

Outcome of Posterior Cruciate Ligament Avulsion Fractures from Tibial Attachment Treated by Open Reduction and Internal Fixation

Shouryashil V. Khambalkar, Tanish C. Patil, Jaydeep K. Patil, Kapil R. Ghorpade, Nagesh Naik

Department of Orthopedics, Prakash Institute of Medical Sciences and Research Centre, Islampur, Sangli, India

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Correspondence:

Kapil R Ghorpade,
Department of Orthopaedics,
Prakash Institute of Medical
Sciences and Research Centre,
Islampur, Sangli, India.
Email: drkapilghorpade@gmail.
com

Abstract

Objective: To study the clinical profile and treatment outcome of mucormycosis associated with the second wave of COVID-19 pandemic.

Methods: An observational study was conducted in a tertiary care center over a period of 12 months, including a 6-month post treatment follow up. Study included all COVID positive patients with a clinical and radiological evidence of rhino-orbito-cerebral mucormycosis during the second wave of COVID-19. All patients underwent further diagnostic workup and confirmed cases underwent surgical debridement and Amphotericin B was started.

Results: A total of 59 patients presented with mucormycosis with the mean age being 52.7 years and unilateral facial and orbital edema as the most common symptoms (28.8%). All were diabetic with HbA1c >7 in 54.2%. The mean duration of presentation was 20.7±7.9 days from the onset of COVID-19 infection. Unilateral involvement of the paranasal sinuses was the most common finding in MRI. Early administration of Amphotericin B with prompt surgical debridement was performed in all cases. Orbital exenteration was conducted in nine patients for better fungal load clearance. Patients showed a good response to surgical debridement and prompt medical treatment, with a mortality rate of 27%.

Conclusion: COVID-19 associated mucormycosis is difficult to treat and often presents in late stage. Uncontrolled diabetes, immunocompromised state, and steroid-induced immunosuppression were important risk factors. A close surveillance for early identification and initiation of treatment is mandatory. Repeated surgical debridement to clear the dead tissue is effective to control fungal load.

Keywords: Amphotericin B, COVID-19, invasive fungal sinusitis, mucormycosis

Introduction

Posterior Cruciate Ligament (PCL) is stronger than the anterior cruciate ligament (ACL) and plays a crucial role in stabilizing the knee.¹ It acts as the primary restraint against posterior tibial displacement and works in conjunction with the anterior cruciate ligament (ACL) to regulate the external rotation of the knee during extension. PCL injuries are estimated to account for approximately 20% of knee

ligament injuries, with higher incidence rates observed in cases of high-energy trauma, such as motorcycle and car accidents, and in contact sports among athletes.² With increasing involvement of youth in sports activities there is increased incidence of these fractures. The other common mechanism of injury to the posterior cruciate ligament is caused by the application of a force to the proximal tibia anteriorly when the knee is flexed. The functional impairment PCL

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injuries may range from mild discomfort to severe functional impairment.³ In cases with PCL avulsion fracture, a history of posteriorly directed force on flexed knee or history of fall on flexed knee may be present. The physical examination may show the presence of joint swelling, hemarthrosis, or contusion over the anterior tibia. Diagnosis may be confirmed on the basis of anteroposterior and lateral X-Ray of the affected knee which may show presence of bone discontinuity at the posterior tibial articular surface.⁴ Computed tomography and MRI may also help in further evaluation of fracture, as well as identifying accompanying injuries such as meniscal tears or soft tissue involvement. Computed Tomography and MRI have a high sensitivity for the diagnosis of PCL avulsion fracture. PCL avulsion fractures usually involve tibial attachment and, when this occurs, it is essential to promptly diagnose and initiate the appropriate management to optimize the clinical and functional outcomes of the patients.⁵ Once diagnosed, the treatment is usually surgical. Unlike in patients with isolated PCL injuries where the repair is usually deferred, cases with avulsion fracture needs prompt surgical interventions in order to prevent complications that may take the forms of malunion and non-union. The repair for these fractures can be done arthroscopically or by open reduction.⁶ In developing countries, arthroscopic surgeries are not commonly done due to the expensive cost and high requirements of facility; in addition, specific expertise is also required to perform arthroscopic repairs, which are not available except in urban areas. Thus, open reduction and internal fixation using screws remain one of the most common surgeries in rural and semi urban areas for PCL avulsion fractures. Various materials that can be used for internal fixation include, among others, lag screws, suture anchors, steel wires, and straddle nails, as well as a well-designed rehabilitation program as an essential part of the management of these patients.⁷ The clinical and functional outcomes of patients with PCL fractures treated by ORIF have been a subject of interest for researchers and clinicians alike. Understanding the long-term outcomes of open reduction and internal fixation for PCL avulsion fractures is crucial for guiding treatment decisions, optimizing surgical techniques, and improving patient care.⁸ Numerous studies have investigated the efficacy of this surgical technique and its impact on patients' quality of life and functional recovery.⁹ However, many of these

