Original Article

Risks of concomitant trauma to the knee in lower limb long bone shaft fractures: A retrospective analysis from a prospective study population

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Abstract

Background: Numerous associated injuries (bony and/or soft tissue lesions) occur commonly in conjunction with fractures of the femoral shaft in young patients after high-energy injuries. Knee ligamentous injuries, historically called as the internal derangements of the knee or IDK, are mostly not visible in plain radiographs taken in the emergency and these injuries are likely to be overlooked by clinicians because first attention always goes to open wounds and radiologically visible injuries of the limb whenever a patient is received in a trauma unit.

Materials and Methods: A total of 93 cases of lower limb long bone fractures were retrospectively analyzed from materials of a prospective study conducted on consecutive patients having high-velocity injuries to lower limb long bones with a view to confirm or rule out concomitant ipsilateral IDK in cases of femoral and tibial shaft fractures, that already employed a policy of focused clinical examination followed by arthroscopy of the ipsilateral knee, immediately after operative fracture fixation under the same anesthesia. The goal was to determine the incidence of concomitant internal derangement of the ipsilateral knee and to understand any value of adding arthroscopy to detect concomitant IDK in lower limb long bone fractures besides careful intraoperative examination to propose a recommendation thereof.

Results: Concomitant knee injury was found in 14 femoral fractures and 1 tibial fracture. Fifteen out of 93 (16%) such cases had concomitant knee ligamentous or meniscal injures. A total of 13 anterior cruciate and 4 posterior cruciate tears, 11 collateral ligament tears, and 10 meniscal injuries were confirmed in these 15 knees. Femoral shaft fractures were associated with a high incidence of serious ligamentous, meniscal, and chondral injury. Twelve out of 41 femoral fractures had chondral injuries (contusion), especially of the patello-femoral articulation, identifiable during arthroscopy.

Conclusion: One should have high index of suspicion about internal knee injuries and capsule-ligamentous injuries while dealing with femoral shaft fractures in particular. Arthroscopy of knee may safely enhance the diagnosis of simultaneous IDK. We propose that when MR imaging is not possible and when contraindication for arthroscopy does not exist, a careful clinical examination followed by arthroscopy of the knee may be considered a useful adjunct in femoral shaft fractures as it can readily confirm IDK by its ability to objectively look, probe, and distinguish fragile tissue from a normal one. Further study in larger number of subjects is needed to validate our findings.

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INTRODUCTION

Whenever a patient is received in a trauma unit, first attention always goes to life-threatening injuries, open wounds, and radiologically visible injuries. The dramatic presentation of the fracture/fractures tends to mask other associated injuries. Knee ligamentous injuries, historically called as the internal derangements of the knee (IDK), are mostly not visible in plain radiographs taken in the emergency and in a good number of cases; these injuries are likely to be overlooked or entirely missed by clinicians. Such associated knee injuries may potentially add to increased morbidity to the patient, especially if they are unrecognized and untreated. The sequelae of occult concomitant trauma, though may not manifest immediately, nevertheless, in the long term, such missed injuries can lead to significant morbidity. For instance, risk of degeneration of the joint if associated intra-articular or juxta-articular soft tissue injuries are not addressed in time. It is difficult to find such studies which scientifically document incidence and types of IDK associated with extra-articular fractures of lower limb bones.

Arthroscopy of knee is a common diagnostic procedure to find out and confirm IDK. It may even be considered by some as superior over magnetic resonance (MR) imaging in its ability to probe, distinguish fragile tissue from normal, and perform additional surgical procedures like removal of loose bodies. In other words, arthroscopy is an extension of the surgeon's own finger. MR imaging is a relatively costly option to diagnose IDK. Doing arthroscopy at the same sitting with internal fixation of fractures may be a cost- and time-effective option and may allow to diagnose and manage treatable conditions at the same sitting or plan for the next best intervention.

