum.

Before 1981, Khoula Hospital orthopaedic department used to practice the old methods of internal fixations using Vitallium implants with a lot of complications, later after 1981 new techniques of orthopaedic were implemented, the department adapted the AO principles and techniques, spinal instruments were changed and modified, arthroplasty instruments were upgraded.

The department of orthopaedic was also involved in many workshops and conferences: In 1986, the 1st International trauma conferences & Basic AO course. In 1995, the Pan Arab conference for orthopaedic & trauma. In 2000, the 28th FIMS (Federation International of Sports Medicine) conference sports

for all. In 2004,the Celebrate of the 75th Anniversary of FIMS, first time outside Europe & America.

The transport of patients from the scene of accidents to the hospitals was usually done by either the relatives, Royal Oman Police, and only few ambulances were used to transport patients between the hospitals. However on the 7th of April 2004 , EMS services were inaugurated with well-equipped and well-trained paramedics to cover Muscat area as first stage, then all over the Sultanate of Oman.

The department of orthopaedic has taken the initiatives to show the impact of RTA (Road Traffic Accident) by being involved in the national programm of injury prevention safety promotion and internationally by taking the matter to the United Nations (UN) and within 16 months managed to get 3 UN resolutions.

World wide the Supracondylar and Intracondylar fractures of the distal femur have historically been difficult to treat. These fractures often are unstable and comminuted and tend to occur in either elderly or multiply injured patients. Regaining of full knee motion and function may be difficult. The incidences of malunion, non union and infection are relatively high in many reported series.

In the decade of the 1960s, non operative 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 Stewart and Sisk (64) from Campell clinic, retrospectively reviewed 213 cases, results were satisfactory; 67% with non operative treatment and 54% of those treated operatively. Delayed union of non union occurred in 9.7% in fractures treated by closed methods and 29% of fractures treated operatively. Two-pin traction was recommended as the treatment of choice. In 1967, Neer (47), Grantham and Shelton compared operative with non operative treatment and they found 84% satisfactory results with operative treatment.

With the development of improved internal fixation devices by the AO group, treatment recommendations began to change. In 1972, Olerud (48) reported 93% satisfactory results in 16 patients treated with blade plates. In 1979 Schatzker and Lamert found that 71% of their patients treated with blade plate had good to excellent results.

In 1989 Mize reported good to excellent results in 76% of his cases with the AO techniques. Also in 1989 Aswell Siliski (63), Mahring and Hofer reported 81% good to excellent results.

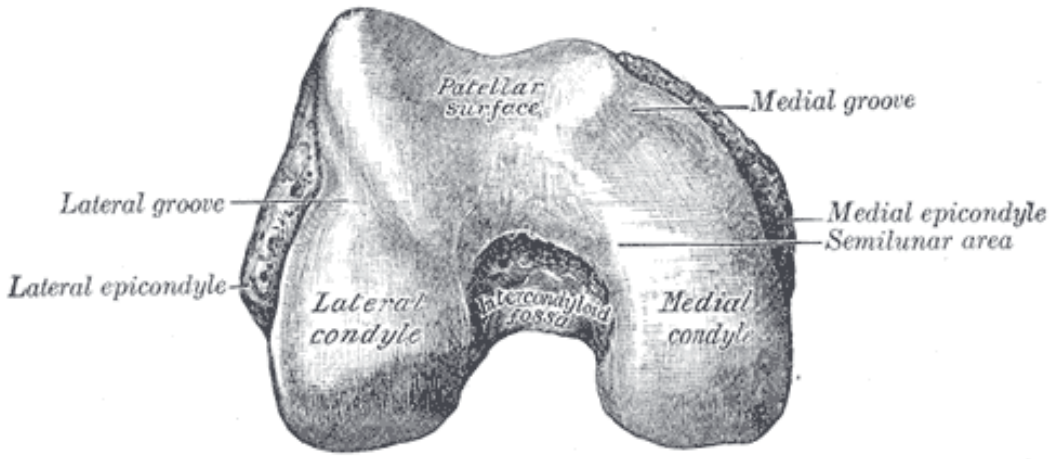
ANATOMY AND CLASSIFICATIONS

Relevant Anatomy of the Distal Femur:

The distal femur traditionally encompasses the lower third of this bone. This zone in the literature varies greatly, from the distal 7.6 cm to the distal 15 cm of the femur.

Bone:

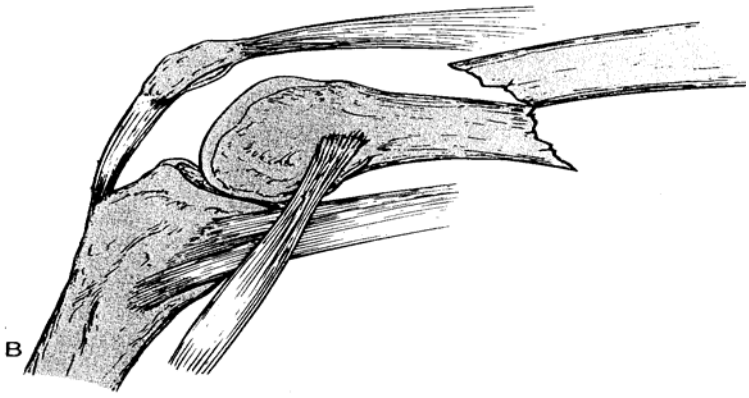
The supracondylar (metaphyseal) area of the distal femur is the transition zone between the distal diaphysis and the femoral articular condyles. At the diaphyseal-metaphyseal junction, the metaphysis flares, especially on the medial side, to provide a platform for the broad condylar weight-bearing surface of the knee joint. Anteriorly between these two condyles is a smooth articular depression for the patella, the trochlear groove. Posteriorly between the two condyles is the intercondylar notch. Medially, a readily identifiable landmark is the adductor tubercule at the maximum point of the flare of the metaphysis. Both condyles have epicondyles on their outer surfaces. (Gray's, 1980)



Of surgical importance, the shaft of the femur in the sagittal view is aligned to the anterior half of the condyles, leaving the posterior half of both condyles in the posterior position relative to the proximal femoral shaft. Also the condyles

are wider posteriorly than anteriorly. A transverse cut through the condyles shows a trapezoid with a 25° decrease in the width, from posterior to anterior, on the medial side (last 1973).

Anteriorly, the extensor compartment contains the quadriceps femoris, the single largest muscle in the body. It consists of four heads: the rectus femoris, more superficially and in the deeper layer from lateral to medial; the vastus lateralis, vastus intermedius and the vastus medialis (grey's 1980).



The anterior extensor compartment is separated from the posterior compartment by the lateral and medial intermuscular septa. These provide important landmarks for both the lateral and medial approaches to the knee joint. Of major significance on the medial side is the superficial femoral artery, which runs down the thigh between the extensor and the adductor compartments. The artery passes into the popliteal fossa approximately 10cm above the knee joint by passing through the adductor magnus muscle. It obviously must be identified and avoided in the medial approaches to the distal femur.

The powerful muscles of the distal thigh produce characteristic bony deformities with fractures. The muscle pull of the quadriceps and the posterior hamstrings produce shortening of the femur .As the shaft overrides anteriorly and the gastrocnemius muscles pull posteriorly, the condyles are displaced and

angulated posteriorly. When the condyles are separated by the fracture, rotational malalignments are the common, because of the unrestrained pull of the gastrocnemius muscles and the anterior overriding of the shaft.

Mechanism of Injury:

The anatomic axis of the shaft of the femur is different from the weight-bearing, or mechanical axis. The latter passes through the head of the femur and the middle of the knee joint. Generally ,the weight-bearing femoral axis subtends an angle of 3° from the vertical. The anatomical femoral axis has a valgus angulation of 7° (average 9°) relative to the vertical axis. Normally, the knee joint axis is parallel to the ground, and the anatomic femoral axis subtends an 81° lateral distal femoral angle relative to the knee joint axis. For each patient it is important to confirm this angle with the opposite femur.

At the time of surgical reconstruction, the correct femoral valgus angulation (anatomic axis) can be recreated and the knee joint kept parallel to the ground.

Fractures of the distal femur have been reported to account for between 4% and 7% of all femoral fractures, 31% of femoral fractures involve distal femur (2)

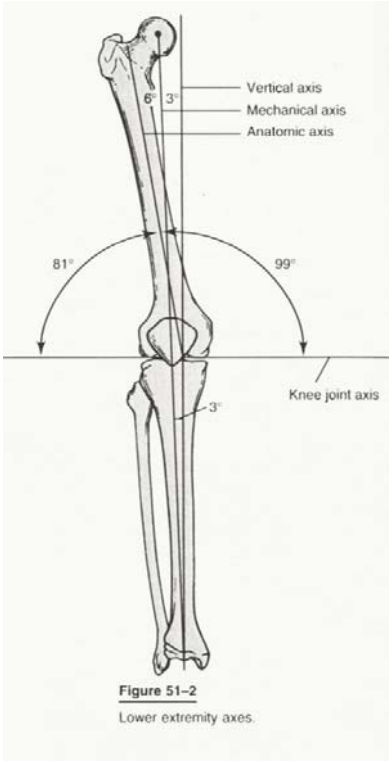
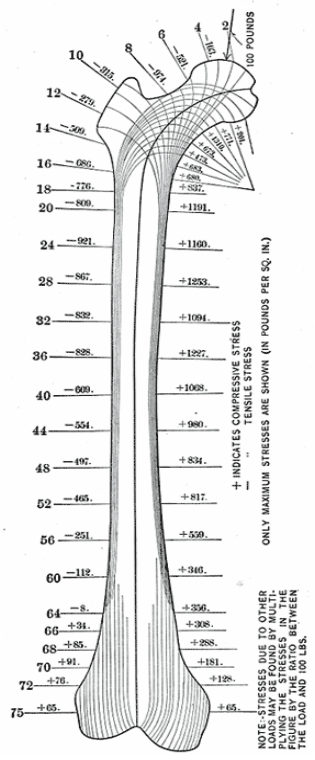


Figure 51–2
Lower extremity axes.



The most common mechanism for distal femur fracture is direct trauma to the flexed knee, typically impact against the dashboard of a moving vehicle (high-energy). Common associated injuries are concomitant acetabular fractures, hip dislocation, femoral neck fractures, and associated femoral shaft fractures. Significant soft tissue injuries of the knee are often associated with distal femoral fractures, Ligamentous disruptions of the knee joint have been reported in approximately 20% of these fractures (68), usually discovered after stabilization of the distal femoral fractures but can be diagnosed with MRI .
Associated tibial plateau or tibial shaft fractures with high-energy trauma (floating knee) is a good indication for early operative treatment to reduce the morbidity. The popliteal artery is at great risk of injury with associated ligamentous disruption of the knee and with floating knee.

Classification of Distal Femur Fractures:

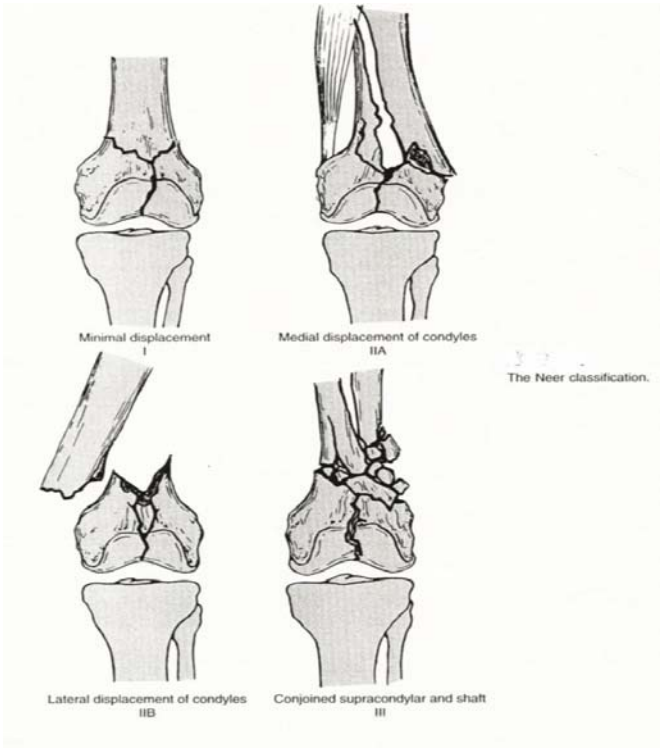
For the classification system to have a clinical significance it must be able to do the following:

1) Allow for adequate documentation of all fractures so that a common language is possible when discussing these injuries.
2) Be simple enough that it is " user friendly".
3) Help the surgeon in his clinical decision making, so that the correct treatment option can be selected for a particular fracture.
4) Provide prognostic information detailing the result that can be expected for a particular fracture depending on treatment option selected.