studies defined the outcomes on the basis of patients' subjective assessment of functional recovery. In this study, multiple objective scores to measure functional outcomes. This study aimed an observational study to analyze clinical and functional outcomes of posterior cruciate ligament avulsion fractures from tibial attachment treated by open reduction and internal fixation.

Methods

This study was conducted at the Department of Orthopedics, Prakash Institute of Medical Sciences and Research Centre, Islampur, Sangli, India. The duration of study was 2 years, starting from April 2021 to March 2023. In this study, 40 adult patients of either gender with PCL avulsion fractures were included on the basis of a predefined inclusion and exclusion criteria. Using the OPENEPI software version 3, by referring to a pilot study done on the PCL Avulsion fractures and assuming 90% power and 95% confidence interval, the sample size was determined to be adequate if it was more than 35 patients; thus, 40 patients were included in this study. The inclusion criteria was adult patients with isolated PCL avulsion fracture as diagnosed by imaging results (X-Ray, Computerized Tomography, and Magnetic resonance imaging) where the PCL fragment was displaced more than 5 mm and were presented within 4 weeks of injury. Patients who refused to participate or those who were presented after 4 weeks of injury, as well as patients with PCL fragment displacement of less than 5 mm were excluded from the study. Patients with musculoskeletal conditions likely to affect the outcomes of the assessment, such as those having osteoarthritis, rheumatoid or psoriatic arthritis and those with multiple fractures, were also excluded. A detailed history was taken from all patients with respect to type of trauma and duration since injury. A thorough clinical examination was done by a senior orthopedician in all the cases. Drawer test was performed to make the preliminary diagnosis of PCL injury. Imaging was done in the form of anteroposterior and lateral view radiographs of the affected knee. In selected cases, 3D computed tomography (CT) was done. Since X-ray and CT has low sensitivity for assessment of soft tissue damage and injury, magnetic resonance imaging was done in selected cases. Preanesthetic evaluation was performed in all cases. Routine investigations, such as complete hemogram, renal function

tests, bleeding and clotting time, and Hepatitis B and HIV ELISA tests were done in all cases. In cases involving patients above 45 years of age, physician's opinion regarding fitness for the surgery was sought. All patients were treated by open reduction and internal fixation of avulsion fracture.

During the surgical procedure, patients were given spinal anesthesia and placed in a prone position with the affected limb flexed. An inverted L-shaped incision was made, exposing the PCL tibial attachment through the interval between the medial gastrocnemius and semimembranosus, and the posterior knee capsule was incised to reveal the avulsed PCL tibial insertion fragment. The fracture hematoma was removed, and in cases of old injuries, any fibrous tissue was debrided from the avulsed fragment or its bed. Under the C-arm guidance, the fractured fragment was visualized and repositioned over the posterior tibial plateau and sutured at the osteo-ligamentous junction. Then, a long, thin guide wire was passed from the center of the fragment, directed from posterior to anterior through the proximal tibia, with the knee in flexion, ensuring it made a 45-degree angle to the posterior surface of the tibia. After safely drilling over the guide wire and measuring the length, a 4 mm cannulated cancellous screw with a washer was later fixed in place. The fragment was reduced under direct vision to its bed (facilitated by slight knee flexion), gently held in place using a spike pusher, and provisionally fixed with a K-wire. The position of the reduced fragment was checked by fluoroscopy. Postoperative above knee slab given with padded support to superior part of calf to keep knee in anterior drawer position. Quadriceps exercises and non-weight bearing mobilization was started from next day. Suture removal was performed after 15 days. Passive knee bending started after 1 month with toe touch weight bearing. Full weight bearing started after full range of movements achieved after 6-8 weeks. Although full routine activities were allowed after 3 months, participation in contact sports was avoided till 9 - 12 months according to rehabilitation and muscle strength recovery. The patients were followed up every monthly for 3 months and, after that, every 3 months for 12 months. At every follow up visit, patient clinical and functional assessments were done using the Lysholm knee score (LKS) and Knee Society Score¹⁰. Qualitative data were represented in percentages and quantitative data were represented as mean with standard deviation.

