

경골 고평부 골절의 반월상 연골 파열 양상

차의과학대학교 분당차병원 정형외과¹, 차의과학대학교 구미차병원 정형외과²

이동훈¹ · 김병국² · 김재화¹ · 정주환¹ · 이인성¹ · 이준구¹ · 이순철¹

Characteristics of Meniscus Tear in Tibial Plateau Fractures

Dong-Hoon Lee, M.D.¹, Byung-Kuk Kim, M.D.², Ju-Hwan Chung, M.D.¹,
In-Sung Lee, M.D.¹, Jun-Ku Lee, M.D.¹, Soon-Chul Lee, M.D.¹

Department of Orthopaedic Surgery, CHA Bundang Medical Center, CHA University of Korea¹,
Department of Orthopaedic Surgery, CHA Gumi Medical Center, CHA University of Korea²

Purpose: Tibial plateau fractures cause a variety of problems in the knee joint. The purpose of this study was to investigate the characteristics of the meniscus injuries in tibial plateau fracture arthroscopically.

Materials and Methods: Thirty-three out of 39 consecutive patients diagnosed with tibial plateau fractures underwent arthroscopy between March 2007 and March 2010. According to Schatzker classification, there were 1 type I (3.3%), 19 type II (53.3%), 4 type III (13.3%), 2 type IV (6.6%), 2 type V (6.6%) and 5 type VI (20%) fracture patterns in 33 patients.

Results: Twenty-five cases (75.8%) had lateral meniscus tears. There were 18 meniscal tears in 19 cases of Schatzker type II fractures (94.7%), 3 meniscal tears out of 4 cases of Schatzker type III fractures (75%) and 4 meniscal tears out of 5 cases of Schatzker type VI fractures (80%). The most commonly affected site (22/25) was the anterior horn of the lateral meniscus. Of the 25 documented meniscal tears, all but one were vertical longitudinal tear at meniscocapsular junction so most cases are amenable to arthroscopic repair.

Conclusion: Arthroscopy for the meniscal injuries in tibial plateau fractures is a valuable diagnostic and treatment tool, we recommend arthroscopy in tibial plateau fracture.

KEY WORDS: Tibial plateau fractures, Soft tissue injury, Meniscus tear, Arthroscopy

Introduction

Tibial plateau fractures comprise a low percentage of all fractures but the severe consequences can result from improper diagnosis or treatment. The magnitude of the force, the position of the extremity

at the time of injury,¹⁾ and the degree of osteopenia^{2,3)} can all help determine the fracture type and extent of soft tissue damage. The treatments for tibial plateau fractures ranged from non-operative treatments to arthroscopy-assisted internal fixation, with pros and cons for each option.⁴⁻⁷⁾ Due to the obvious proximity to the knee joint, tibial plateau fractures may accompany a variety of soft tissue injuries^{8,9)} including injuries to the menisci, collateral and cruciate ligaments, arteries, and nerves. The reported incidence of associated soft tissue injury in cases of tibial plateau fractures diagnosed by physical examination or operative findings was 7% to 50%.^{8,9)} Cruciate ligament injuries may occur as avulsion, midsubstance, or attenuation injuries, and meniscal injuries may

* Address reprint request to

Byung-Kuk Kim, M.D.

Department of Orthopaedic Surgery, CHA Gumi Medical Center, CHA University,
855 Hyungkok-dong, Gumi-si, Gyeongsangbuk-do 730-040, Korea
Tel: 82-31-780-5289, Fax: 82-31-708-3578
E-mail: jg197@naver.com

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appear as peripheral, radial, or flap tears.^{8,9)} The meniscus can be especially prone to injuries due to its attachment to the tibial plateau via the joint capsule. Injuries of the meniscus may be subtle compared to obvious injuries as ones to the cruciate ligaments, but the consequences from meniscal injury could be as serious as osteoarthritis of the knee joint due to the loss of meniscus load sharing role. The purpose of this study was to assess the incidence and characteristics of meniscus injury with the use of arthroscopy in tibial plateau fracture.

Materials and Methods

We found 39 consecutive patients diagnosed with tibial plateau fractures between March 2007 and March 2010. Out of them, 6 patients were excluded because 4 patients showed nondisplaced fracture without any other suspected pathology in the knee joint who had gone through conservative treatment and 2 patients refused surgical treatment. Therefore, our study included 33 consecutive patients who had undergone arthroscopic-assisted osteosynthesis. There were 14 men and 19 women with 19 injuries to the right knees and 14 injuries to the left knees. The average age of the patients was 51.6 years (range, 29~81 years). A total of 20 patients (60.6%) were injured by traffic accidents (motorcycle and motor vehicle accidents) and 8 patients (24.2%) were injured by falling accidents. The remaining 5 patients were injured from slippage on the floor. The tibial fractures were analyzed and graded according to Schatzker's classification (Table 1).

