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Estimation of corollary ligamentous and meniscal knee injuries with femoral shaft fractures

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Abstract
Background
Corollary knee injury is a common finding in femoral fractures but can be easily missed during early management of the initial trauma. Degree of damage to the articular structures vary considerably; from only a mild effusion to complete ligamentous and meniscal tears. Since previous reports were mostly from developed countries, this study was designed to look into characteristics of associated knee injury in a sample from India, to represent a developing country perspective.
Materials and methods
Consecutive patients admitted to an orthopaedic department of Saraswati institute of medical scienceHapur district Uttar Pradesh with diagnosis of femoral fracture were enrolled in this study between February2023 and December 2024. In patients who met the inclusion criteria of the study, arthroscopic or open surgical examination of the knee, anterior drawer test, Lachman test, varus and valgus stress tests under anesthesia were carried out to determine the incidence of knee injury.
Results
Forty-five patients with ipsilateral and two patients with bilateral femoral fractures were studied. Arthroscopy revealed medial meniscus injury in 14 (27 %) knees. 5 (7 %) lateral meniscus injuries, 19 (40.9 %) ACL injuries and 2 (4.5 %) PCL injuries were also found. In varus and valgus stress tests, 15 (34 %) MCL and 4 (9 %) LCL laxities were noticed. The Lachman test was positive in 3 (6 %), and ADT was positive in 2 (4.5 %) patients.
Conclusions Based on our observations, concomitant ligamentous and meniscal knee injury is a common finding in femoral shaft fractures and rates of these injuries are generally in concert with reports from developed nations.

Keywords *Femur fracture, Knee injury,Arthroscopy, Concomitant knee injury*

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I. Introduction

Femoral fractures are severe injuries that quickly draw physicians' attention and are often associated with other fractures. Ipsilateral knee ligament injuries may also be associated with such fractures, and most of these are diagnosed at a later stage[1]. Incidences of 32–48% have been reported for ipsilateral ligament knee injuries among individuals with femoral fractures[2],[3]. Time elapsed between the initial trauma and the diagnosis was up to 12.8 months. These ligament injuries were silent or occult andup to 78% of them progressed undiagnosed, with negative consequences for patients and orthopedists[4].

In the literature, there are references to an association between these injuries and high-energy accidents. Traffic accidents were the most frequent type of trauma for this association of injuries[5],[6],[7]. For polytrauma patients who present with femoral shaft fractures, ipsilateral knee ligament injuries represent a diagnostic challenge because of difficult physical examination, although such examination is fundamental to defining the treatment and prognosis[1],[3],[4],[8].

Simultaneous knee injury is frequently seen in patients with femoral fractures [9]. These accompanying injuries can be easily missed during early management; since the physician or orthopedists attention is usually focused on the initial injury [10]. In the past 40 years, different studies have been published and focused on knee injury concomitant with femoral fracture. Most have described ligamentous damage [9, 11–16] and in the past few years some have also studied concomitant meniscal injuries [10, 17, 18].

While a relatively rich body of evidence exists regarding types and characteristics of corollary knee joint injuries with femoral injuries, almost all of these reports are confined to the developed world and observations from the perspective of a developing country are lacking. Therefore, in this study, we aimed to investigate for the first time, the prevalence, types, and features of damaged knee accompanying femoral fractures.

For the diagnosis of knee ligament injuries in association with ipsilateral femoral fractures, several methods have already been reported. Esmaeilijah used physical examination under anesthesia; De Campos used arthroscopy; Walker and Kennedy used distal fixation of the femur in association with knee stress radiographs, meanwhile, Dickson *et al*. performed MRI on their patients[5],[6],[7],[9],[10].

Additionally, statistical analyses were conducted to look into the correlations between fracture characteristics and knee joint injury.

II. Materials and methods

Patients

A cross-sectional study of patients admitted to an orthopedic ward of Saraswati Institute of Medical Science (India) with diagnosis of femoral fracture between February 2023 and December 2024 was initiated.

The inclusion criteria were as follows:

(1) open or closed femoral fracture (those with simultaneous tibial fracture were also included);

(2) no history of previous injury to the knee.

All patients were given written informed consent and the local ethics committee at Saraswati Institute Of Medical Science Hospital confirmed the study protocol.

