

Clinical Instability of the Knee and Functional Differences Following Tibial Plateau Fractures Versus Distal Femoral Fractures

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Background: Fractures of the knee account for about 6% of all trauma admissions. While its management is mostly focused on fracture treatment, it is not the only factor that defines the final outcome.

Objectives: This study aimed to study objective and subjective outcomes after proximal tibial versus distal femoral fractures in terms of knee instability and health-related quality of life.

Patients and Methods: This retrospective, cross-sectional, cohort study was carried out on 80 patients with either isolated proximal tibial (n = 42) or distal femoral (n = 38) fractures, who underwent open reduction and internal fixation. All the fractures were classified based on the Schatzker and AO classification for tibial plateau and distal femoral fractures, respectively. The patients were followed and examined by an orthopedic knee surgeon for clinical assessment of knee instability. In their last follow-up visit, these patients completed a Lysholm knee score and the short-form (SF) 36 health survey.

Results: Among the 42 tibial plateau fractures, 25% were classified as Schatzker type 2. Of the 38 distal femoral fractures, we did not find any type B1 or B3 fractures. The overall prevalence of anterior and posterior instability was 42% and 20%, respectively. Medial Collateral Ligament (MCL) and Lateral Collateral Ligament (LCL) injuries were detected clinically in 50% and 28%, respectively. The incidence rates of ligament injuries in tibial plateau fractures were as follows: Anterior Collateral Ligament (ACL) 26%, Posterior Collateral Ligament (PCL) 7%, MCL 24%, and LCL 14%. Medial collateral ligament injury was the most common in the Schatzker type 2 (50% of the injuries). Distal femoral fractures were associated with ACL injury in 16%, PCL in 13%, MCL in 26% and LCL in 14%. However, final knee range of motion (ROM) and function (Lysholm score) were not associated with fracture location. No statistically significant difference was observed between the two groups, except for the valgus stress test at 30° knee flexion, which was more positive in tibial fractures. All eight domains of SF-36 score in the distal femoral and proximal tibial fractures were significantly different from the normal values; however, there were no statistically significant differences between femoral and tibial fracture scores.

Conclusions: Although ROM is acceptable in knee joint fractures, instability is common. However, it seems that knee function and quality of life are not associated with the location of the fracture.

Keywords: Knee; Knee Instability; ACL; PCL; Quality of Life

1. Background

Fractures around the knee account for about 6% of all trauma admissions (1). While its management is mostly focused on fracture treatment, it is not the only factor that defines the final outcome. The compressive and shear forces leading to distal femur and proximal tibia at the time of trauma not only lead to fractures, but also predispose the ligaments and soft tissue of the knee to injury (2). Therefore, it is necessary to pay more attention to ligaments during treatment of these fractures. Knowledge of these injuries plays a primary role in patients receiving appropriate treatment and suitable follow-up care (3). Moreover, patients may not be aware of occult instability that might cause them symptoms later on and

may not seek medical consultation, associating it with the nature of the fracture. Determining the appropriate treatment options and follow-up programs necessitates a profound understanding of this issue.

2. Objectives

The purpose of this study was to assess the frequency of residual knee instability after internal fixation. In particular, different features of distal femoral fractures and proximal tibial fractures were also compared. Moreover, we assessed the differences between these two groups of patients in terms of subjective knee score and health-related quality of life.

3. Patients and Methods

3.1. Population

A total of 92 adult patients with either distal femoral or tibial plateau fractures, who underwent open reduction and internal fixation, between 2010 and 2011, were invited to our level I trauma center (Shahid-Kamyab Trauma Hospital) for follow-up. The patients had had surgery (open reduction and internal fixation) at least 12 months prior to the follow-up and none of them had a history of ligament reconstruction. All of the patients had standing knee AP (anteroposterior) and lateral radiographies to confirm union and to exclude any bone loss. Since this study aimed to compare the different features of distal femoral with proximal tibial fractures, synchronic distal femoral and proximal fractures were excluded from the study. In addition, 12 patients were excluded; one due to amputation of the injured limb, two for late diagnosis of PCL avulsions and others due to bone loss, which could cause instability and unwillingness to participate in our study. A series of 80 patients remained in our study. The study was approved by the Research Committee of Mashhad University of Medical Sciences and all patients signed a consent form to participate in the study.