Unfortunately, anatomical fracture classifications fail to address the conditions commonly associated with supracondylar femur fractures, which often influence treatment or outcome.
These factors, which play a dynamic role in management, determine the "personality" of a fracture. Among these are (1) amount of fracture displacement, (2) degree of comminution, (3) extent of soft-tissue injury, (4) associated neurovascular injuries, (5) magnitude of joint involvement, (6)

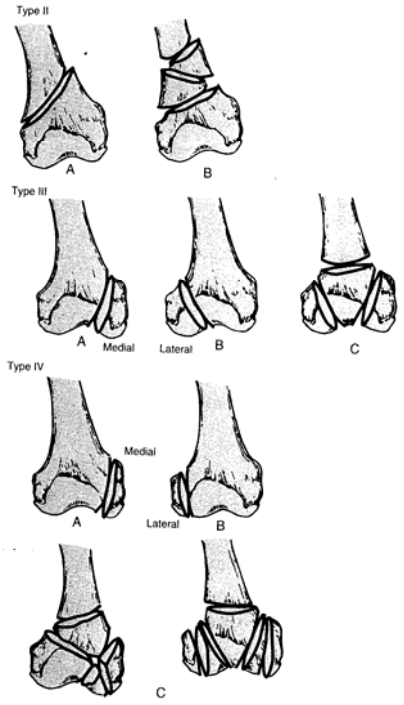
degree of osteoporosis, (7) presence of multiple trauma, and (8) complex ipsilateral injuries (ie, patella or plateau fracture) (17, 28, 34)

One of the original and more simple classification was that of Neer and associates (47), which classify the fractures according to the amount of displacement.



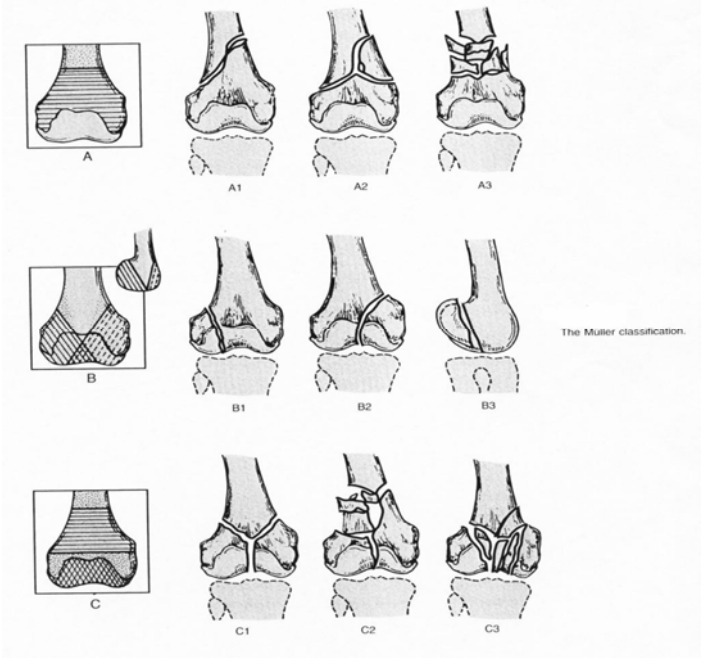
The Neer classification.

Seinsheimer (62) found that all patients with type I and type II had preexisting pathologic osteoprosis before their injuries.



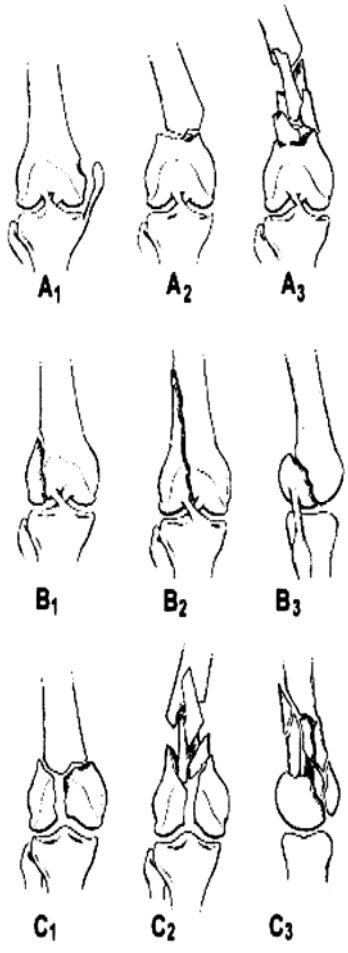
The Sensheimer classification. Type I—undisplaced—is omitted.

Muller (46) and colleagues updated AO classification system for fractures of the distal femur,separated the fractures into three main groups.



The Muller classification.

Comprehensive AO Classification



Diagnosis:

History and Physical Examination:

A careful evaluation of the whole patient and also of the involved lower extremity is mandatory, especially in the polytraumatised patient. This must include careful detailed examination of the hip joint above the fracture and of the knee and leg below it. If there is any concern about the vascularity to the lower extremity, Doppler pulse pressures can be obtained. If there is still concern after these procedures, an urgent arteriogram may be indicated. Rarely, if there is tense swelling of the thigh, the presence of an undetected thigh compartment syndrome also must be ruled out by compartment pressure monitoring.

Grossly, open and contaminated wounds are easily identifiable. However, when the injury results from direct trauma there are often skin abrasions that must be differentiated from open fracture wounds of the soft tissues. The examination usually reveals swelling of the knee and supracondylar area, often obvious deformity and marked tenderness on palpation. Manipulation of the extremity, if tolerated by the patient, demonstrates motion and crepitance at the fracture site. However, such manipulation is cruel and unnecessary if immediate radiographs are available.

Radiographic Evaluation:

Routine antero posterior (AP) and lateral radiographs of the knee and supracondylar region are standard. When the fractures are comminuted or displaced an exact classification of the fracture is often difficult to make. AP and lateral radiographs, both with manual traction applied to the lower extremity, often demonstrate more clearly the fracture morphology. These studies can be done in the emergency department or the operating room. If there is intercondylar involvement, 45º oblique radiographs also help delineate the extent of the injury, especially if comminution or additional tibial plateau

injuries are present. Stress radiographs to identify ligamentous disruptions of the knee or associated tibial plateau fractures usually are not indicated until the distal femoral injury is stabilised. Tomograms or computed tomography (CT) scans are indicated to further delineate significant intra articular involvement or displacement (4). They may also be useful for isolated chondral or osteochondal lesions.

As with all orthopaedic injuries, it is necessary to rule out additional injuries of the joint above and the joint below. There is a significant incidence of ipsilateral fractures to the femur, especially in cases of high-energy trauma. An adequate AP view of the pelvis and AP and lateral view of the hip and whole femur are indicated in all of these fractures.

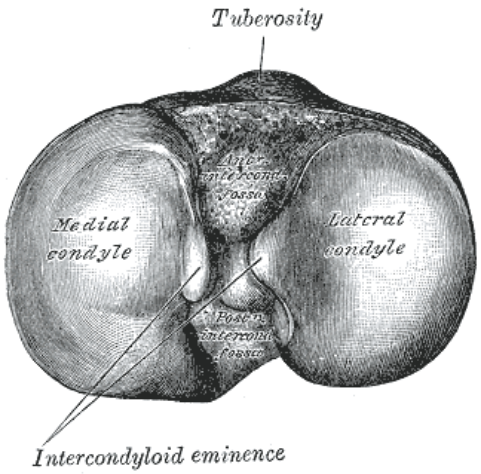
Unless there is a frank dislocation of the knee joint associated with the distal femoral fracture, radiographic evaluation of the knee joint has not proved as reliable as a careful examination in evaluating extent of the ligamentous and soft tissue injury (20). If such lesions are clinically suspected, magnetic resonance imaging (MRI) may be effective pre-operatively to confirm injuries to the knee joint ligamentous or meniscal tissue. Comparison radiographs of the normal or uninvolved opposite extremity help the surgeon with pre-operative planning. These should include an AP view of the whole femur to determine

the valgus alignment and AP and lateral views of the distal femur to allow superimposition of the fracture fragments on the normal template .

Arteriography is indicated when there is an associated frank dislocation of the knee joint, because there is a reported 40% incidence of arterial injuries with knee dislocations (28, 68). An absent or diminished pulse (determined clinically or by Doppler assessment in the emergency room) when compared with the normal lower extremity, is also an indication for immediate arteriography or vascular exploration.

Relevant Anatomy of Tibial Plateau

The medial and lateral tibial plateaus are the articular surfaces of the medial and lateral tibial condyles. They articulate with the medial and lateral femoral condyles respectively to form the knee joint.(Last,1973) The medial plateau is the larger of the two and is concave from front to back as well as from side to side. The lateral plateau is smaller and higher than the medial and is convex from front to back as well as from side to side.(Last,1984). The fact that the lateral plateau is higher than the medial one must be remembered during internal fixation. The two plateaus are separated by the intercondylar eminence, with its prominent medial and lateral tubercles (tibial spines) . This region is nonarticular.



The tibial attachment of the anterior cruciate ligament (ACL) is just anterior to the medial intercondylar tubercle. The posterior cruciate ligament's attachment is in the posterior intercondylar area, extending into the posterior surface of the metaphysis.(Insal,1984)

The outer portion of each plateau is covered by semilunar fibrocartilaginous meniscus. The lateral meniscus covers a much larger portion of the articular surface than does the medial. The medial articular surface and its supporting medial condyle are stronger than their lateral counterparts.(Last,1984)
As a result, fractures of the lateral plateau are more common. When fractures of the medial plateau occur, they are invariably associated with more violent injuries and more commonly have associated soft tissue injuries , such as disruptions of the lateral collateral ligament complex, lesions of the lateral peroneal nerve, or damage to the popliteal vessels.

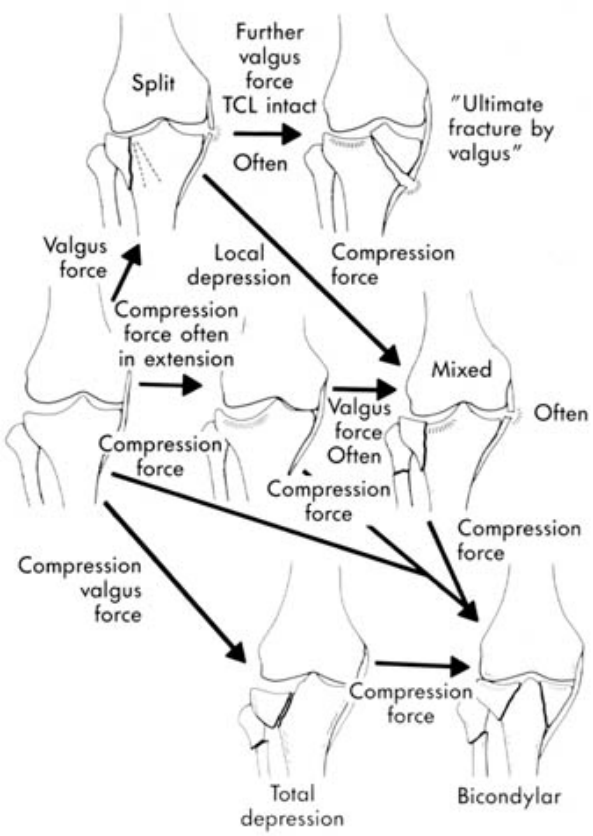
Mechanism of Injury:

Injuries to the plateaus occur as a result of :

1) Force directed either medially(valgus deformity,the classic bumper fracture)or laterally(varus deformity)
2) An axial compressive force
3) Both an axial force and a force from the side.