Clinical assessment

After femoral fixation with intramedullary rod placement, external fixation, or plate fixation, all patients underwent a thorough physical examination of the involved limb including varus and valgus stress tests, Lachman test, and anterior drawer test (ADT), under anesthesia. Clinical assessments were done to compare with the contralateral knee.

In cases where the knee had to be exposed for retrograde nailing, a direct examination of the involved joint was also performed. Therefore, in this group of patients there was no need to perform arthroscopic evaluation. Instead, direct examination was done.

The anterior drawer test was performed with the patient lying supine. Hips were flexed, knees were flexed to 90, with the feet placed flat on the table. The tibia was pulled forward on the femur by placing hands around the tibia. When the tibia moved forward more than 6 mm on the femur, the test considered as positive [19].

The Lachman test was done with the patient lying supine; the patient's knee at 15 of flexion and an external rotation was performed, stabilizing the femur with one hand as the tibia moved forward. Presence of a mushy or soft endpoint when the tibia was moved forward on the femur was considered as positive [19].

Valgus and varus stress tests were performed while the patient was lying supine and the knee was in complete extension. The examiner placed one palm against the lateral aspect of the patient's knee at the joint line.

Additionally, all knees were examined using arthroscopy. Arthroscopy was carried out with patients lying down in the supine position and anterolateral and anteromedial portals of entry were used. All clinical assessments were carried out by a single trained orthopedic.

Figure 1: (a) Valgus stress test and (b) varus stress test.

Figure 2: (a) Lachman test and (b) anterior drawer test.

Figure3: Posterior drawer test.

Statistical analysis

Data were collected, tabulated, and statistically analyzed using an IBM-compatible personal computer with the Statistical Package for the Social Sciences (SPSS), version 23 (SPSS Inc. Released 2015. IBM SPSS statistics for Windows, version 23.0; IBM Corp., Armonk, New York, USA).

Two types of statistical analysis were performed. Descriptive statistics qualitative data were expressed as number and percentage, while quantitative data were expressed as mean, SD, and range (minimum–maximum). Analytical statistics: Mann–Whitney test was used for comparison of quantitative variables between two groups of non-normally distributed data. The χ^2 test was used to study the association between qualitative variables. Whenever any of the expected cells were less than five, Fisher's exact test was used. Significant test results were quoted as two-tailed probabilities. The significance of the obtained results was judged at the 5% level ($P > 0.05$).

III. Results

A total of 47 patients with femoral fractures were admitted to an orthopedic ward between February 2023 and December 2024; however, since 5 had previous ACL tears and two did not undergo arthroscopic examination, only 42 patients met the study criteria. Forty patients had ipsilateral femoral fracture and two had bilateral involvement. A total of 44 knees were enrolled in this study. Mean age of the study participants was 29.2 years (ranging from 17 to 48) with men constituting 86.4 % (n = 38) of the study population. The right and left femur were fractured in 24 (54.5 %) and 20 (45.5 %) cases, respectively. The most common cause of injury was high energy trauma due to motor vehicle accident (n = 39). Management of femoral fracture was done using intramedullary nailing in 40 (91 %) cases, external fixation in 3 (7 %) and plate fixation in 1 (2 %) patient. From 40 patients who underwent intramedullary nailing, based on the site and type of fracture, in 16 cases the knee was opened for distal femoral nailing. These patients did not undergo arthroscopic evaluation, since the procedure made direct examination of the knee possible. The rest of patients underwent arthroscopic assessments after fixation of fractures. Characteristics of femur fractures are presented in Table 1.

Table 1 Characteristics of femur fractures in the study population

	n (%)
Cause of fracture Motor vehicle accident	39 (89 %)
Falling	4 (9 %)
Gunshot	1 (2 %)
Laterality	
Right side only	24 (54 %)
Left side only	20 (46 %)
Classification of fractures[a]	
Type I	11 (25 %)
Type II	13 (29 %)
Type III	12 (28 %)
Type IV	8 (18 %)
Localization of injury	
Proximal third	8 (18 %)
Middle third	16 (36 %)
Distal third	20 (46 %)
Management	
Intramedullary rod placement	40 (91 %)
External fixation	3 (7 %)
Plate fixation	1 (2 %)

According to Winquist and Hansen classification of femoral shaft fracture [25]

Using arthroscopy or direct examination, a medial meniscal tear was detected in 12 (27 %) knees. In seven cases the tear was in the central third of the meniscus and in the remainder, the posterior third was involved. Lateral meniscal tear was found in three (7 %) knees. Eighteen (40.9 %) knees had ACL injury, of which only two were complete and the other 16 were incomplete injuries. Two (4.5 %) knees had incomplete PCL tears. Chondral injury was found in 20 (45.4 %) knees, 12 (27 %) were medial, six (13 %) were lateral, and the other two (4.5 %) had injuries at the posterior surface of the patella.