3.2. Data Collection

We classified the distal femoral and proximal tibial fractures according to AO and Schatzker classification, respectively. After reviewing the patients' files, one knee surgeon from the team individually examined all of the patients for knee instability. We examined the knee for varus and valgus stress tests at 30 degrees, (4, 5). We compared the affected limb to the normal side. If any of these stress tests were positive we considered that knee as unstable. Knee range of motion (ROM) was measured by an orthopedic goniometer. For subjective evaluation of knee function, the Lysholm knee questionnaire was used. All of the patients completed a Persian SF-36 questionnaire in order to assess their general health status (6).

3.3. Statistical Analysis

SPSS software version 16 (SPSS Inc., Chicago IL) was used for descriptive statistical analysis. Moreover, the independent t-test was used to compare two independent variables. Nonparametric variables were assessed with the Fisher's exact test and chi-square test. A p-value of less than 0.05 was deemed significant.

4. Results

In the study group of 80 patients (67 males and 13 females) with a mean age of 41 years (range: 18 to 90), forty-two patients (53%) had tibial plateau and 38 (47%)

had distal femur fractures (Tables 1 and 2). Mechanisms of injury were motor -vehicle accidents in 96% and falling from a height in 4% of the patients. The most common type of tibial plateau fracture was Schatzker type 5 (25%) and type A1 and B2 for distal femur fractures, accounting for 10% of total knee fractures. There were no B1 or B3 distal femur fractures in our series. The average knee ROM in patients was 99.2 ± 50.9 (range: 30-140) (Table 3). The Lachman test was positive in 18.8% of the patients. Overall anterior and posterior drawer tests were positive in 21% and 10% of the patients, respectively. Varus and valgus stress tests were positive at 30 degrees of flexion in 17.5% and 16.2%, and at 0 degree in 20% and 21.8%, respectively. The average Lysholm knee score was 62 ± 48 (range: 13-99) (Table 4). The mean SF-36 score was 49 ± 21 (range: 37-90).

4.1. Distal Femur Fracture

Almost 16% (6 patients) of the knees had a positive anterior drawer test and 13% (5 patients) had a positive posterior drawer test. Varus stress test was positive at 30 degrees among 42% of the patients, while the valgus stress test was positive in only 5%. The average ROM was 96 ± 54 . The mean values of the Lysholm and SF-36 scores were 60 and 40, respectively. In type A2, the anterior translation of the tibia on the femur was more prominent and the highest level of posterior translation was detected in type A3. Varus instability was more prominent in comparison with valgus and it was most severe in type C2 fractures (Table 2).

4.2. Proximal Tibial Fracture

Of the 42 tibial plateau fractures, 26% (11 patients) were unstable anteriorly and 7% (3 patients) posteriorly, which were both more common in type 1. Varus and valgus instability was present in 14% (6 patients) and 26% (10 patients) of the patients, respectively at 30 degrees knee flexion. Varus instability was more common in Schatzker types 2, 4, and 5, while valgus instability was more in types 1, 2, 5, and 6. Posterolateral instability was detected in two cases of 4 and 2. Anterolateral instability was detected in three patients; two of them were type 2 (Table 1).

4.3. Comparing Tibial With Femoral Fractures

There was no statistical differences in the two groups, except for in the valgus stress test at 30 degrees knee flexion, which was more positive in tibial fractures (Table 5). Lysholm and SF-36 scores were compared in Table 6 and 7, respectively. All eight domains of SF-36 score in the distal femoral and proximal tibial fractures were significantly different from the normal values ($P < 0.001$ in all domains). However, there was no statistically significant difference between femoral and tibial fracture scores.