MATERIALS AND METHODS

A retrospective analysis was conducted from prospective study materials from old records of consecutive patients having high-velocity injuries to lower limb long bones, femur, tibia, pelvis, attending the Department of Orthopedics. The data were obtained from a previously conducted prospective study on consecutive patients ($N = 97$) involving 41 fractures of femur, 52 leg bones, and 4 pelvic fractures, attending the Department of Orthopedics and Traumatology, Meenakshi Mission Hospital and Research Centre, Madurai, for a year where the first author was one of the main investigators. After fracture fixation, examination under anesthesia and arthroscopy were performed. The mechanism of injury was high-energy trauma. Study was to determine the incidence of concomitant ipsilateral extra- and intra-articular knee injury. The aims of the original prospective study were many: 1) to evaluate the incidence of concomitant knee injuries sustained during high-velocity fractures involving pelvis, femur, and tibia; 2) to correlate clinical findings with arthroscopic findings during diagnostic arthroscopy; 3) to correlate the mechanism of original injuries with types of associated knee injuries when present; and 4) to find out the incidence of specific knee injury/IDK and its correlation with the location of the fracture. The goal was to estimate and enhance detection of concomitant IDK in lower limb long bone fractures by adding arthroscopy, immediately after fracture fixation.

But we realized that statistical methods were not employed in the original study for correlation or association. Moreover, sample size is small for pelvis fracture and their mechanism of injury may be entirely different; therefore, pelvic cases were excluded. So, the sole aim of our retrospective study was narrowed down only to determine the incidence and type of concomitant true ipsilateral capsule-ligamentous injuries of IDK and chondral injuries sustained along with ipsilateral fractures involving lower limb long bones, the femur and tibia ($N = 93$). Our goal was to determine the incidence of concomitant internal derangement of the ipsilateral knee and to understand any value of adding arthroscopy to detect concomitant IDK in lower limb long bone fractures besides careful intraoperative examination to propose a recommendation thereof. In our study, IDK was discretely redefined for pragmatism as significant injury to anterior cruciate ligament (ACL), medial and lateral collateral ligament (MCL and LCL), posterior cruciate ligament (PCL), and medial and lateral meniscus. We excluded chondral contusion from IDK as such and counted these injuries, but under separate heading.

In the original study from where we selected all our cases, only surgically unfit cases and patients with major limb vascular injuries, compartment syndrome, and radiologically evident intra-articular fractures were excluded. All patients were aged between 15 and 60 years. In the original study, the number of male patients was 85 (87.6%) and that of female patients was 12 (12.4%). Males were predominantly affected (ratio 7:1). The majority of patients were aged 26-35 years. According to protocol, once patient's general condition was stabilized and patient was fit for surgery, attempt was made to stabilize bony injuries. After stabilization of the fracture with suitable implant, aspiration of any hemarthrosis was carried out and clinical examination of knee was performed under the same anesthesia. Arthroscopy was performed through standard anterolateral and anteromedial portals using normal saline as distension

and irrigation fluid. Whenever possible, electronic pneumatic tourniquet was applied and maintained 120 mm above the systolic pressure. Both menisci were lifted with standard arthroscopic probe hook and checked for separation, tear, and hypermobility. Arthroscopy was performed in a systemic manner inspecting suprapatellar pouch, medial gutter, medial compartment, intercondylar notch, posteromedial compartment, lateral compartment, lateral gutter, and posterolateral compartment in sequence. Additional portals were made when visualization of any compartment was difficult. Epidemiological aspects of the original study were summarized and included in this paper to have a better insight.

RESULTS

Out of 97 patients, 52 (53.6%) patients had fractures in both bones of the leg, 41 (42.3%) patients had fracture shaft of femur, and only 4 were pelvic fractures. The causes of injury were: road traffic accident 88 patients and fall from height (including from buildings, trees, or into well) 9 patients. Overall, concomitant knee injury was found in 17out of 97 (17.5%) in the original study. Out of these 17 cases, an average of 2.35 injuries per knee was detected in injured knees. The common injury pattern was mixed injuries; only five knees had isolated soft tissue injury [Table 1]. A total of 13 ACL tears, 5 PCL tears, 7 MCL tears, 4 LCL tears, 6 medial meniscal, and 4 lateral meniscal injuries were confirmed in 17 knees. Out of all 17 injured knees, 14 were associated with femoral shaft fractures, 1 was due to tibia fracture, and 2 were associated with pelvic fractures [Table 2].