Varus and valgus stress tests revealed that 15 (34 %) and four (9 %) knees had MCL and LCL laxity, respectively. The Lachman test was positive in three (6 %) knees. ADT was positive in two (4.5 %) knees. In total, 21 (47.6 %) knees had injury; with 14 (31 %) knees presenting with significant effusion. Incidences of knee ligamentous and meniscal injuries are presented in Table 2.

Table 2 Incidence and types of knee injuries

	n (%)
Arthroscopic findings	
Medial meniscal tear	12 (27 %)
Central third tear	7 (15 %)
Posterior third tear	5 (11 %)
Lateral meniscal tear	3 (7 %)
ACL injury	18 (40.9 %)
Complete injury	2 (4.5 %)
Incomplete injury	16 (36 %)
PCL injury 2 (4.5 %)	
Complete injury 0	
Incomplete injury	2 (4.5 %)
Chondral injury	20 (45.4 %)
Medial	12 (27 %)
Lateral	6 (13 %)
Posterior surface of patella	2 (4.5 %)
Stress tests	
MCL laxity	15 (34 %)
LCL laxity	4 (9 %)
Positive Lachman	3 (6 %)
Positive ADT	2 (4.5 %)

Men were significantly more likely to suffer a high energy trauma ($p = 0.015$). No association was found between site or type of fracture and gender ($p = 0.35$ and $p = 0.56$, respectively). Also, there was no significant correlation between site of fracture and ACL injury ($p = 0.2$), PCL injury ($p = 0.3$), or meniscal involvement ($p = 0.7$). Type of femoral fracture was associated with ACL and medial meniscal injury ($p = 0.031$ and $p = 0.046$, respectively). On the other hand, neither PCL tear nor lateral meniscal trauma were linked to fracture type ($p = 0.439$ and $p = 0.736$, respectively).

Distribution of chondral injuries were significantly different in various types of trauma ($p = 0.02$). However, no association was found between chondral injuries and ACL, PCL, LCL and MCL injury ($p = 0.7$, 0.38, 0.51).

In one patient who had concomitant femoral and tibial fracture (floating knee), proximal intramedullary nailing was done. In this case, the cause of fracture was high energy trauma and resulted in ACL and medial meniscus injury along with chondral lesions.

Although different types of ligamentous and meniscal injury were observed in our patients, arthroscopic or direct evaluation did not disclose any vascular or nerve injury.

IV. Discussion

High energy trauma can be the cause of femoral shaft fractures and also simultaneous pathology in the ipsilateral knee. As expected, a high percentage of patients examined in this study had significant knee injury. The most common site of injury was ACL. Chondral injury was also a common finding. Since Pedersen and Serra[11] reported ligament injuries of the ipsilateral knee joint associated with femoral shaft fracture, careful physical examination and awareness of the possibility of associated injury during the treatment of femoral shaft fracture was emphasized. However, because of the severe pain and deformity caused by femoral shaft fractures, associated knee injuries were often neglected. Associated knee injuries that are not properly diagnosed and treated can cause sequelae such as instability or posttraumatic osteoarthritis, and therefore affect a patient's quality oflife.It is known that in evaluating acute knee injuries, the gold standard is physical examination, sometimes done under anesthesia, in association with magnetic resonance analysis. In our situation, MRI is difficult to obtain, which has made physical examination under anesthesia fundamentally important for the diagnosis.