All patients underwent anteroposterior (AP) and lateral plain radiography and computed tomography

(CT) of their injured knees. Fractures with articular incongruity of 3 mm or greater were considered for operative treatment.¹⁰⁾ Calcaneal traction was applied to severely swollen knees if needed. Although surgery was delayed until swelling of the leg had subsided, all the operations could be performed within 2 weeks from the date of injury. Once the swelling was reduced, a formal arthroscopy-assisted surgery was performed with minimal stripping and dissection. All operations in this study were performed by the senior author. In all cases, inflow pressure is maintained with the use of gravity only instead of infusion pump. The tourniquet was applied to all patients and the mean tourniquet pressure we used was 300 mmHg. Arthroscopic findings of associated soft tissue injury in the 33 patients with tibial plateau fracture were recorded, and the relationship between fracture type and soft tissue injury was then analyzed.

1. Surgical Techniques

The patients were placed in a supine position on the operating table with the knee flexed to a 90° angle. A pneumatic tourniquet was applied on the proximal thigh and a kidney bar was used instead of a leg holder because the "figure 4" position enabled us to freely maneuver the arthroscope. Anterolateral and anteromedial portals were created to accommodate a viewing and working portal, respectively. A thorough irrigation was performed until a clear view was achieved. All debris such as blood clots, bone fragments and denuded articular cartilage was removed. Next, a systemic evaluation to examine the medial and lateral compartments of the knee for

Table 1. Schatzker Classification of Fracture Types and Associated Soft Tissue Injuries

	Meniscus	ACL	PCL	MCL	LCL
Type I		1*			
Type II	18	1*	1*		
Type III	3				
Type IV		1			
Type V		1*	1		
Type VI	4		1*		
Total	25	4	3	0	0

*: Avulsion fracture

ACL: anterior cruciate ligament, PCL: posterior cruciate ligament, MCL: medial collateral ligament, LCL: lateral collateral ligament.

possible meniscal or ligamentous injuries was performed. All soft tissue lesions were recorded and analyzed according to fracture types.

In order to first reduce the depressed fragment, a bony window was created on the anteromedial or anterolateral aspect of the tibial condyle depending on the fracture location as determined by fluoroscopic examination and an impactor was introduced (Fig. 1A). By hammering the impactor on the depressed fragment, reduction was achieved. Allo-bone chip and blocks (frozen dried human allograft) were implanted to fill up the defect of the tibial condyle. We then confirmed reduction by arthroscopy, and subsequent fixation by buttress plate (LCP Proximal Tibial Plate; Synthes, Inc., PA, USA) was performed (Fig. 1B).

Intra-articular pathologies discovered during the

diagnostic arthroscopy were treated in an appropriate sequence after fixation of the fracture (Table 2). For the meniscal repair, 2 methods, as described by Ahn et al.,^{11,12)} were used: the modified outside-in and inside-out suture technique for anterior and midbody meniscal lesions (Fig. 2). Anterior cruciate ligament (ACL) injuries were treated in the usual manner by arthroscopy-assisted fixation of the ACL avulsion fracture in a first-stage surgical procedure using suture wires and second-stage reconstruction after fracture healing for complete ACL tears (Fig. 3).

2. Clinical Assessment

Clinical assessment to validate the arthroscopy included extra time for completing measurements required for the procedure in addition to fixation of