When pelvic fractures were excluded in our retrospective analysis, concomitant knee injury other than occult chondral contusion was found in 15 out of 93 (16%) lower limb long bone fractures. When chondral contusion was added, 17 cases out of 93 (18%) long bone fractures had IDK. Out of these 15 injured knees, nearly all (n = 14) had femoral fractures. Femoral shaft fractures were associated with a high incidence of serious ligamentous, meniscal, and chondral injury, often needing separate surgery. Chondral injury has been separately discussed for clarity in our study. A total of 20 chondral contusion injuries out of 97 were identified at arthroscopy in the original study. Out of 17 chondral injuries out of our 93 study cases, 15 were combined type (associated with soft tissue injuries of IDK) and 5 were isolated injuries. Seventeen out of our 93 long bone fractures (18%) had concomitant chondral contusion. Twelve out of 41 femoral fractures (29.3%) and 5 out of 52 tibial fractures (9.6%) had chondral contusion, especially of the patello-femoral articulation identifiable during arthroscopy [Tables 3 and 4]. The most common site for contusion was patello-femoral region involving the patellar side more than on the femoral trochlea. Chondral injury of patello-femoral articulation in particular has high association with femoral shaft fractures. No patient developed compartment syndrome or significant added morbidity due to arthroscopy, requiring additional attention.

Table 1: The observed patter of combination of injuries

IDK pattern	No.
ACL + PCL + MCL + MM	2
ACL + LCL + LM	4
ACL + MCL + MM	3
ACL + MCL	1
ACL + PCL	1
MCL + MM	1
Mixed chondral contusions	12
Isolated chondral contusions	5
PCL (isolated)	1
ACL (isolated)	1

DISCUSSION

The possibility of concomitant knee ligamentous injury with high-energy mechanism fractures of femur is well known to traumatologists. Recognition of ligamentous injuries of the knee in the acute phase is essential for optimum treatment and prognosis. A multitraumatized patient with a fractured femur and occult knee ligament damage presents a difficult diagnostic challenge. In study of 40 adults with closed high-energy diaphyseal femoral fractures studied prospectively to determine the incidence of concomitant ipsilateral extra- and intra-articular knee injury by examination under anesthesia and arthroscopy, De Campos *et al.*[1] reported significant arthroscopic findings in 22 patients (55%). These included 19 partial (48%) and 2 complete (5%) anterior cruciate injuries, 2 partial (5%) and 1 complete (2.5%) posterior cruciate injuries, and 5 medial (12%) and 8 lateral (20%) meniscus tears. Significant arthroscopic findings (ACL or PCL injuries, meniscal tear, osteochondral fracture) were noted in conjunction with effusion or laxity > Grade I in more than half of the group, and

Table 2: The incidence of concomitant knee menisco-ligamentous injuries for fracture Locations

Fracture type	Total patient	Knee injury	%
Femur fracture	41	14	34
Leg bones/ Tibia fracture	52	1	1.9
Pelvic fracture	4	2	50

Table 3: Pattern of concomitant knee injuries seen with 14 out of 41 femoral shaft fractures and six tibial fractures

Fractured long bone	Case no.	ACL	PCL	MCL	LCL	Medial meniscus	Lateral meniscus	Chondral contusion
Femoral fractures	1	+	+	+		+		+
having ipsilateral	2	+	+	+		+		+
knee lesions	3	+		+		+		+
	4	+		+		+		+
	5	+		+		+		+
	6	+			+		+	+
	7	+			+		+	+
	8	+			+		+	+
	9	+			+		+	+
	10	+	+					+
	11	+		+				+
	12	+						
	13	+						
	14		+					+
Tibial fractures	1			+		+		
having ipsilateral	2							+
knee lesions	3							+
	4							+
	5							+
	6							+

High incidence of ACL in femoral fractures. Chondral contusions were common in both femoral & tibial fractures

Table 4: Specific knee injuries with respect to femoral fractures

IDK pattern	No.
ACL + PCL + MCL + MM	2
ACL + LCL + LM	4
ACL + MCL + MM	3
ACL + MCL	1
ACL + PCL	1
MCL + MM	1
Mixed chondral contusions	12
Isolated chondral contusions	5
PCL (isolated)	1
ACL (isolated)	1

ACL is the most common associated injury in femoral fracture followed by MCL

such findings were present in one third despite the absence of effusion or laxity. A high incidence of knee injuries, including many that were occult, occurred in conjunction with ipsilateral femoral shaft fractures. Based on these findings, the authors recommend a high index of suspicion for coexisting knee injuries with ipsilateral femoral fracture and use of appropriate diagnostic and therapeutic measures. When chondral contusion is added, 17 cases out of 93 (18%) long bone fractures had IDK in our retrospective analysis, lower than De Campos *et al*.'s reported series.