In this study, associated knee ligament injuries were found in 34.1% (15/44) of all femoral shaft fractures using direct knee examination after femoral fixation.This agrees with Caldas *et al.*[2], who studied 36 patients with femoral shaft fractures and found 11 (30.5%) patients, who had a knee ligament injury using examination under anesthesia after femoral fixation.In the Taheriazam and Tahmasebi[12] study, a total of 125 patients with isolated femoral shaft fractures who underwent a thorough clinical examination of the knee immediately after fixation found an incidence of 31.2% (39 patients) with simultaneous knee ligament injuries.However, Solanki *et al.*[13] studied 84 patients with 87 femoral shaft fractures, who underwent a

thorough clinical examination of the knee immediately after fixation under anesthesia and found an incidence of 32 (36.7%) patients with an ipsilateral knee ligament injury.

While we evaluated the patients by physical examination only, other studies added arthroscopy after clinical examination. Doing arthroscopy at the same sitting with internal fixation of fractures may be a cost and time-effective option and may allow diagnosing and managing treatable conditions at the same sitting or plan for the next best investigation.In the Meybodi *et al.*[3] study, 40 patients with fracture shaft femur were evaluated clinically and arthroscopically and found an overall incidence of knee ligament injuries in 15 (35.6%) patients.

Kumar *et al.*[10] studied 41 patients with femoral shaft fractures clinically and arthroscopically immediately after fixation and found an overall incidence of a knee ligament injury in 14 (34%) patients. ACL was the most common injury followed by MCL.

In a recent investigation, Blacksin et al. [20] assessed 34 femoral fractures with magnetic resonance imaging. Imaging was done, on average, 2.5 days after injury. Assessment revealed meniscal tears in 27 %, medial collateral ligament injury in 38 %, and posterior cruciate ligament injury in 21 % of the patients. After imaging was performed, they compared MRI results with clinical examinations. The Lachman test was positive in two patients, but MRI showed no evidence of anterior cruciate ligament injury in these patients. Comparing physical examinations and MRI findings shows that there is no correlation between these two methods.

Auffrath et al. [10] reviewed 103 Austrian patients with femoral shaft fractures during 2000–2007. They excluded patients who had obvious knee injury at the time of admission; their goal was to investigate the number and severity of knee injuries that remain undetected at the time of admission. Fifty-three patients with 55 midshaft femoral fractures were included, based on their criteria. They found three injuries: one was partial tear of the posterior cruciate ligament, and two were medial meniscus injuries.

Many of the correlations assessed did not reach statistical significance. This is in part due to the relatively small sample size in our study. Future studies with large enough sample sizes are paramount to elucidate possible risk factors for articular damage accompanying thigh bone fractures. In our study, the Lachman test was negative in the majority of subjects who suffered ligamentous injuries. This is likely due to the Lachman test being unable to detect partial tears. Sixteen out of 18 injuries observed herein were of a partial nature, and the Lachman test was only positive in one. It has been previously stated by different authors that it is difficult to identify partial ACL tears in a physical examination; additional assessment using MRI or arthroscopy is needed for detection of these injuries [21, 22]. This discrepancy further highlights the need for careful evaluation of affected knees in patients with femoral fractures, even in the face of an evidently normal physical examination, since the Lachman test has a limited ability in detecting partial tears.

Traffic and road accidents in Iran are a public health concern and their prevention remains a health priority. Accidents in Iran are the second most common cause of mortality in the country, trailing only behind cardiovascular diseases [23]. Individuals involved in road accidents are often of young age and tend to suffer significant musculoskeletal injuries. Based on available reports, the most prevalent bone injuries due to accidents are tibial and femoral fractures, accounting for 49.8 and 19.9 % of musculoskeletal injuries, respectively [24]. Here, we have shown that these fractures often are accompanied by ligamentous injuries that without a thorough and careful assessment of the injured organ would go undiagnosed. Given the immense burden that lower limb fractures impose on the individual, and lifetime disability and 38 J Orthopaed Traumatol (2014) 15:35–39 123 productivity loss associated with it, proper early management of the fracture is of utmost priority.

In summary, for the first time we investigated the presence and features of simultaneous knee injuries in femur fractures in a well-defined sample of Iranian adult patients. Our observations confirm the fact that knee injuries are a rather common finding in femoral fracture cases; therefore, careful examination sof the affected joint with aid of other imaging modalities or arthroscopic examinations can result in early diagnosis, management and repair of the injured soft tissue.

Conflict of interest None.

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