Table 1. Tibial Fracture Types and Characteristics ^a

Types	Cases	Age	LATCH-MAN Test	Anterior Drawer Test	Posterior Drawer Test	Varus Stress Test in 30	Valgus Stress Test in 30	Varus Stress Test in 0	Vlgus Stress Test in 0	Range of Motion	SF-36 Score		Lysholm Score
											PCS	MCS	
1	4	40	25	50	25	0	50	0	50	110	36	52	56
2	6	45	0	17	17	33	33	17	17	106	37	52	76
3	3	46	0	0	0	0	0	0	0	120	38	32	52
4	6	45	17	17	0	17	0	33	33	100	38	45	70
5	20	38	25	35	5	15	30	10	25	102	36	45	61
6	3	41	0	0	0	0	33	33	0	80	34	43	64
Total	42	41	16.7	26.1	7.1	14.3	26.2	14.3	23.8	103	37	46	63.5

^a Abbreviations: PCS, physical component summary; MCS, mental component summary.

Table 2. Femoral Fracture Types and Their Characteristics ^a

Types	Cases	Age	Latch-man Test	Anterior Drawer Test	Posterior Drawer Test	Varus Stress Test in 30	Valgus Stress Test in 30	Varus Stress Test in 0	Vlgus Stress Test in 0	Range of Motion	SF-36 Score		Lysholm Score
											PCS	MCS	
A1	8	35	25	0	13	0	0	13	25	105	40	45	63
A2	5	45	40	40	0	40	0	40	0	104	34	42	55
A3	6	38	0	17	17	50	0	34	13	86	34	36	54
B2	8	46	25	25	13	0	0	13	0	100	37	47	69
C1	4	29	0	0	0	0	0	0	0	90	30	40	78
C2	5	59	40	20	13	60	40	60	40	88	36	48	46
C3	2	48	0	0	0	0	0	0	0	80	34	36	42
Total	38	41.6	21.1	15.8	13.2	41.6	5.3	26.3	13.2	95.6	35.8	42.9	59.8

^a Abbreviations: MCS, mental component summary; PCS, physical component summary.

Table 3. The Final Range of Motion in Fracture Dislocations ^a

	Less Than 50 Degrees	50 to 90 Degrees	More Than 90 Degrees
Femur	10.5	39.5	50
Tibia	4.8	33.3	61.9
Total	7.5	36.2	56.2

^a Data are presented as %.

Table 4. The Lysholm Score Results in Tibial and Femoral Groups ^a

	Poor	Fair	Good	Excellent
Femur (Cases)	5 (13.2)	3 (7.9)	11 (28.9)	19 (50.0)
Tibia (Cases)	5 (11.9)	4 (9.5)	16 (38.1)	17 (40.5)

^a Data are presented as No. (%).

Table 5. Comparison of Femoral Fractures and Tibial Fractures ^a

Variable	Femoral Fractures	Tibial Fractures	Test	P Value
Number of patients	47%	53%	Fisher's exact test	0.08
Age, y	41.6 ± 32	41 ± 25	Independent t- test	0.08
Gender			Fisher's exact test	0.07
Male	29	38		
Female	9	4		
Mechanism of injury			Fisher's exact test	0.50
MVA	36	41		
Falling	2	1		
Positive Latchman test, %	21.1	16.7	Fisher's exact test	0.41
Positive Anterior drawer test, %	15.8	26.1	Fisher's exact test	0.14
Positive Posterior drawer test, %	13.2	7.1	Fisher's exact test	0.72
Positive Varus stress test at 30, %	41.6	14.3	Fisher's exact test	0.85
Positive Valgus stress test at 30, %	5.3	26.2	Fisher's exact test	0.02
Positive Varus stress test at 0, %	26.3	14.3	Fisher's exact test	0.18
Positive valgus stress test at 0, %	13.2	23.8	Fisher's exact test	0.51
Range of motion	95.6 ± 54	103 ± 47	Independent T- test	0.21
SF-36 score				
PCS	35.8 ± 17	37 ± 18	Independent T- test	0.54
MCS	42.9 ± 21	46 ± 23	Independent T- test	0.28
Lysholm score	59.8 ± 47	63.5 ± 50	Independent T- test	0.50

^a Abbreviations: MCS, mental component summary; MVA, motor vehicle accident; PCS, physical component summary.