The statistical analysis was done using the SPSS 22.0 software and a p-value of less than 0.05 was taken as statistically significant.

Results

Fourty cases of posterior cruciate ligament avulsion fractures from tibial attachment that were treated by open reduction and internal fixation were included in this study, of which there were 34 (75 %) males and 6 (15%) females with an M: F ratio of 1:0.17. Twenty-six (65 %) of the participants had their right side affected, whereas the remaining 14 (35 %) of the cases had left sided PCL avulsion fracture. The analysis of the age group of the patients showed that the most common affected age group was between 31-40 years (57.5%), followed by 41-50 years (27.50%). The mean age of affected patients was found to be 37.3 +/- 7.34 years (Table 1).

Out of 40 patients, 29 (72.50%) sustained fracture secondary to road traffic accidents while 7 (17.50%) had sports-related injuries. In 4 (10%) patients fracture was secondary to falls. The majority of the patients (52.50%) were presented within 7 days of sustaining injury, while 19 (47.50%) were presented between 8 days to 4 weeks after injury (Table 2).

Functional assessments at the time of each follow up was performed using the Lysholm score and knee society score. At the time of presentation, the mean Lysholm score was found to be 4.5 +/- 2.8, with a gradual improvement with each follow up and reaching 72.8 +/- 9.2 at 3 months, and 98.2 +/- 10.1 at the time of final follow up. This difference between the initial score and final score was statistically highly significant (Fig. 1).

The functional assessment of the knee was also done by knee society score. At the time of presentation, the mean knee society score was

Table 1 Age Distribution of the Studied Cases

Age	No of cases	Percentage
18-30 years	3	7.50%
31-40 years	23	57.50%
41-50 years	11	27.50%
Above 50 years	3	7.50%
Total	40	100 %
Mean Age	37.3 +/- 7.34 years	

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Table 2 Mechanism of Injury and Duration Since Injury

Mechanism and Duration of Injury		Number of Cases	Percentage
Mechanism of Injury	Road Traffic Accidents	29	72.50%
	Sports Injuries	7	17.50%
	Falls	4	10.00%
Duration Since Injury	Within 24 hours	9	22.50%
	2-7 days	12	30.00%
	8 days-2 weeks	10	25.00%
	15 days-4 weeks	9	22.50%

34.16 +/- 12.34, which gradually improved to 82.76 +/- 10.36 at 6 months, and at the time of final follow up, the mean knee society score was 92.34 +/- 8.12. In addition, there was a significant improvement in cases as assessed by knee society score (p<0.0001). At the time

of presentation, all patients were having moderate to severe pain. The mean VAS score at the time of presentation was 6.3 +/- 2.62. In the postoperative period, the pain reduced significantly over a period of weeks to months. At the time of final follow up at 12 months,

Table 3 Mean Knee Society Score at Presentation and During Follow Up

Comparison of Knee Society and VAS Scores		Mean +/- Std Deviation	P Value
Knee Society Score	At Presentation	26.34 +/- 9.98	P < 0.0001 (Paired t-test) Highly significant
	At 1 Month	42.16 +/- 12.34	
	At 2 Months	46.78 +/- 14.62	
	At 3 Months	64.38 +/- 14.02	
	At 6 months	78.64 +/- 12.16	
	At 9 months	82.76 +/- 10.36	
	Final Follow Up (1 year)	88.20 +/- 8.12	
VAS Score	At Presentation	6.36 +/- 2.64	P < 0.0001 (Paired t-test) Highly significant
	At 1 Month	3.94 +/- 1.84	
	At 2 Months	3.12 +/- 1.74	
	At 3 Months	2.68 +/- 1.36	
	At 6 months	2.12 +/- 1.22	
	At 9 months	1.80 +/- 0.92	
	Final Follow Up (1 year)	1.24 +/- 0.72	