The respective femoral condyle in this mechanism of injury exerts both shearing and compressive forces into the underlaying tibial plateau. The resulting fracture is therefore most commonly a split fracture or a depression fracture,or both . Pure split fractures are more common in younger patients, in whom the strong bone of the tibial condyle is able to withstand the compressive force of the overlaying femoral condyle. With age; the dense cancellous bone of the young tibial condyle becomes osteopenic, with diminished compressive forces as well. As a result,split- depression fractures become common in patient after their fifth decade of life.These typically result from low-energy injuries.(5)

Some investigators believe that an intact collateral ligament on one side of the knee is necessary for a fracture to occur in the contralateral plateau. (43, 70) The medial collateral ligament acts like a hinge as valgus forces drive the lateral femoral condyle into the tibial plateau ,causing the fracture. The lateral collateral ligament acts in a similar way with varus forces and causing medial plateau fractures.



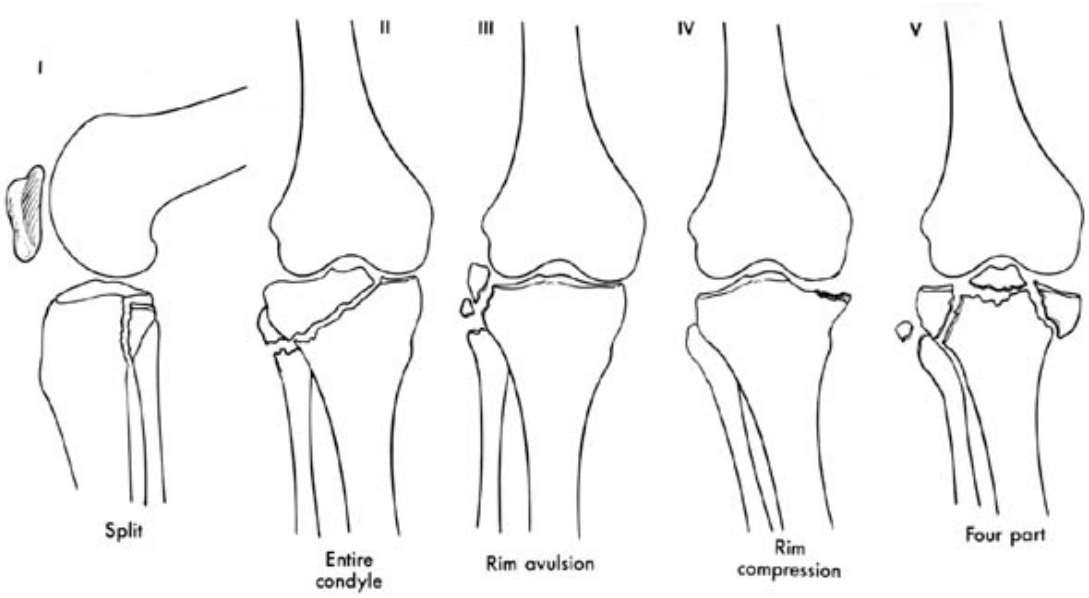
The magnitude of the force determines not only the degree of comminution but also the degree of displacement.Thus, in addition to the fracture, there may be associated soft-tissue lesions, such as tears of the medial collateral ligament or anterior cruciate ligament with lateral plateau fractures (9, 14)

Conversely,tears of the lateral collateral or cruciate ligaments or lesions of the peroneal nerve or popliteal vessel may be associated with fractures of the medial plateau.(59)

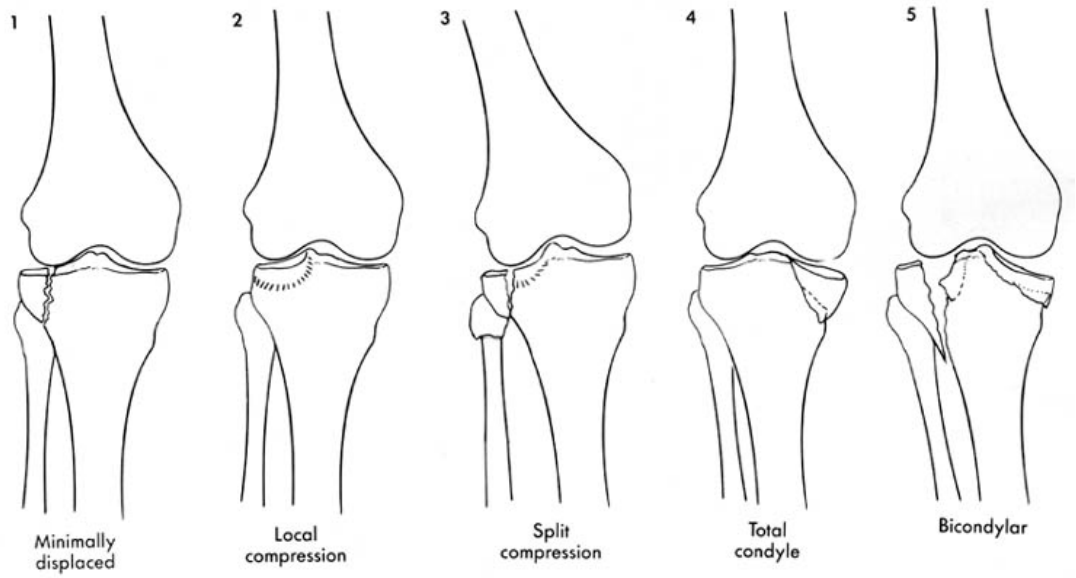
Split fractures that result primarily from shear forces must be differentiated from rim avulsion and compression fractures that are associated with fracture-dislocations of the knee and much greater degrees of instability.

Classification of Tibial Plateau Fracture:

Over the years, many classifications for the tibial plateau fractures have been developed.(43) All classifications are based on fracture location and degree of displacement. Some are simple,easy to remember,and relevant to both treatment and outcome. In 1956,Hohl and Luck classification which was later expanded by Hohl, from the terminology point of view. (23, 24)

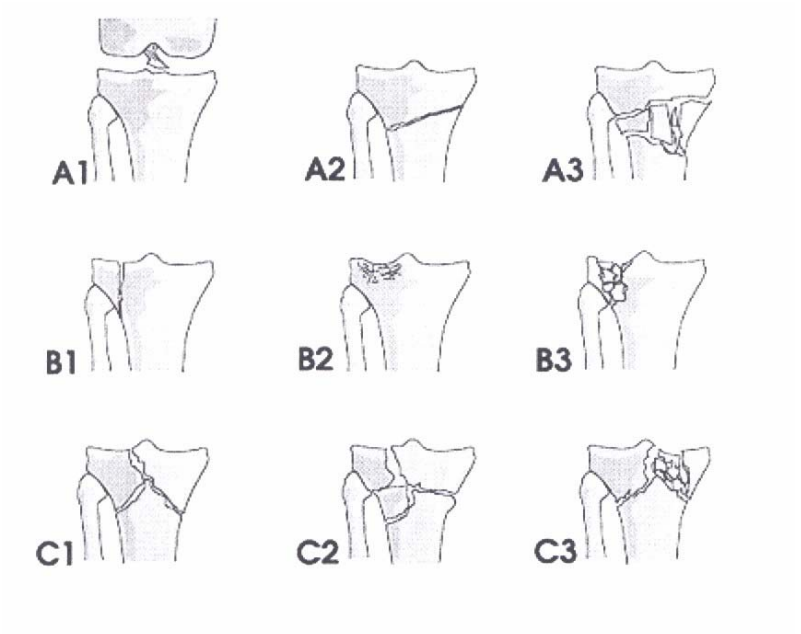


Moore (43) put the name fracture –dislocation of the knee. He considered some split fractures from Hohl classification to be true fracture-dislocation because of their instability.

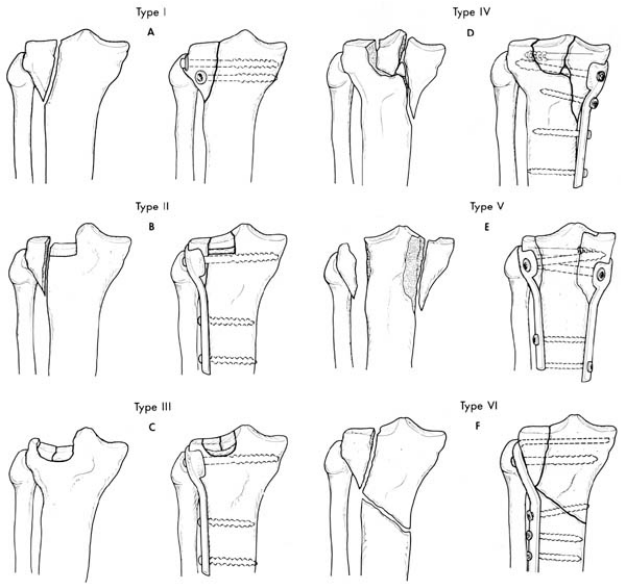


Classification of tibial plateau fractures as described by Hohl and Moore: type 1, minimally displaced; type 2, local compression; type 3, split compression; type 4, total condyle; and type 5, bicondylar. (Redrawn from Hohl M, Moore TM: Articular fractures of the proximal tibia.

The Association for the study of Internal Fixation (ASIF-AO) IN 1990 published the comprehensive classification of fractures of long bones.



Perhaps the most widely used classification of tibial plateau fractures in North America is the one proposed by Schatzker (59) with six types.



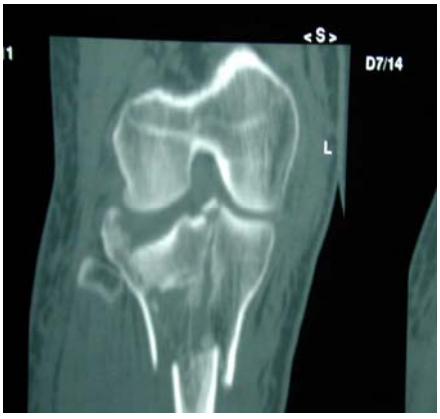
Type I, pure cleavage fracture. B, Type II, cleavage combined with depression. Reduction requires elevation of fragments with bone grafting of resultant hole in metaphysis. Lateral wedge is lagged on lateral cortex protected with buttress plate. C, Type III, pure central depression. There is no lateral wedge. Depression also can be anterior, posterior, or involve whole plateau. After elevation of depression and bone grafting, lateral cortex is best protected with buttress plate. D, Type IV. Medial condyle is either split off as wedge (type A) as illustrated, or it can be crumbled and depressed (type B), which is characteristic of older patients with osteoporosis (not illustrated). E, Type V. Continuity of metaphysis and diaphysis should be considered. In internal fixation both sides must be protected with buttress plates. F, Type VI. Essence of this fracture is fracture line that dissociates metaphysis from diaphysis. Fracture pattern of condyles is variable and all types can occur. If both condyles are involved, proximal tibia should be buttressed on both sides (59).

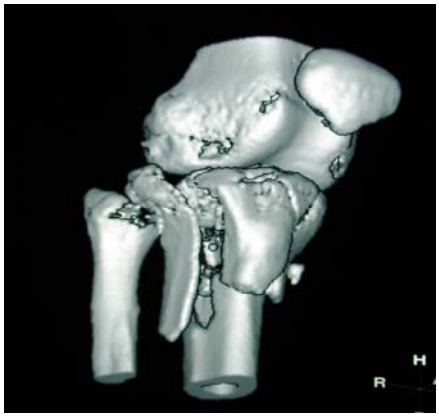
Diagnosis of Tibial Plateau Fracture:

Patient with tibial plateau fractures usually presents with a painful swollen knee and is unable to bear full weight on the affected extremity. The patient is able usually to describe the mechanism of injury. Most commonly, these are valgus injury such as bumper injuries to the knee, football or soccer accident, or fall from a height. The history of the injury is important to show the surgeon whether the injury was caused by high or low energy forces. This is important because associated injuries such as fracture blisters, compartment syndromes, ligamentous disruption, and neurovascular injuries are common with high energy forces.