Table 6. Comparison of Femoral Fractures and Tibial Fractures

Domains	Femoral Fractures	Tibial Fractures	P Value	Total Score
Limp	2.3 ± 3.4	2.6 ± 3.7	0.45	2.5 ± 3.6
Support	3.6 ± 3.8	3.9 ± 3.6	0.40	3.7 ± 3.7
Locking	9.5 ± 11.5	11.3 ± 9.4	0.13	10.4 ± 10.6
Instability	18.6 ± 17.6	18.0 ± 16.8	0.77	18.2 ± 17.2
Pain	14.7 ± 17.2	14.3 ± 17.6	0.81	14.5 ± 17.3
Swelling	6.0 ± 8.4	6.1 ± 8.6	0.85	6.0 ± 8.5
Stair-climbing	3.3 ± 6.2	5.0 ± 6.3	0.02	4.2 ± 6.5
Squatting	2.0 ± 4.0	2.4 ± 4.1	0.38	2.2 ± 4.1

Table 7. Different Scores of SF-36 Domains in Normal Population Compared With Patients Suffering From Distal Femoral or Proximal Tibial Fractures

	Physical Function	Physical Role	Body Pain	General Health	Vital	Social Function	Emotional Role	Mental Health
Normal population	55	50	48	55	63	66	63	67
Femoral fracture	34	35	40	42	51	39	35	40
Tibial fracture	37	37	41	44	51	42	39	42

5. Discussion

Tibial plateau fracture is associated with not only soft tissue injury management controversy, which is our main concern in this study, but also classification of such fractures (7-9). The most commonly used classification for tibial plateau fractures is the Schatzker classification, which was first introduced by Schatzker et al. in 1979. They classified these fractures into 6 types and based on them type 2 is the most common (10). Gardner et al. recently reported the same results (2), while Blokker reported type 4 as the most common, questioning the reliability of the Schatzker classification (11). In our study, similar to the results of Schatzker et al. study, type 2 was found to be the most common type with 47% (20 of 42 fractures) (10). Gardner believes that there is no type 3 or pure depression fracture based on a fracture line visible on MRI imaging alongside the depression part and has classified them as type 2 (2). We based our imaging study on CT scans and intra-operative observation and thus report 3 cases (7.1%) of type 3 fractures. There has been much more conflicting data regarding ligament injury. Schatzker reported 7.4% ligament injury (10) and Delamarter, based on stress radiographies and intra-operative findings, reported 31 injuries among 39 patients, 22 of which had a MC, 8 LCL, and 1 ACL injury (12). These findings are much less than what we have reported, which are based on postoperative examinations. This inconsistency, which is described in many studies, might be due to the pain and swelling that makes the detection of the injuries less probable (13) as we reported positive Anterior Drawer Test (ADT), Posterior Drawer Test (PDT), varus and valgus stress tests in 26%, 7%, 14%, and 24%, respectively. Bennet using arthroscopy reported 20% MCL, 3% LCL, and 10% ACL ruptures (14). In another study, Abdel-Hamid et al. found injuries to be 25% for ACL, 30% MCL and LCL, and 10% for PCL (15). Colletti et al. reported 55% for MCL, 34% for LCL, 41% for ACL and 28% for PCL based on the magnetic resonance imaging (MRI) findings (16) and Gardner et al. found 32% for MCL, 29% for LCL, and 57% for ACL ruptures (2). Arthroscopic studies have reported less ligament injuries than MRI. We found less prevalence than previously reported based on MRI and arthroscopy results, which indicates not all of these injuries diagnosed paraclinically are clinically important in affecting the patients' knee function. Many studies have reported MCL injuries to be the most common in Schatzker fracture type 2 (11, 15), and we found the same result, which is compatible with the mechanism of this type of fracture resulting from a valgus force caused by trauma to the lateral side of the knee yielding lateral plateau fractures (17). Conversely, we found LCL injuries to be less common in type 2, which is also explained by the mechanism of the fracture. We found no other correlation between the type of fracture and ligament injury. Instability is one of the major causes of unacceptable results after tibial plateau fracture treatment. It is not yet understood whether the treatment of ligament injuries