Blacksin *et al.*[2] reported that out of 34 patients with closed femoral shaft fractures, 97% of patients demonstrated ipsilateral knee effusions in MR imaging. All patients had knee examinations done under anesthesia, and the MR results were compared with the clinical examinations. Twenty-seven percent patients demonstrated meniscal tears, with the posterior horn of the medial meniscus most frequently torn. The MCL was the most frequent site of ligamentous injury (38%), followed by the PCL (21%). Bone bruises were noted in 32% of patients. Articular cartilage injuries were confined to the patella in four cases. One occult tibial plateau fracture and one meniscocapsular separation were seen. Fifty percent of patients had injuries of the extensor mechanism. Our study neglected extensor mechanism injuries and bone bruise. MR imaging can be quite useful in assessing the extent of injury, and may reveal findings unsuspected after clinical examination of the knee. But availability of MRI, skeletal pin *in situ*, metallic splints, and cost may be important issues, especially in developing countries.

Johnson[3] in a comparison of clinical versus arthroscopic diagnosis found that out of 138 clinically diagnosed ACL tears, only 10% were determined to be an isolated type and 73% had either torn cartilage or meniscus. We found 15.4% isolated ACL tear without cartilage or meniscal injury. In our series, 69.2% of ACL injuries were associated either a medial or a lateral meniscal injury. There was high (64.7%) incidence of chondral injuries

in association with ACL injuries. Our findings suggest higher incidence of medial meniscal (38.5%) and lateral meniscal injury (30.7%) in association with ACL injury. The incidence of ACL plus meniscal injury in trauma setting appears to be much less than that reported by Kumar *et al.*[4] In our series also, 84.6% ACL tears had additional injury documented during arthroscopy.

Incidence of meniscal tear in femoral shaft fractures was 27% in Blacksin *et al*.'s[2] series. Vangsness *et al.*[5] studied 47 patients with closed, displaced, diaphyseal fractures of the femur, caused by blunt trauma by arthroscopy and examination under anesthesia, to determine the incidence of associated knee injuries, particularly of the meniscus, and reported 53.25% incidence of meniscal tears associated with femoral shaft fractures, out of which 25.5% was of medial meniscus and 27.7% was of lateral meniscus. Complex and radial tears were more common than peripheral or bucket-handle tears. Examination under anesthesia revealed ligamentous laxity in 23 patients (49%). In our series, the incidence of meniscal injury associated with femoral shaft fractures was 22%, with 12.2% incidence of medial meniscus and 9.8% incidence of lateral meniscal tears, which is much less than Vangsness *et al*.'s[5] series. The incidence of chondral injury associated with femoral shaft fracture was 29.3% in our series. Vangsness *et al.*[5] reported 27% ACL injury, 12.8% MCL injury, 25.5% LCL injury, 6.4% PCL injury, 25.5% medial meniscal injury, and 27.7% lateral meniscal injury in a series of 47 acute femoral shaft fractures. The overall incidence of all ligamentous injuries was 49% in his series. In our study of 41 femoral shaft fractures, the incidence of ACL injury was 31.7%, MCL 14.6%, medial meniscus 12.2%, and LCL, lateral meniscus, and PCL, all below 10% (9.8%).

Mathewson and Dandy[6] viewed that osteochondral fracture within the knee may be caused by impaction, avulsion, or shearing, and mostly remains unrecognized. In initial radiographs, this injury is not visible, but may become more obvious with passage of time as the margins become sclerotic. Johnson and Dandy[7] found trauma as a cause of chondral defect in 51 out of 76 (67%) of arthroscopically diagnosed articular cartilage lesions. We found that most of the patello-femoral chondral lesions were seen in association with femoral shaft fractures.