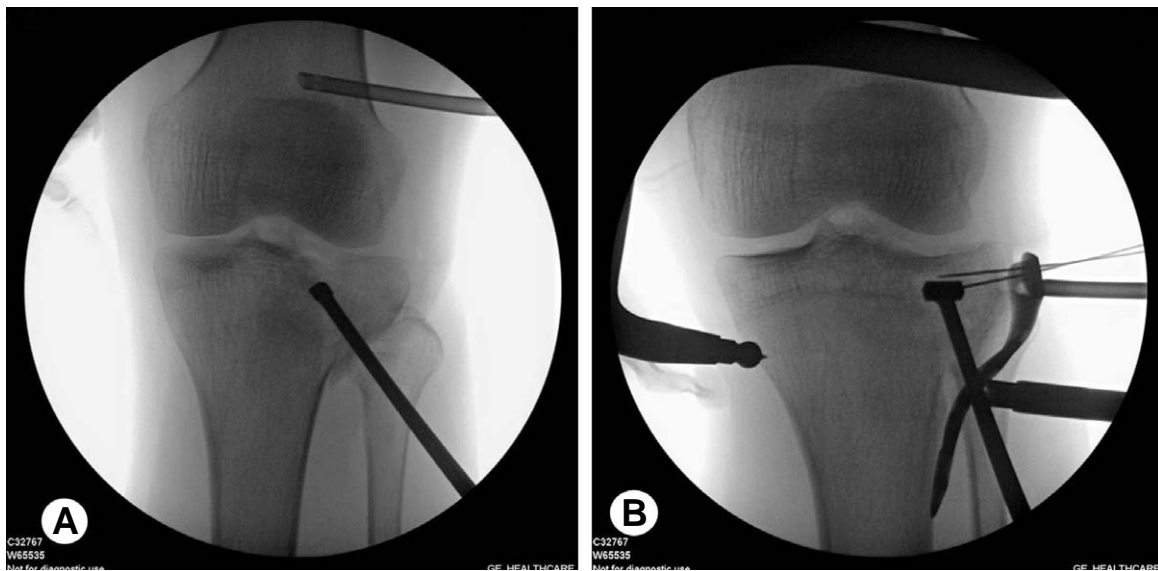


Fig. 1. Intraoperative fluoroscopic images. (A) Impactor was introduced through anterolateral tibial condyle. (B) Temporary fixation with plate using two K-wires after fracture site reduction.

Table 2. Treatment of Associated Soft Tissue Injuries in 33 Tibial Plateau Fractures

Soft tissue injuries	No. of injuries	Treatment
Meniscal tear	23	Arthroscopic suture repair
	1	Arthroscopic partial menisectomy
	1	Conservative treatment
ACL avulsion Fx	3	Arthroscopically assisted fixation by pullout suture
ACL rupture	1	Second stage reconstruction following fracture healing
PCL avulsion Fx	2	Arthroscopically assisted fixation by pullout suture
PCL rupture	1	Second stage reconstruction following fracture healing
MCL rupture	1	Conservative treatment

ACL: anterior cruciate ligament, Fx: fracture, PCL: posterior cruciate ligament, MCL: medial collateral ligament.

the fracture. Additionally, the complications such as vascular or neurological injury, articular cartilage injury, hemarthrosis, deep vein thrombosis, infection, compartment syndrome caused by the arthroscopy alone were investigated.

3. Statistical method

Statistical analysis was conducted using a Chi-square test for discrete variables with SPSS version 9.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $P < 0.05$.

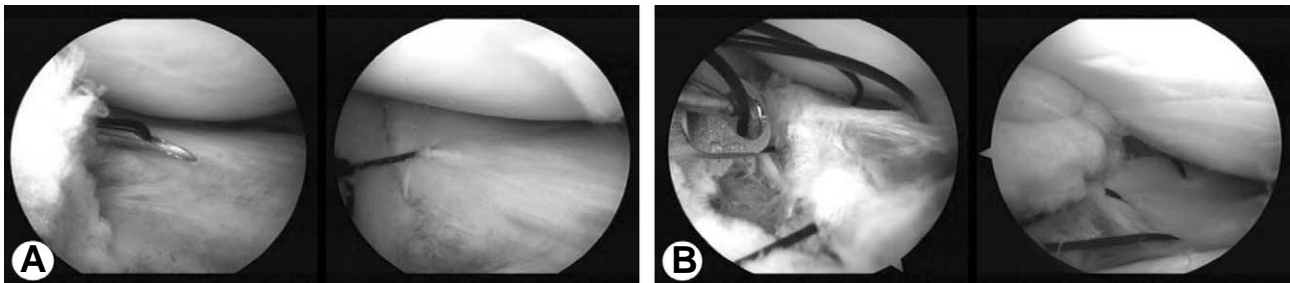


Fig. 2. Meniscus repair. (A) Outside-in technique. (B) Inside-out technique.



Fig. 3. Tibial plateau fracture (Schatzker type V) with anterior cruciate ligament (ACL) avulsion fracture. Preoperative (A) anteroposterior (AP) and (B) lateral plain x-ray. (C) Arthroscopy-assisted fixation of the ACL avulsion fracture using suture wire. Postoperative (D) AP and (E) lateral plain radiograph.