Table 4 Patient Outcomes by Knee Society Score

Outcome (KSS score)	Number of patients	Percentage
Excellent (80-100)	29	72.50%
Good (70-79)	6	15.00%
Fair (60-69)	4	10.00%
Poor (<60)	1	2.50%

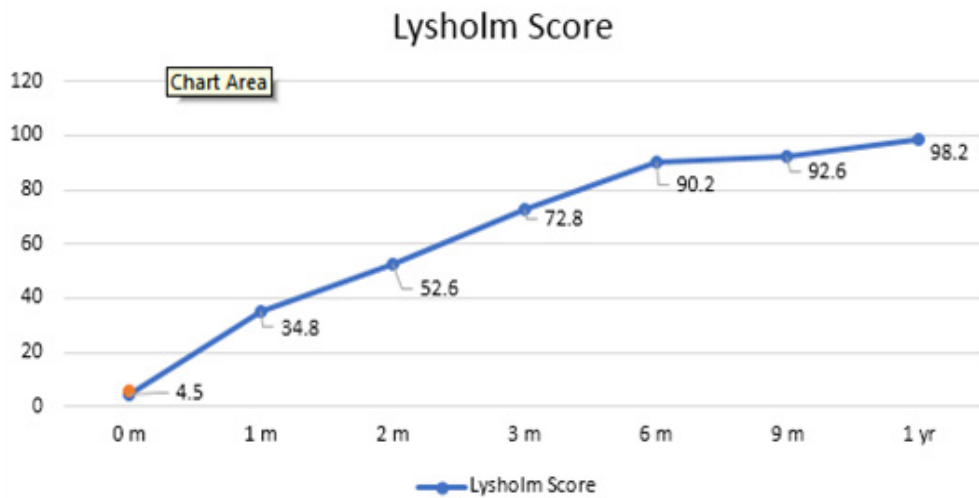


Fig. 1 Mean Lysholm Score at Presentation and During Follow Up

there was a significant reduction in the VAS scores. At the time of the final follow up, the mean VAS score was found to be 1.24 ± 0.72 ($p < 0.0001$) (Table 3).

The final functional outcome as assessed by the Knee society score showed that out of 40 cases, 29 (72.50%) cases had an excellent outcome whereas 6 (15%) and 4 (10%) patients had a fair outcome. Only 1 patient (2.50%) had a KSS below 60, suggestive of poor outcome (Table 4).

The analysis of the patients on the basis of complications showed that out of 40 patients, 32 (80%) patients did not have experience any complications. Five (12.5%) patients had residual intermittent pain, 2 (5%) patients

had wound infections, which was successfully treated by oral antibiotics and local wound care. Only 1 (2.5%) patient developed residual joint instability as evidenced by the drawer test (Fig. 2).

Discussion

Posterior cruciate ligament injuries usually result from road traffic accidents or contact sports injuries. Unlike in cases of isolated PCL tears where the management remains controversial, guidelines for PCL avulsion fractures is unanimous, and open reduction and internal fixation remains the preferable line of management and conservative management