Anteroposterior and lateral x-rays of the knee will usually show a plateau fracture. If a fracture is suspected ,but is not observed in these views, 40^{o} internal and external oblique views should be obtained. The internal oblique view profiles the lateral plateau while the external oblique view project the medial condyle and plateau (25).

Computed tomography (CT) with axial,coronal and sagittal reconstructions have replaced linear tomography . They are used for delineating the extent of the articular surface involvement in comminuted fractures but give limited information about the soft tissues of the knee.





Because of the high incidence of associated soft tissue injuries to the knee after tibial plateau fractures, many surgeons favor MRI. Although MRI has become the preeminent imaging technique of the musculoskeletal system to evaluate soft-tissue pathology, much less is known about its efficacy in assessing major extremity trauma with complex fractures.(50)

Kode and associates (31) compared the efficacy of MRI with that of CT scanning of the tibial plateau fractures and concluded that MRI was equivalent to two-dimensional CT scans for detection of fracture configuration and was clearly superior in assessing significant soft-tissue injuries.

Barrow and colleagues(4) compared linear tomography with MRI in 31 tibial plateau fractures and he found that both did equally well in deticting articular depression,but MRI was capable of revealing associated ligamentous and meniscal injuries.

Angiography should be considered whenever there is an alteration in the distal pulses or when there is serious concern about any arterial lesion.

MATERIALS AND METHODS

We studied, retrospectively, 30 patients with complex fractures of inter-articular distal femur (AO classification B,C) and tibial plateau fractures displaced more than 5mm of the articular surface or more than 10 degrees angulation, associated with either an open wound or severe soft tissue injuries.

Exclusion criteria included patients who were not fully mobile before their injury and patients who did not continue the follow up in Khoula Hospital. All the patients were treated between January 1999 and December 2003 with at least one year of follow up. All the patients were operated and followed up by the same doctor.

All the patients were treated according to a protocol which consisted of:

1. Standard Antero posterior and lateral plain X-ray.
2. Pre Operative CT Scan for pre operative planning.
3. Open wounds were taken to theatre for wound debridements within 5 hours of admission.
4. Poly trauma patients were fixed as soon as their general condition allowed for surgery.
5. CPM (Continous Passive Movement) for 3-5 days immediately post operative.
6. Patient discharge with above knee cast for 3-5 weeks depending on the patient understanding.
7. Partial weight bearing with early signs clinically and radiologically of union.
8. Patient follow up depended on the clinical examination as well as the x ray findings.

METHODS OF FIXATIONS

The goal of treatment of fractures around the knee is to achieve anatomical reduction and stable fixation. The patient can have early mobilization and function with functional union and to achieve this goal, we must follow these principles:

1. Good pre-operative planning.
2. Gentle handling of soft tissues.
3. Accurate anatomical reduction of the fracture.
4. Rigid, stable fixation.
5. Bone grafting of any major defects if needed.
6. Early and active rehabilitation of the limb and the patient.

In our study we used different types of implants. For the tibial plateau we used percutaneous Asnis screws in 2 patients (16.7%) in minimally displaced fractures because we didn't have canulated screws. We used the percutaneous Asnis screws as well with intraarticular unicondylar fractures of the distal femur, 2 patients (11.1%). and the screws were usually perpendicular to the fracture line for built of buttressing effect. We used L-shape and T-shape plates in 10 patients (83.3%) with fractures of the tibial plateau; for lateral tibial plateau we used the anterolateral parapatellar approach, and for the medial tibial plateau we used the anteromedial parapatellar approach, for the bicondylar fractures we used either the central midline approach or we used Tri-radiate skin incision in 3 cases (25%) without any skin complications due to full skin flap technique.

In intercondylar fractures of the distal femur with displacement, we used the appoach discribed by Mize, Busholz and Grogn 1982, (40) for perfect visualisation of the fracture. We used AO 95^0 Angled Blade Plate in 2 patients

(11.1%) and because of its one piece construction and broad flat blade, it provides stable fixation for most fracture types but technically it is difficult to use because it needs precision and correct alignment in all three planes.

We used as well the Dynamic Condylar screw plate system (DCS) in 6 patients (33.3%) with interarticular distal femur which is more forgiving and allows correction in the sagittal plane after the lag screw is inserted.

We used heavy duty buttress femoral plate in 8 patients (44.4%). Its designed to fit the lateral side of the distal femur, it allows multiple screws in the intercondylar area with good compression, but it is one size, so sometimes the plate is over sized for some patients.

Drain was used for all our patients and the drain was removed within 48 hours post operatively. Antibiotics were given to the patients at least until removal of the drain. In this study, our patients had CPM (Continous Passive Movement) for 3-5 days immediately post operatively, then the patients were discharged with cast for 3 to 5 weeks depending on how much the patient was co-operative, his fracture personality and the quality of bone and stability of fixing implant. With early signs of union the patient would start partial to full weight bearing and physiotherapy programme including quadriceps strengthening exercises, range of movement exercises and hydrotherapy.

There were 23 males (76.7%) and 7 females (23.3%). There were 18 patients with fracture interarticular distal femur (60%) and 12 patients with displaced fractures of the tibial plateau (40%). The etiology of the fractures was: road traffic accident (RTA) in (70%) 21 patients, or fall from height in 9 patients (30%). The fractures were on right side in 16 patients (53.3%) on left side in 13 patients (43.3%) and one patient with right tibia and left femur (3.3%). There was 8 poly traumatized patients (26.7%), associated fracture spine in 2 patients (6.6%), head injury in 3 patients (10%).

RESULTS

Statistical methods:

SPSS (Statistical Package for Social Sciences) version 10.0 was used for data analysis. Mean and standard deviation are descriptive values for quantitative data with median and range for non-normally distributed data. Non parametric *t* test (Mann Whitney test) was used for comparing means of two independent groups. Spearman Rho correlation measured the association between quantitative variables (age and healing time). Chi-square – Fisher exact test were the tests for proportion independence. P value is significant at 0.05 level.

The 30 patients were assessed clinically and radiologically with mean follow up of 30 months (18 to 51 months). All achieved bony union at the end of follow up. While 6 patients had implants removal after 24 – 36 months from the injury. The mean age was 39 years (21 to 63 years) and the mean length of hospital stay is 21 days (3 to 82 days). One patient had implant failure after five weeks from surgery due to premature weight bearing and was reoperated.

Pain: Our observation suggests that the pain tolerance was much higher in the older age group compared to younger age group regardless of the x-ray picture or the clinical findings.

Range of Movements: Our observation suggests that the range of movement in patients with fractures of tibial plateau is much better than the femoral one regardless of the amount of comminution and the quality of reduction and fixation.

Walking Distance: 74% of tibial fracture patients were able to walk 5 blocks or more and 65% of the femoral fracture patients were able to walk 5 blocks or more, only one patient with fracture femur was unable to move.

Healing time: Our results showed that the median healing time for the tibia was 4 months (3 – 8 months) and the median healing time for the femur was 4.5 months (3 – 7 months).

- 6 patients with comminuted fractures needed bone grafts after 8-12 weeks and all our patients fractures healed.
- 8 patients needed double plating.
- 6 tibias and 2 femurs, the femur patients second plate was done as second stage when post operatively we discovered that the fracture fixation is unstable usually during bone grafting.

One of our patients with buttress femoral plate had implant failure and needed re-operation and fixation with DCS and larger plate because the patient was not co-operative and walked full weight bearing without crutches after five weeks of the trauma.

In general, our observations in fractures of the tibial plateau, the clinical outcome was very good to excellent, inspite of the X-ray picture and the quality of the reduction.

In fractures of intercondylar femur, the results were not as satisfactory, even with good X-ray and intraoperative reduction of the fracture.

We could not use any of the known knee scores (Lowa and Rasmussen) because our criteria was not fitting completely with any of them.

Immediate post operative complications

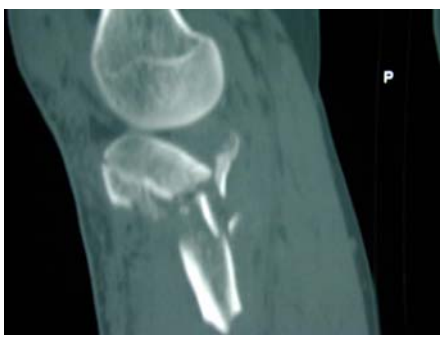
There was no complications in 23 patients (76.7%), wound infections in 3 patients (10.0%), neuropraxia in one patient (3.3%), DVT (Deep Venous Thrombosis) in 3 patients (10.0%).

Examples :

Case 1

A 34 male patient involved in RTA (Road Traffic Accident) and had sustained Tibial Plateau Schatzker type VI fracture with marked depression and split of condylar fragments and metaphyseal comminution. The fracture of medial condyle was fixed with 4 holes DCP plate and lateral condyle with 8 holes buttress plate. The large articular lateral condyle fragment which was depressed was elevated and fixed with cancellous screws.

He was discharged from the hospital with knee brace, After 4 weeks he started partial weight bearing and after 8 weeks full weight bearing; after 4 months his knee range of movement was $5^0 – 110^0$.

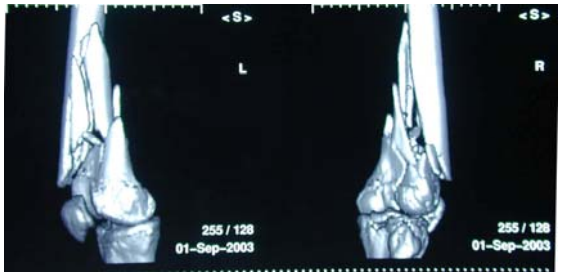


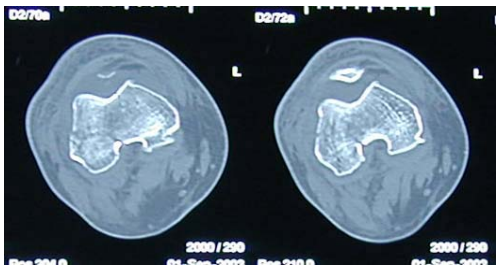
Case 2

A 21 male patient involved in RTA (Road Traffic Accident) had sustained comminuted fracture distal left femur with compound wound Gastelo II. He was taken for debridement and fixation within 6 hours from the accident with femoral buttress plate holes and circulage wires for the comminuted area. Post operatively there was no signs of infection, with follow up there was no signs of healing or callus formation, this

patient was taken for removal of circulage wires, additional screws fixation and bone grafting.

After 6 months the X rays showed callus formation and his range of movement was 0^0 – 80^0 without pain on walking.





DISCUSSION

The management of an adult patient with interarticular fractures around the knee continues to pose a challenge. Specially for Omani patients when good range of movement around the knee is needed for daily social activities, sitting on the ground and praying.

Before 1982 almost all fractures around the knee in Oman was treated by general surgeons and usually through non operative treatment, unfortunately we don't have any documents for this period but we used to review elderly patients with post traumatic deformities or severely arthritic knee as long term result of old injuries to the knee and they were usually treated by TKR (Total Knee Replacement) as final management. In our study, patients continue to improve with time after treatment and the healing of bone and soft tissue injuries, their range of movement slowly improved and their pain tolerance gradually improved.

In our study as well, so many patients could not participate in the study due to the fact that they were expatriates working in Oman and they left the country after their accidents. We didn't use any of the knee scores as Lowa, Hariss or SF-36 questionnaire because our data were not fitting as timing of union or patient going back to work.