Results

1. Fracture types

According to Schatzker classification, there were 1 type I (3.3%), 19 type II (53.3%), 4 type III (13.3%), 2 type IV (6.6%), 2 type V (6.6%) and 5 type VI (20%) fracture patterns in 33 patients. There was one open fracture (Gustilo–Anderson open type I) of Schatzker type VI. Two cases were accompanied by other concomitant fractures. In one case of Schatzker type II, there was a concomitant medial femoral condyle fracture. The other case was complicated by comminuted femoral shaft and ankle fractures in the same extremity in a Schatzker type V fracture. The mean articular depression of patients was 5.5 mm (range, 3.3~11.7 mm) on the coronal image of CT evaluation. The mean interval between the injury and surgery was different depending on the fracture type. In type I, II and III fracture, the interval was 3.5 days (1 to 7 days) compared to 11.7 days (3 to 14 days) in higher type IV, V, and VI fracture.

2. Meniscal tears

Among the patients in our study, there were 25 lateral meniscus tears (73%), and no medial meniscus tear was observed. Of the 19 Schatzker type II fractures, 18 showed meniscus tears. Three meniscus tears were seen in Schatzker type III fractures and 4 in Schatzker type VI. Meniscus tears were found at a statistically higher rate in Schatzker type II fractures ($P<0.01$). Of the 25 documented tears, all but one were vertical longitudinal tear at the meniscocapsular junction. No other tear pattern was found. In the majority of the meniscal tears, repairs were

performed instead of meniscectomy (23 versus 1). Regardless of Schatzker classification, anterior horn was most commonly involved (Table 3).

3. Other soft tissue injuries

There were total of 4 ACL related injuries and 3 posterior cruciate ligament (PCL) injuries (Table 1). The cruciate ligament-related injuries were treated in an appropriate time sequence. We performed arthroscopy-assisted first-stage fixation for the ACL or PCL avulsion fracture, and second-stage reconstruction following fracture healing for complete ACL or PCL tears.

The collateral injury showed low incidence in our patients.

4. Time related to arthroscopic procedures & postoperative complications

Extra time spent on specific procedures was measured as a part of an attempt to assess disadvantages of the arthroscopic procedure. The average time taken for diagnostic arthroscopy was 7.2 minutes (range, 5~10 minutes). The average time of meniscus-related arthroscopic procedures was 34.3 minutes (range, 17~52 minutes). These procedures included meniscal repairs as well as meniscectomies. The average time for other soft tissue procedures such as ACL or PCL reconstruction was 38.1 minutes (range, 32~45 minutes). Total tourniquet time which include bony and soft tissue procedures was 53.4 minutes (range, 33~131 minutes). Complications specifically related to arthroscopic procedures such as compartment syndrome and neurovascular injury were not noted. No postoperative infections or cases

Table 3. Relationship between Fracture Type and Meniscal Injury and its Location

Fracture type	No. of patients	Location of the meniscal tear		
		Anterior	Midbody	Posterior horn
Type I				
Type II	18	15*	9*	3*
Type III	3	3*	2*	
Type IV				
Type V				
Type VI	4	4*	3*	2*

*: Involving more than two tear locations

of deep vein thrombosis were seen.

Discussion

As with any other intra-articular fracture, the tibial plateau fracture is always challenging for orthopaedic surgeons because of its widely varying trauma, and associated soft-tissue injuries add further complexity. With regard to meniscal injury, Honkonen¹³ reported a 50% rate of meniscal lesions, mainly in the lateral menisci. Vangsness et al.¹⁴ arthroscopically evaluated 36 tibial plateau fractures and discovered 17 (47%) meniscal tears. Abdel-Hamid et al.¹⁵ reported a 71% frequency of associated soft-tissue injuries among tibial plateau fractures (70/98), and found that the menisci were injured in 57% of the subjects (56/98) patients.

In 2005, recent report of Gardner et al.¹⁶ showed a higher incidence of meniscus tears compared to previous report, 91% of lateral meniscus and 44% of medial meniscus. Similar with this report we found a higher incidence (73%) of meniscus tears compared to previous studies. We believe that this high incidence of intra-articular pathology should be encouraging evidence for arthroscopic intervention for every tibial plateau fracture amenable to surgical interventions.