affect the outcome or not and most authors recommend no treatment. Blokker et al. treated ligament injuries acutely at the time of fracture fixation, but found no improvement in outcome and concluded that desirable reduction is the single most important prognostic factor (11). Moore et al. reported no varus-valgus laxity based on stress radiographies postoperatively, concluding that a brace is enough for treating collateral unicondylar fractures. Moore et al. believed acute repair of collateral ligaments and delayed reconstruction of cruciate ligaments improves treatment outcome (18). All of the studies we reviewed were focused on ligament injury along with femoral shaft fracture and not distal femur fracture. Concomitant ligament injuries with distal femur fractures seem to be uncommon, although ACL is the most common (1, 19-21). Moore et al. reported 5.3% ligament injuries based on preoperative examination, intra-operative findings, and stress radiographs (22). Walker et al. reported 48%, in which ACL was the most common with 51%, followed by 31% for MCL, 13% for LCL, and 6% for PCL (19). Szalay et al. found 27% ligament laxity, with ACL being the most common (20). Dickson reported 19% for ACL, 7% for PCL, 41% for MCL and 30% for LCL rupture on MRI (23). Campos reported 53% for ACL and PCL performing arthroscopy in 7.5%. All the above studies were on femoral shaft fractures. We evaluated distal femur fractures after rigid fixation and we did not find any relationship between the type of the fracture and ligament injury.

The SF-36 questionnaire has been used extensively to define the quality of life of patients with knee fractures. Berkes et al. evaluated Schatzker type 2 fractures and reported PCS and MCS scores of 43.8 and 53.1, respectively (24). The average PCS score after one year of follow-up of tibial plateau fractures was reported to be as low as 46.6 by Dattani et al. (25). In another study on tibial plateau fractures, the average physical function was significantly lower than the normal population (26). Thomson et al. in a long-term study on distal femoral fractures concluded that the SF-36 score is approximately two standard deviations below the normal population of the United States (27). Stevens et al. in a study by comparing the SF-36 score in multiple risk factors, found that being over 40 years old is the greatest predictor of the final outcome (28). Our scores were lower than the normal population; similar to Dattani and Tamson's studies (25, 27). One of the limitations of our study was its retrospective design. Although the patients were related to a referral road accident center, our study was not polycentric. We evaluated only solitary proximal tibial fractures or distal femoral ones. Although ROM is acceptable in knee joint fractures, instability is common. More than one-fourth of the proximal tibial fractures have anterior instability. Medial instability is present in tibial fractures at the same rate. Lateral collateral ligaments sustain injury as high as 40% in distal femoral fractures. There was no significant difference

between distal femoral and proximal tibial fractures in terms of knee function and quality of life of patients except for the valgus stress test, which was more positive in tibial fractures. Therefore, it seems that knee function and quality of life are not associated with the location of the fracture.

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Authors' Contributions

Mohamad Hosein Ebrahimzadeh, Ali Moradi and Ali Birjandinejad participated in the design of the research, implementation of the study protocol and interpretation of data and publication of the manuscript. Maysam Fathi Choghadeh and Jafar Rezazadeh and Farzad Omdikashani participated in the analysis and interpretation of data and drafting of the manuscript. All of the authors read and approved the final manuscript.

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