If we go to literature we will find that in fracture supra condylar and intracondylar of distal femur, some authors achieved good to excellent results with closed methods in about 54% of their patients (Sf wart, Sisk and Wallace 1966 (64), Neer 1967 (47), Mooney 1970 (41) and 1/3 of the patients had non union. However, Neer had satisfactory result in 84%, his study was retrospective, non randomized and he used different measures

from those used by Schatker 1979 (59) and he used an earlier method of internal fixation.

After 1982 we started in Oman to adapt AO Philosophy and techniques of open reduction and internal fixation, various devices have been used for internal fixation. For supracondylar fracture femur, the literature including angled blade plates [Sheatizker 1979] (59), Rush pins [Shelbourne & Brueckman 1982] (8), Enders nails [Kolmert, Egund & Persson 1983] (34) and purpose designed nails [Zickel, Hobeika & Robbins 1986], Pryor & Doran 1988, Marks, Isbister & Porter 1994, the dynamic candylar screw (DCS) has been shown to give satisfactory results [Sanders 1989 (56).

Recently liss plates and retrograde femoral nail show satisfactory results but there is no studies with enough follow up period to give accurate results [Rademakers 2004] (49).

Table 1 (Implant Options)

Type of Implant	Relative Indications	Relative Contraindications	Advantages	Disadvantages
Blade Plate	Comminuted Supracondylar fracture Low fracture	Intracondylar comminution	Strong able to maintain varus / valgus and antecurvatum or retrocurvatum alignment Most stable fixation	Technically demanding Can comminute unrecognized intracondylar fractures
Compression Screw	Comminuted supracondylar fractures associated with simple intracondylar splits	Intracondylar comminution Very low fractures Coronal fractures	Technically easier to use than blade plate Compresses simple intracondylar spilts Able to maintain varus / valgus alignment	More difficult to maintain recurvatum / antecurvatum alignment in low fractures Occupies a large bone volume in the intracondylar region Requires additional screw fixation in disal fragment for stability
Condylar Plate	Simple supracondylar fracture in association with intracondylar comminution	Comminuted supracondylar fracture	Can be contoured to achieve anatomic reduction of a simple fracture Multiple screw insertion can help reduction of intracondylar comminution	Poor resistance to varus / valgus moments, so requires reconstruction of medical cortical continuity
Dual Plate	Supracondylar and intracondylar comminution	Should be reserved for situation in which no other device will work	Allows multiple-screw fixation of intracondylar comminution Dual plates provide strength for supracondylar comminution	Massive dissection with resultant stiffness Potential for “dead bone sandwich”
Antegrade Nail	Extensive supracondylar comminution, especially proximal	Low fractures Intracondylar extension	Minimal dissection and injury of the soft tissue envelope Strong fixation automatic grafting (reamings)	Can “blow apart” unrecognized intracondylar fractures Can be difficult to achieve anatomic alignment
Retrograde Nail	Osteoporosis Supracondylar periprosthetic fracture	“High-demand” patient Low Fracture	Minimal dissection and injury to soft-tissue envelope Some grafting of the fracture site by reaming	Low strength device Residual fracture instability may necessitate caution when initiating postoperative motion

Treatment of complex high-energy fractures of the tibial plateau remains difficult. The goals of treatment of these injuries are the restoration of joint congruity, normal alignment, joint stability, and a functional range of knee motion. For markedly displaced bicondylar fractures of the tibial plateau and those associated with joint instability, conventional open reduction and internal fixation through a single anterior approach has been the standard way of care. For many bicondylar fractures of the tibial plateau [Schatzker types V and VI] (58), fixation with two plates may be necessary to prevent axial collapse.

However, the soft-tissue stripping in these injuries, together with the surgical dissection needed to apply large plates, has been associated with a high rate of complications particularly infection and wound breakdown. In an effort to improve the outcome of the repair of high-energy fractures of the tibial plateau, less invasive methods of treatment (54) have been introduced with the use of either tensioned circular wire, hybrid, or large-pin monolateral external fixators (37) or internal fixation through two incisions and use of small-fragment specialized plates.

In the last decade, treatment strategies for high-energy fractures of the tibial plateau have changed, resulting in numerous recent results of treatment, unfortunately, there was no results for the functional status of the patients. Most patients show acceptable outcome after sustaining a high-energy fractures of the tibial plateau despite of injury to the articular surface, imperfect reduction, and associated meniscal and ligament injuries, most patients reported that they were functioning well and were able to pursue recreational activities and their occupations with few limitations which was supported by our results.

In our study,fracture of the tibial plateau, 85% of our patients with closed fractures had good to excellent function regardless of the X- ray findings, this is more obvious with lateral tibial plateau fractures.

For minimally displaced fractures of tibial plateau,we treated our patients with percutaneous canulated screws, which is acceptable in most of the studies, some articles discussed the role of external fixator either mono frame or circular frame. In displaced fractures uni or bicondyle of tibial plateau reduction and fixation with one plate or double plates either through one midline tri-radiate incision or through separate two incisions.

There is little information in the literature regarding the outcomes of total knee arthroplasty following open reduction and internal fixation of tibial plateau fractures. Saleh et al (55) reviewed fifteen patients after a minimum duration of follow up of five years. They concluded that total knee arthroplasty after open reduction and internal fixation of the tibial plateau fractures decreased pain and improved knee function but the procedure is technically demanding and is associated with a high failure rate.

CONCLUSION

Although interarticular fractures around the knee are very difficult and are challenging to the surgeon but with good preoperative planning and using good operative techniques the results of operative treatment is very superior to the other types of treatment, with good to excellent results and less complications.

Using the new techniques of internal fixation provided by the AO group, improvement of the quality of care and the final outcome is now well established. Some controversy about the perfect type of fixation internal or external. The type, the time and the need for bone graft or not, still need more research.

In our study the life style of the Omani people has shown good effect on the final range of movement due to sitting on the ground and prayers. Pain tolerance was excellent in older generation due to their life style. Recently, more biological techniques show better progress like Liss plate and retrograde distal femoral nail. In Oman we are in the process of adapting these new techniques to improve the outcome of our patients.

We have collected our data and analysed our results for auditing and teaching purposes. This shows that the adoption of these modern techniques of open reduction and internal fixation within the Omani Health Care system have significantly improved the outcome of these severe injuries in the Omani population.

REFERENCES

1. Apley, A. : Fractures of the Lateral Tibial Condyle Treated by Skeletal Traction and Early Mobilization, J. Bone Jount Surg., 38B:699, 1956.

2. Arneson, T.J.; Melton, L.J. III; Lewallen, D.G.; and O'Fallon, W.M. : Epidermiology of Diaphyseal and Distal Femoral Fractures in Rochester, Minnesota, 1965-1984. Clin. Orthop 234:188-194, 1988

3. Barei D.P.; Nork, S.E.; Mills, W.J.; Henley, M.B.; and Benirschke S.K.: Complications Associated with Internal Fixation of High-energy Bicondylar Tibial Plateau Fractures Utilizing a Two-incision Technique., J. Orthop Trauma. 18(10): 649-57, Nov-Dec. 2004.

4. Barrow, B.A.; Fajman, W.A.; Parker, L.M.; et ail. : Tibial Plateau Fractures; Evaluation with MR Imaging. Radiographics 14:553-559, 1994.

5. Bennett, W.F.; and Browner, B. : Tibial Plateau Fractures; A Study of Associated Soft Tissue Injuries. J. Orthop Trauma 8:183-188, 1994.

6. Blokker, C.P.; Rorabeck; C.H.; and Bourne, R.B. : Tibial Plateau Fractures and Analysis of Treatment in 60 patients. Clin. Orthop., 182:193, 1984.

7. Brooker W.L.: Distal Femoral Fractures: Comparison of Open and Closed Methods of Treatment. Clin. Orthop., 174; 166-71, 1983.

8. Brueckmann FR.: Rush Pin Fixation of the Supracondylar and Intercondylar Fractures of the Femur. J. Bone Joint Surg. [Am] 64-A:161-9, 1982.

9. Burri, C.; Bartzke, G.; Coldeway, J., and Muggler, E.: Fractures of the Tibial Plateau. Clin. Orthop., 138:84, 1979.

10. Catagni, M.: Fractures of the Leg (Tibia). *In* Maioccki, A.B., and Aronson, J. (eds.): Operative Principles of Ilizarov, p. 91. Baltimore, Williams & Wilkins, 1991.

11. Chapman, M.W.; and Mahoney, M.: The Role of Early Internal Fixation in the Management of Open Fractures. Clin. Orthop., 138:120, 1979.

12. Chiron, H.S.; Tremoulet, J.; Casey, P.; and Muller, M: Fractures of the Distal Third of the Femur Treated by Internal Fixation. Clin. Orthop., 100:160-170, 1974.

13. Decoster, T.A.; and Nepola, J.V.: Cast Brace Treatment of Proximal Tibial Plateau Fractures Ten Years Follow-up Study. Clin. Orthop., 231:196, 1988.

14. Dias, J.J.; Stirling, A.M.; Finlay, D.B.; and Gregg, R.J.: Computerised Axial Tomography for Tibial Plateau Fractures. J. Bone Joint Surg., 69B:84, 1987.

15. Drennan, D.B.; Locher, F.G.; and Maylahn, D.J.: Fractures of the Tibial Plateau: Treatment by Closed Reduction and Spica Cast. J. Bone Joint Surg., 61A:989, 1979.

16. Duweilus, P.J.; and Connolly, J.F.: Closed Reduction of Tibial Plateau Fractures: A Comparison of Functional and Roentgenographic End Results. Clin. Orthop., 230:116, 1988.

17. Frankel, V.H.; Green, S.A.; Paley, D., et al. : Symposium: Current Applications of the Ilizarov Technique. Contemp Orthop., 28:51, 1994.

18. Giles, J.B.; DeLee, J.C.; Heckman, J.D.; and Keever, J.E.: Supracondylar-Intercondylar Fractures of the Femur Treated with a Supracondylar Plate and Lag Screw. J. Bone Joint Surg., 64A:864-870, 1982.

19. Gossling, H.R.; and Peterson, C.A.: A New Surgical Approach in the Treatment of Depressed Lateral Condylar Fractures of the Tibia. Clin. Orthop., 140:96, 1979.

20. Green, N.E.; and Allen, F.L.: Vascular Injuries Associated with Dislocation of the Knee. J. Bone Joint Surg. 59A:236-239,1977.

21. Gustilo, R.B.: Fractures of the Tibial Plateau. *In* Gustilo, R.B., Kyle, R., and Templeman, D. (eds.): Fractures and Dislocations, p. 945. St. Louis, C.V. Mosby, 1993.

22. Healy, W.L.; and Brooker, A.F.: Distal Femoral Fractures: Comparison of Open and Closed Methods of Treatment. Clin. Orthop., 174:166-171, 1983.

23. Hohl, M.: Tibial Condylar Fractures. Instruct Course Lect 33:206-217, 1963.

24. Hohl, M.: Tibial Condylar Fractures. J. Bone Joint Surg., 49A:1455, 1967.

25. Hohl, M.: Part I: Fractures of the Proximal Tibia and Fibula. *In* Rockwood, C., Green, D., and Bucholz, R. (eds.): Fractures in Adults, 3rd ed. Philadelphia, J.B. Lippincott, 1991.

26. Hohl, M.; and Luck, J.V.: Fractures of the Tibial Condyle. J. Bone Joint Surg., 38A:1001, 1956.

27. Honkonen, S.E.: Indications for Surgical Treatment of Tibial Condyle Fractures. Clin. Orthop., 302:199-205, 1994.

28. Johnson, K.D.; and Hicken, G.: Distal Femoral Fractures. Orthop. Clin. North Am., 18:115-132, 1987.

29. Karunakar M.A.; and Egol K.A.: Split Depression Tibial Plateau Fractures., J. Orthop. Trauma. 16:172-7, 2002.

30. Kennedy, J.C.: Complete Dislocation of the Knee Joint. J. Bone Joint Surg. 45A:889-904, 1963.

31. Kode, L.; Lieberman, J.M.; Motta, A.O.; Wilber, J.H.; Vasen, A.; and Yagan, R.: Evaluation of Tibial Plateau Fractures: Efficacy of MR Imaging Compared with CT.A.J.R., 163:141, 1994.