Walker and colleagues,[8] in a retrospectively review of 52 patients with 54 mid-shaft femoral fractures, found an alarming high incidence (48%) of ipsilateral knee ligament damage, particularly of a severe nature (30%), evident at follow-up (mean 24.5 months). They found that the ACL is most often injured (50%), followed by the MCL (31%), LCL (13%), and PCL (6%) in femoral fractures. Lachman test, aspiration of the effusions, examination under anesthesia including stress films, and arthroscopy are recommended as diagnostic procedures.[8] Acute ipsilateral knee instability is a strong relative indication for primary rigid immobilization of the fracture femur to allow early ligamentous repair,[8] as was done in our cases.

A retrospective report of a series of 110 patients by Szalay *et al.*[10] with 114 fractures of the femur reviewed an average of 3.9 years after injury. Demonstrable knee ligament laxity was present in 31 (27%) of these patients, while 13 (11%) complained of instability. Thirty-three patients with 34 ipsilateral femoral and tibial shaft fractures were examined on an average of 3.7 years after injury. Demonstrable knee ligament laxity was present in 18 (53%) of these patients, while 6 (18%) complained of instability. Majority of the patients of Szalay *et al.* with instability had a rupture of the ACL with or without damage to other ligaments. They concluded that knee ligament injury is more common with ipsilateral fracture of the femur and tibia than with just a single ipsilateral femoral fracture. In our study cases also, careful assessment of the knee was performed in all cases of fracture of the femur since in our series of femoral fracture, the incidence of knee ligament injury was 34%. Vangsness *et al.*[5] reported 38.3% collateral ligament injuries associated with femoral shaft fractures. In our series, the incidence of collateral ligament injuries was 24.4%, out of which 14.6% amounted for MCL injury and 9.8% for LCL injury.

The incidence of rupture of the knee ligaments was retrospectively studied by Van Ray *et al.*[9] in 47 patients with ipsilateral fractures of the femoral and tibial diaphyseal shaft. Fifteen patients proved to have instability of the knee at the time of follow-up. Disruption of the knee ligaments had not been recognized initially. At the time of initial treatment, injury of the knee ligaments had been diagnosed in only three cases. After stabilization of both fractures in these cases, the knee ligaments had been repaired; at re-examination, these patients had no complaints and their knees were stable. In view of the high incidence of missed cases, the possibility of disruption of the knee ligaments should be considered in all patients with fractures of both the femoral and tibial shafts.[9] Meticulous examination of the knee at the time of injury is strongly advocated. In floating knee injury, the ipsilateral femoral and tibial shaft fractures and knee ligament injury appear to be part of a continuum of combined injuries resulting from complex, high-energy forces.[9,11] In a retrospective analysis of medical records and radiographs by

Rethnam *et al*.,[11] 29 patients who had floating knee injuries also had frequent associated injuries. Some of the associated injuries caused a delay in surgical management and postoperative rehabilitation, but majority of their patients with associated injuries had a good or excellent outcome after appropriate diagnosis and timely treatment.

Numerous associated injuries (bony and/or soft tissue lesions) occur in conjunction with fractures of the femoral shaft and are more commonly observed in young patients after high-energy traumatic injuries.[12] Soft tissue trauma to the knee occurs commonly with femoral shaft fractures and requires a careful physical examination and further radiologic studies, as suggested by various studies including our study.[13] Ruptured ligaments are difficult to be identified during the initial evaluation because the classical physical signs of ligamentous injury may be obscured due to swelling and muscle spasm attributed to the associated fracture.[14] One should have a high index of suspicion about internal knee injuries and capsulo-ligamentous injuries while dealing with high-energy femoral shaft fractures and awake patient with associated knee pain in particular.[15] Bone bruises, which can be identified by MRI, are increasingly being acknowledged as a source of persistent symptoms.[13] We propose that when MR imaging is not possible and when contraindication for arthroscopy does not exist, a careful clinical examination followed by arthroscopy of the knee may be considered as a safe and useful adjunct in femoral shaft fractures as it can readily confirm IDK by its ability to objectively look, probe, and distinguish fragile tissue from a normal tissue. Since ours is neither a comparative nor a multicentric study, further multicentric randomized studies in larger number of subjects are needed to validate our findings on the basis of evidence-based medicine.

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