Abdel-Hamid et al.¹⁵ reported that the peripheral tear was the most common type of meniscal injury. In their series, it occurred at a higher rate (37/98, 37.8%) than radial (18/98, 18.4%) or flap tears (1/98, 1%, $P=0.08$). In fact, we observed only longitudinal tears in our series. No radial or flap tears were noted. We believe that this is due to the nature of the injury. As the peripheral portion of the tibial condyles is depressed or split, tension is applied to the tethered meniscus which easily results in the peripheral longitudinal type of injury. While previous studies only reported the incidence of meniscal tears,¹⁵ we found that the most commonly injured portion within the meniscus was from the anterior horn to midbody of the lateral meniscus. In our series, meniscal tears were repairable in all but 2 patients because the tears were fresh with clear margin, longitudinal tear and located in peripheral area within red-red zones.¹⁷ All these characteristics of the tear increase the likelihood of recovery. We performed a partial menisecto-

my in one patient because the tear was located more than 5 mm from the periphery. In another patient, the tear size was small enough to conservatively manage.

To properly diagnose and treat such a variety of soft tissue injuries, many have used arthroscopy. This provides a safe, quick, and accurate method of diagnosis and treatment. It is difficult to visualize the posterior horn of the contralateral meniscus through medial or lateral arthrotomy, and the cruciate ligaments can be adequately examined only through an anterior incision.¹⁴ However, these can be easily examined using an arthroscope. The entire articular surface may be visualized without the extensive dissection required for traditional open reduction and internal fixation (ORIF).¹⁸ The arthroscope allows for evacuation of hemarthrosis and any fracture debris. In addition, arthroscopic treatment of meniscal and ligamentous injuries is often superior to repairing or reconstruction using larger, open incisions.^{18,19}

Although the theoretic danger of compartment syndrome complicating arthroscopy for tibial plateau fracture warrants some caution, only 1 case of compartment syndrome in the leg after arthroscopic examination of a tibial plateau fracture has been reported.²⁰ Arthroscopic surgery for tibial plateau fractures can be a technically demanding procedure which requires a much steeper learning curve than open techniques. However, considering the lower rate of complications associated with arthroscopic evaluation and subsequent treatments along with little time added to the whole surgical time, most tibial plateau fractures seem to be good candidates for arthroscopic intervention. Vangsness et al.¹⁴ recommended arthroscopy as a safe, quick and precise means of diagnosing associated soft tissue injuries with no specific complications. In all of our cases, we observed substantial swelling in the knee joint initially, but it subsided significantly within 2 weeks, making arthroscopic intervention possible. Therefore, we recommend arthroscopic examination for every tibial plateau fracture which needs operative management.

The limitation of this study is its small number of patients. Furthermore, only the patients who require surgical intervention were included. This means the

scope of our study was limited to tibial plateau fractures that were considered for operative treatment. Soft tissue injuries in non-displaced tibial plateau fractures are not addressed in this study.

Conclusion

The most common locations of injury were anterior to the midbody of the meniscus and meniscocapsular junction. Since most of the meniscal tears, vertical longitudinal tear, associated with tibial fractures have been amenable to arthroscopic repair, we believe that most cases which require surgical interventions should be considered for arthroscopic evaluation.

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초 록

목적: 경골 고평부 골절은 슬관절에 다양한 문제를 발생시킨다. 본 연구는 관절경하 경골 고평부 골절에서 반월상 연골 손상 양상을 확인하고자 한다.

대상 및 방법: 2007년 3월부터 2010년 3월까지 경골 고평부 골절을 진단 받은 39명의 환자 중 33명 환자를 대상으로 골절 고정 시내 관절경을 시행하였다. Schatzker 분류에 따르면 1명의 I형(3.3%), 19명의 II형(53.3%), 4명의 III형(13.3%), 2명의 IV형(6.6%), 2명의 V형(6.6%), 5명의 VI형(20%) 소견을 보였다.

결과: 25명의 환자(75.8%)에서 외측 반월상 연골 파열 소견을 보였다. Schatzker II형 환자 19명 중 18명의 환자(94.7%)가, Schatzker III형 환자 4명 중 3명의 환자(75%)가, Schatzker VI형 환자 5명 중 4명의 환자(80%)가 반월상 연골 파열 소견을 보였다. 반월상 연골 중 가장 많이 손상된 부분은 외측 연골의 전각부이다(22/25). 25명의 반월상 연골 파열 환자 중, 한 명을 제외한 모든 환자에서 반월상 연골 변연부 수직 종파열 양상을 보였으며, 이는 대부분의 경우에 있어 관절경하 봉합술을 시도할 수 있었다.

결론: 경골 고평부 골절에 있어 관절경하 반월상 연골 손상에 대한 파악 및 치료에 유용하며, 경골 고평부 골절환자에서 관절경을 권한다.

색인 단어: 경골 고평부 골절, 연부조직손상, 반월상 연골 파열, 관절경