32. Koechlin, P.; Nael, J.F.; Bonnet, J.C.; D'Ythurbide, B.; and Apoil, A.: Ligamentous Lesions Associated with Fractures of the Tibial Plateau. Acta Orthop. Belg., 49:751, 1983.

33. Kolmert, L.; Egund, N.; and Persson, B.D.: Internal Fixation of Supracondylar and Bicondylar Fractures using a New Semi-Elastic Device. Clin. Orthop., 181:204-219, 1983.

34. Kolmert, L.; and Wulff, K.: Epidemiology and Treatment of Distal Femoral in Adults. Acta Orthop. Scand 53:957-962, 1982.

35. Koval, K.J.; Sanders, R.; Borrelli, J.; Helfet, D.; DiPasquale, T.; and Mast, J.W.: Indirect Reduction and Percutaneous Screw Fixation of Displaced Tibial Plateau Fractures. J. Orthop. Trauma, 6:340, 1992.

36. Lansinger, O.; Bergman, B.; Komer, L.; and Anderssonn, G.M.J.: Tibial Condylar Fractures: A twenty-year follow-up. J. Bone Joint Surg., 68A:13, 1986.

37. Mallik, A.R.; Covall, D.J.; and Whitelaw, G.P.: Internal Versus External Fixation of Bicondylar Tibial Plateau Fractures. Orthop. Rev., 21:1433, 1992.

38. Mast, J.; Jakob, R.; and Ganz, R., eds.: Planning and Reduction Technique. *In* Fracture Surgery, p. 100-114. New York, Springer-Verlag, 1989.

39. Mast, J.; Jakob, R.; and Ganz, R.: Planning and Reduction Technique in Fracture Surgery, Berlin, Springer, 1989.

40. Mize, R.D.; Bucholz, R.W.; and Grogan, D.P.: Surgical Treatment of Displaced, Comminuted Fractures of the Distal End of the Femur. J. Bone Joint Surg., 64A:871-879, 1982.

41. Mooney,V;Nickel,VL;Harvey,JP; and Snelson,R:Cast-Brace Treatment for Fractures of the Distal Part of the Femur.J.Bone Joint Surg.,52-A:1563,1970.

42. Moore, T.M.; Meyers, M.H.; and Harbey, J.P., Jr.: Collateral Ligament Laxity of the Knee Long-term Comparison Between Plateau Fractures and Normal J. Bone Joint Surg., 58A:594, 1976.

43. Moore, T.M.; Patzakis M.G.; and Harvey, J.B.: Tibial Plateau Fractures Definition, Demographics, Treatment Rationale, and Long-term results of Closed Traction Management or Operative Reduction. J. Orthop Trauma 1:97-119, 1987.

44. Muller, M.E.; Allgower, M.; Schneider, R.; and Willenegger, H.: Manual of Internal Fixation. New York, Springer-Verlag, 1979.

45. Muller, M.E.; Allgower. M.; Schneider, R.; and Willenegger, H.: Manual of Internal Fixation, 2nd ed. New York, Springer-Verlag. 1979.

46. Muller, M.E.; Nazarian, S.; and Koch, P.: Classification AO Des Fractures. New York, Springer-Verlag, 1987.

47. Neer, C.S.; II, Grantham, S.A.; and Shelton, M.L.: Supracondylar Fracture of the Adult Femur. J. Bone Joint Surg. 49A:591-613, 1967.

48. Olerud, S.: Operative Treatment of Supracondylar-Condylar Fractures of the Femur. J. Bone Joint Surg., 54A:1015-1032, 1972.

49. Rademakers, M.V.; Kerkhoffs, G.M.; Sierevelt, I.N.; Raaymakers, E.L.; and Marti, R.K.: Intra-articular Fractures of the Distal Femur: A Long-term Follow-up Study of Surgically Treated Patients., J. Orthop Trauma. 18(4): 213-9, Apr. 2004.

50. Rafii, M.; Lamont, J.G.; and Firooznia, H.: Tibial Plateau Fractures: CT Evaluation and Classification. Crit. Rev. Diagn. Imaging. 27:91, 1987.

51. Radford, PJ; and Howell, CJ;The AO Dynamic Condylar Screw for Fractures of the Femur:Injury.,Br.J.Acc.Surg.,23:89,1992.

52. Regazzoni, P.; Leutenegger, A.; Ruedi, T.; and Staehelin, F.: Erste Erfahrungen mit der dynamischen kondylenschraube (DCS) bei distalen femurfrakturen. Helv Chir Acta 53:61-64, 1986.

53. Regazzoni, P.; Ruedi, T.; and Allgower, M.: The Dynamic Condylar Screw Implant System for Fractures of the Distal Femur. AO/ASIF Dialogue, 1:8-9, 1986.

54. Ricci, W.M.; Rudzki, J.R.; and Borrelli J. Jr.: Treatment of Complex Proximal Tibia Fractures with the Less Invasive Skeletal Stabilization System., J. Orthop Trauma. 18(8):521-7, Sep. 2004.

55. Saleh K.J.; and Sherman P: Total Knee Arthoplasty after Open Reduction and Internal Fixation of Fractures Tibial Plateau., J. Bone Joint Surg. Am. 83:1144-48, 2001.

56. Sanders, R.; Regazzoni, P.; and Ruedi, T.P.: Treatment of Supracondylar-Intercondylar Fractures of the Femur Using the Dynamic Condylar Screw. J. Orthop. Trauma, 3:214-222, 1989.

57. Schatzker, J.: Fractures of the Tibial Plateau. *In* Schatzker, J., Tile, M. (eds.): Rationale of Operative Fracture Care, p. 279. New York: Springer, 1987.

58. Schatzker, J.: Tibial Plateau Fractures. *In* Browner, Jupiter, Levine, and Trafton (eds.): Skeletal Trauma, p. 1745. Philadelphia, W.B. Saunders, 1993.

59. Schatzker, J.; and Lambert, D.C.: Supracondylar Fractures of the Femur. Clin. Orthop., 138:77-83, 1979.

60. Schatzker, J.; McBroom, R.; and Bruce, D.: Tibial Plateau Fractures: The Toronto Experience 1968-1975. Clin. Orthop., 138:94, 1979.

61. Segal, D.; Mallik, A.R.; Wetzler, M.J.; Franchi, A.V.; and Whitelaw, G.P.: Early Weight Bearing of Lateral Tibial Plateau Fractures. Clin. Orthop., 294:232, 1993.

62. Seinsheimer, F.: Fractures of the Distal Femur. Clin. Orthop., 153:169-179, 1980.

63. Siliski, J.M.; Mahring, M.; and Hofer, H.P.: Supracondylar-Intercondylar Fractures of the Femur. J. Bone Joint Surg., 71A:95-104, 1989.

64. Sisk T.D.; and Wallace S.L.: Fractures of the Distal Third of the Femur: A Comparison of Methods of Treatment. J. Bone Joint. Surg. [AM] 48-A:784-2807, 1966.

65. Spiegel, P.G.; and Shybut, G.T.: Tibial Plateau Fractures. Editorial. Clin. Orthop. 183:12-16, 1979.

66. Stannard J.P.; Wilson, T.C.; Volgas, D.A.; and Alonso, J.E.: The Less Invasive Stabilization System in the Treatment of Complex Fractures of the Tibial Plateau: short-term results., J. Orthop Trauma. 18(8):528-35, Sep. 2004.

67. Stevens D.G.; and Beharry R.: The Long-term Functional Outcome of Operatively Treated Tibial Plateau Fractures., J. Orthop. Trauma. 15:312-20, 2001.

68. Walling, A.K.; Seradge, H.; and Spiegel, P.G.: Injuries to the Knee Ligaments with Fractures of the Femur. J. Bone Joint Surg. 64A:1324-1327, 1982.

69. Watson, J.T.: High Energy Fractures of the Tibial Plateau. Orthop. Clin. North Am., 25:723, 1994.

70. Wilppula, E.; and Bakalim, G.: Ligamentous Tear Concomitant with Tibial Condylar Fracture. Acta Orthop. Scand., 43:292, 1972.

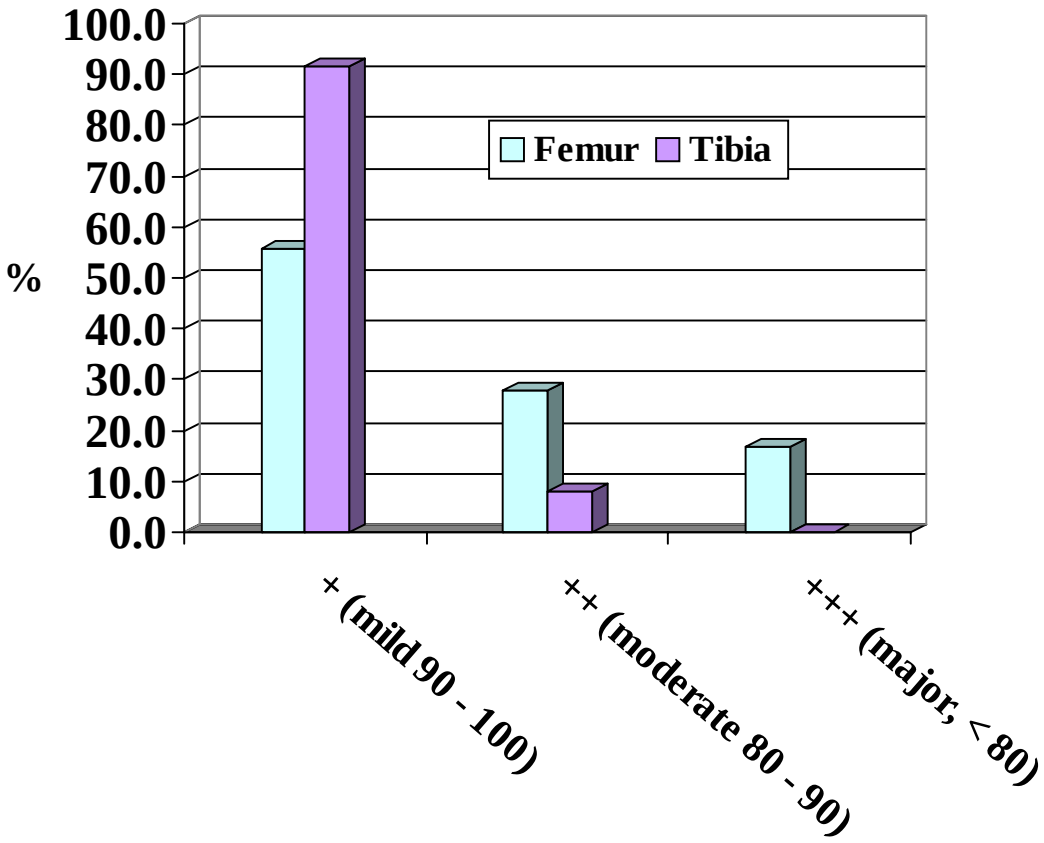
71. Wiss,D.A:What's New in Orthopaedic Trauma.J.Bone Joint Surg., 84A:2111-9,2002.