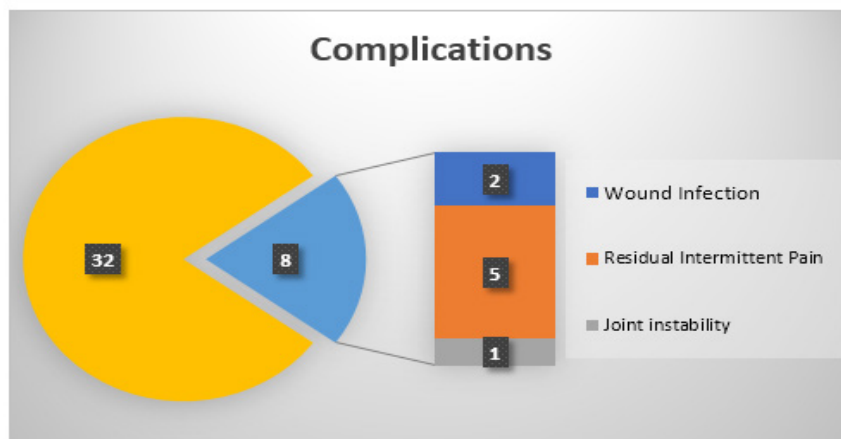


Fig. 2 Complications in the Studied Cases

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is not desirable given the high chances of non-union or malunion, which may further destabilize the affected knee.¹¹ In this study, there was a significant male preponderance in cases of PCL avulsion fractures. Male preponderance is almost universal across studies because of predominant involvement of males in road traffic accidents and contact sports, which remains common causes of PCL avulsion fractures. Bali *et al.*¹², in their study to analyze the outcome of posterior cruciate ligament (PCL) avulsion fractures of tibia with open reduction and internal fixation, involved 42 patients (30 males and 12 females), with a median age of 26 years (range: 14–53 years) who underwent ORIF through a modified, posterior approach for PCL fossa avulsion fractures assessed after a median follow up of 18 months (range 10-42 months). In 30 patients, surgeries were performed within three weeks of injury. Their study showed a significant male preponderance with an M:F ratio of 1:0.4. Similarly, male preponderance was also reported by the authors such as Khatri *et al.*¹³ and Fan *et al.*¹⁴ The mean age of studied cases in the study was found to be 37.3 +/- 7.34 years. Twenty-nine (72.50%) patients was found to experience fracture secondary to road traffic accidents while seven (17.50%) patients had sports related injuries. In four (10%) patients, fracture was secondary to falls. In the western world, most of the PCL injuries are results of a type of injury popularly known as dashboard injuries where the injury occurs in sitting position and sudden abrupt force is applied on the anterior aspect of tibia. However, in developing world, including in India, PCL injuries are usually results of road traffic accidents involving bikes. Chen *et al.*¹⁵ conducted a study to investigate the feasibility and clinical efficacy of using a toothed plate and hollow lag screw in the surgical treatment of posterior cruciate ligament (PCL) avulsion fractures of the tibia, which was a retrospective study of patients with PCL avulsion fractures of the tibia caused by road traffic accidents (n=9), sports-related injuries (n=6), falls (n=5), and machinery-related injuries (n=1) involving twenty patients who are presented with fresh fractures and one with an old fracture. These

patients (13 men, eight women) had a mean age of 41.5 (range 19–72) years. Their findings were similar with respect to cause of avulsion fracture; however, the mean age of patients in their study was slightly higher. Similar findings were also reported by authors such as Owesen *et al.*¹⁶ and Sanders *et al.*¹⁷ In those studies, all patients were treated by open reduction and internal fixation of avulsed part of tibia. Patients were followed up for 1 year. During follow up visits x-rays were taken to assess the union. Also, the functional assessment was done using Lysholm score and knee society score. Both Lysholm and knee society score were found to gradually improve over the period of follow up and there was a significant functional improvement in both mean Lysholm and knee society scores when compared from presentation to the previous follow up visit. The outcome assessment by KSS (Knee society score) showed that out of 40 cases 29 (72.50%) cases had an excellent outcome whereas 6 (15%) and 4 (10%) patients had fair outcome. Only one patient (2.50%) had a KSS below 60, suggestive of a poor outcome.

Joshi *et al.*¹⁸ also performed a similar study of open reduction and internal fixation using cannulated cancellous screws in 14 patients (mean age, 33.9 years) with isolated PCL avulsion injuries. At the time of the final follow up the authors found that the Lysholm functional score was excellent in 11 patients, good in 2 patients, and fair in 1 patient with an average score of 97±7.6. Similar findings were also reported by the authors such as Wu *et al.*¹⁹ and Khalifa *et al.*²⁰ Being a purely observational study, this study has its inherent biases. A randomized control trial would be needed to further substantiate the outcome of this observational study. A prolonged follow up observation will also be helpful in knowing long term complications of this treatment approach.

In conclusion, patients with posterior cruciate ligament avulsion fracture treated by open reduction and internal fixation combined with quadriceps exercises in post-operative period were found to have excellent results in terms of functional outcomes.

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