Case Summaries of femur

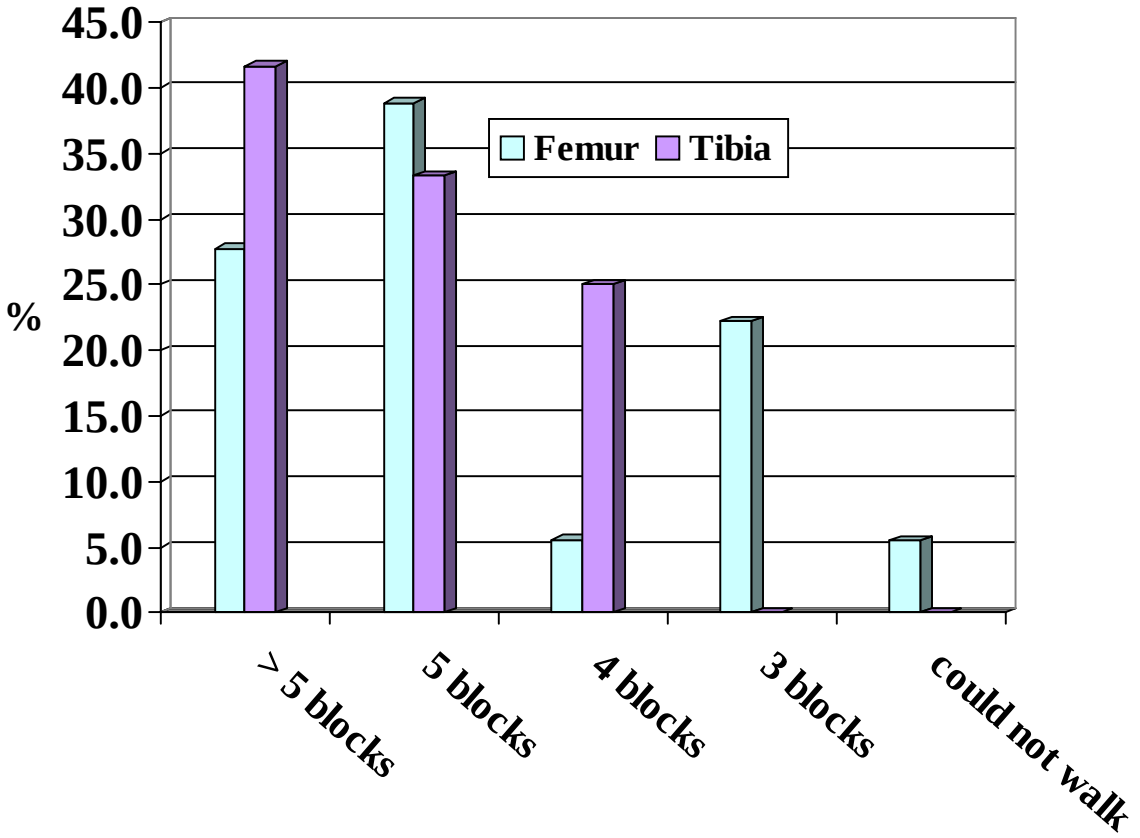
	AGE	SEX	Occupation	ETIOLOGY	SIDE	Length of hospital stay (days)	Pain score	Range of movement	Walking distance	Healing time (month)	Deformity	Post-operative complications	Other injuries
1	21	M	Employer	RTA	Left	45	2	0-80	5 blocks	6	No	No	Multiple fractures
2	56	M	Worker	RTA	Left	22	4	0-90	3 blocks	6	15	Wound infection	Multiple fractures
3	62	F	House wife	Fall	Right	51	2	10-90	4 blocks	7	10	DVT	No
4	45	F	House wife	RTA	Right	20	6	0	3 blocks	5	Ankylosed	No	Multiple fractures
5	47	M	Employer	Fall	Left	3	0	0-110	5 blocks	6	No	No	No
6	59	F	House wife	RTA	Right	7	0	0-100	5 blocks	7	No	No	No
7	33	M	Worker	Fall	Right	20	3	0-85	3 blocks	5	No	No	Multiple fractures
8	31	M	Worker	Fall	Left	7	0	0-120	>5 blocks	4	No	No	No
9	27	M	Worker	RTA	Left	9	3	0-90	5 blocks	4	No	No	Fracture D12
10	34	M	Worker	RTA	Right	46	2	0-110	>5 blocks	4	No	DVT	Fracture pelvis
11	31	M	Worker	Fall	Right	7	2	0-100	>5 blocks	3	No	No	No
12	42	M	Worker	RTA	Right	22	2	0-110	>5 blocks	3	No	No	Multiple fractures
13	32	M	Worker	RTA	Left	38	3	10-80	3 blocks	5	10	No	Multiple fractures
14	22	M	Worker	Fall	Left	11	1	0-130	>5 blocks	3	No	No	No
15	31	M	Worker	RTA	Left	30	0	15-80	Can't walk	3	15	No	Head injury
16	45	F	House wife	RTA	Right	20	2	0-110	5 blocks	5	No	Wound infection	Fracture L1+paraplegia
17	40	M	Worker	RTA	Right	18	1	0-120	5 blocks	4	No	No	No
18	34	M	Employer	RTA	Right	5	2	0-100	5 blocks	4	5	No	Head injury
No	18	18	18	18	18	18	18	18	18	18	18	18	18

Case Summaries of tibia

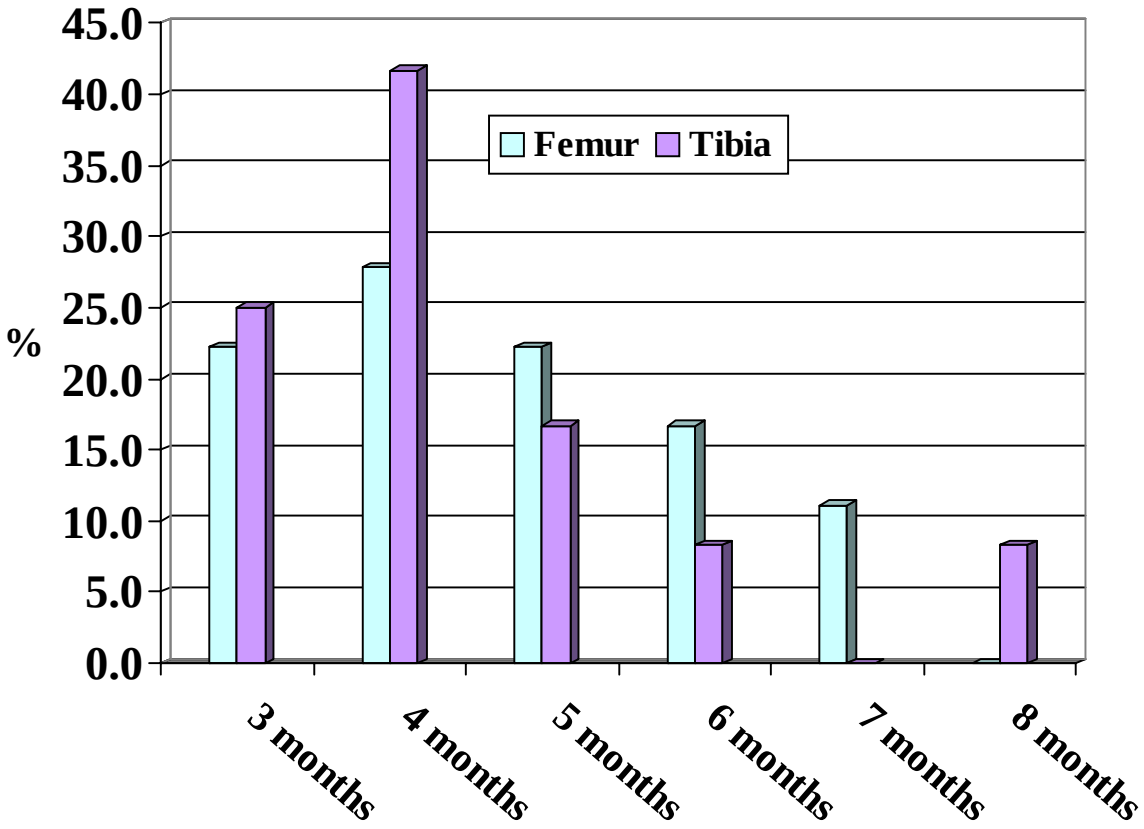
	AGE	SEX	Occupation	ETIOLOGY	SIDE	Length of hospital stay (days)	Pain score	Range of movement	Walking distance	Healing time (month)	Deformity	Post-operative complications	Other injuries
1	63	M	Farmer	RTA	Right	82	3	0-100	>5 blocks	4	No	Wound infection	Multiple fractures
2	41	M	Worker	RTA	Left	17	1	0-110	4 blocks	4	No	No	Fracture metatarsal bone, ACL tear
3	38	M	Worker	Fall	Right	5	0	0-120	>5 blocks	6	No	No	No
4	31	M	Worker	RTA	Right	27	2	0-100	5 blocks	4	No	Neuropraxia	Neuropraxia
5	34	M	Employer	RTA	Right	21	0	5-110	>5 blocks	5	5	No	Multiple skin contusions
6	28	M	Worker	RTA	Left	57	3	0-100	5 blocks	4	No	No	Multiple fractures
7	62	M	Retired	Fall	Right	20	3	5-100	5 blocks	8	5	DVT	Multiple mylomas
8	35	M	Policeman	RTA	Left	4	0	0-100	>5 blocks	4	No	No	No
9	62	F	House wife	RTA	Rt tibia	14	4	0-80	4 blocks	5	15	No	Floating knee
10	31	M	Worker	Fall	Right	12	1	0-130	>5 blocks	3	No	No	No
11	25	F	Employer	RTA	Left	4	1	0-110	5 blocks	3	No	No	No
12	28	F	Employer	RTA	Left	9	3	0-90	4 blocks	3	10	No	Head injury
No	12	12	12	12	12	12	12	12	12	12	12	12	12



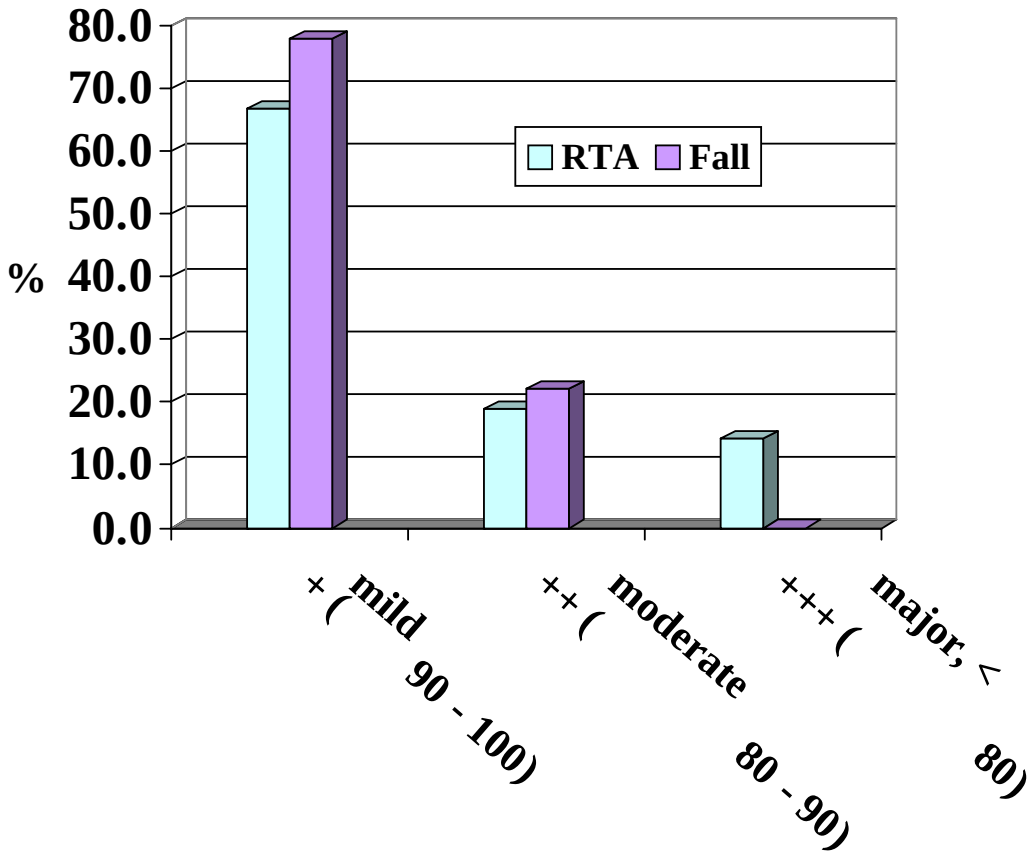
Comparision of range of movement according to fracture site.



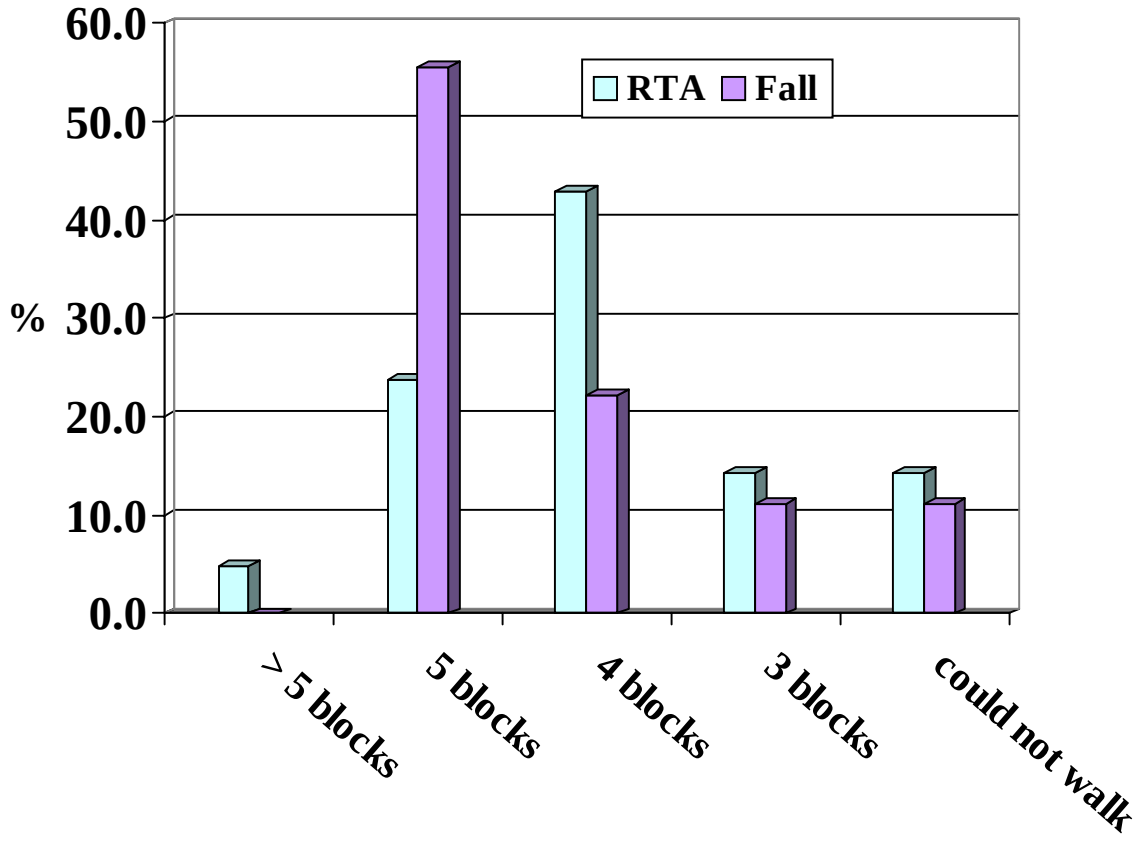
Comparison of walking distance according to fracture site.



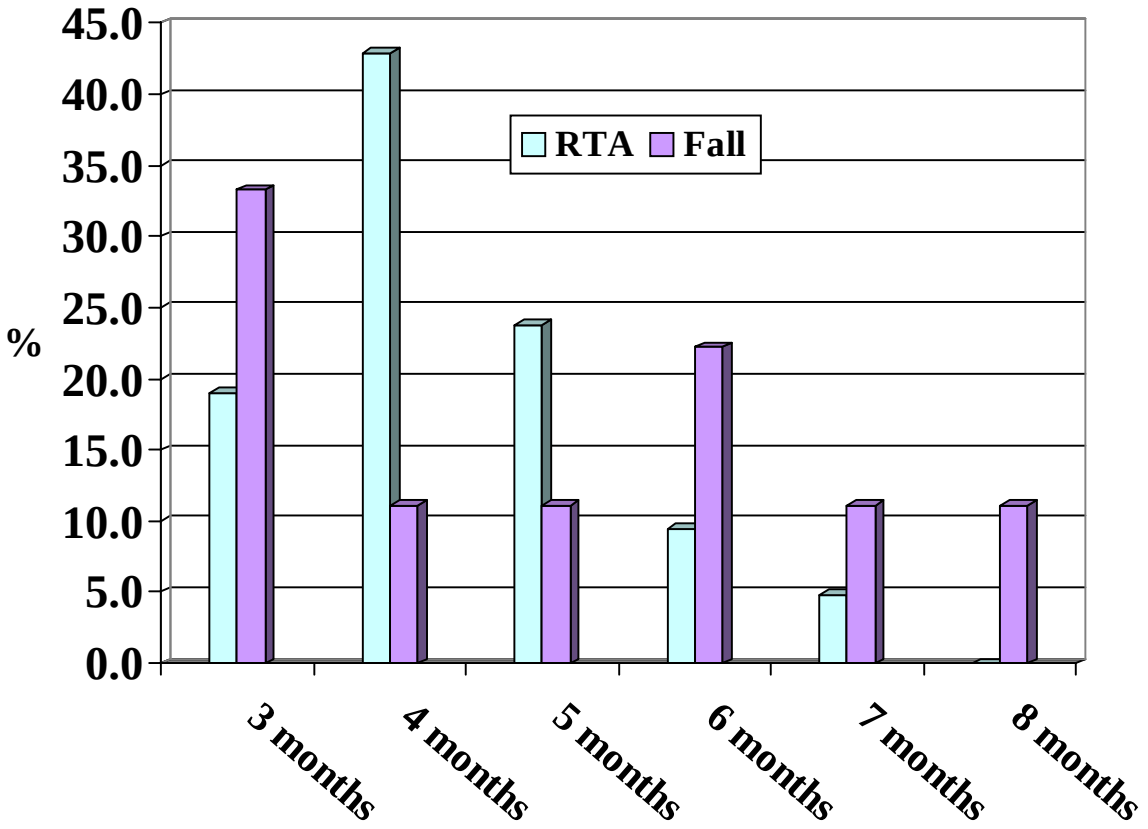
Comparison of healing time (month)
according to fracture site.



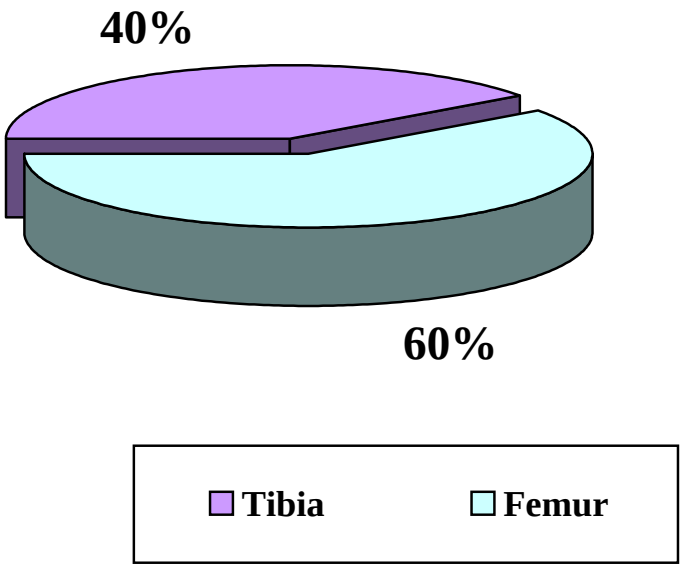
Comparison of range of movement according to etiology of fracture.



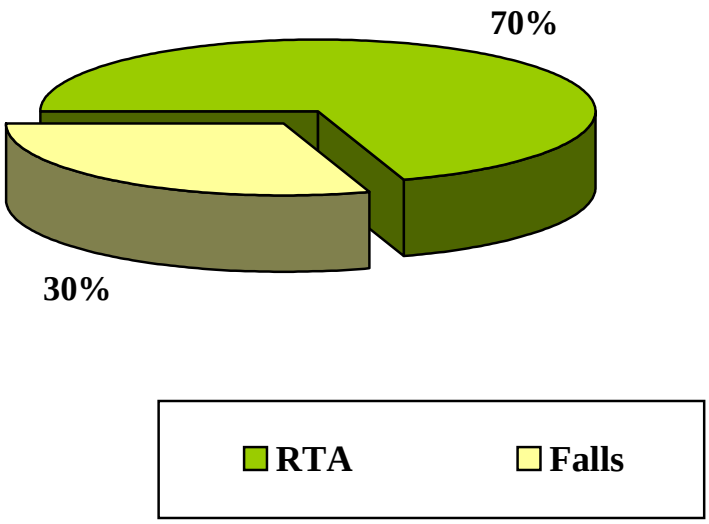
Comparison of walking distance according to etiology of fracture.



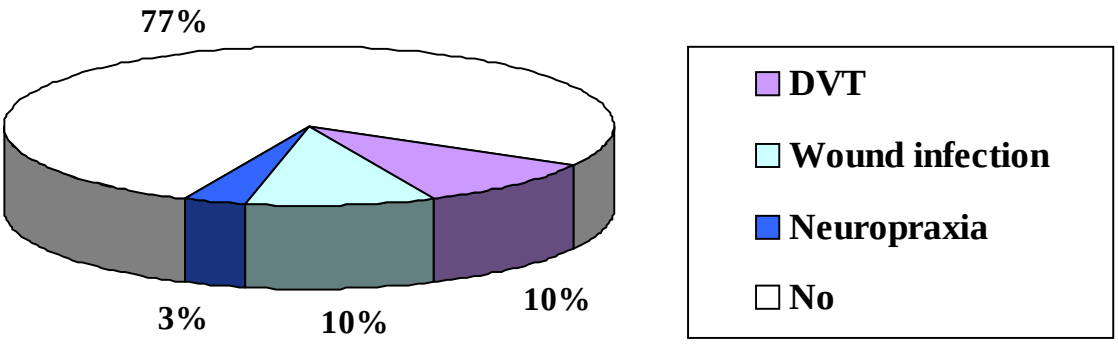
Comparison of healing time (month)
according to etiology of fracture. .



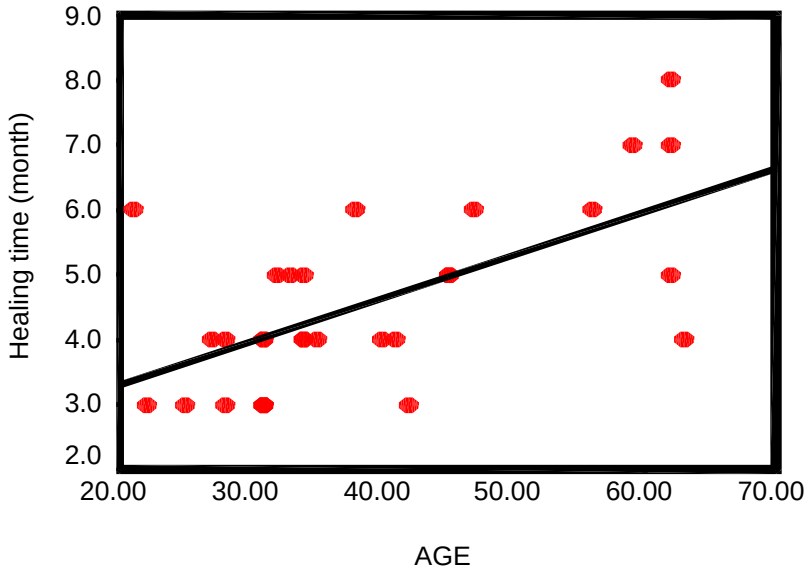
Site of fracture in studied groups.



Etiology of fracture in studied groups.



Post-operative complications among the studied groups.



Correlation of age (years) to healing time (month) among patients with fracture femur / tibia, $r = 0.63$, $p < 0.001$