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Functional outcome of fixation of tibial bony avulsion of the posterior cruciate ligament with open reduction and cancellous screw fixation using posteromedial approach

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Abstract
Objective: To report the functional outcome in Posterior Cruciate Ligament (PCL) tibial avulsion fractures treated with open reduction and internal fixation with cancellous screw fixation through the posteromedial approach.
Materials and Methods: This is a prospective and retrospective study conducted in Katuri medical college and hospital, Guntur, from September 2016 to May 2019. Total eight number of patients who came with White's type 2 & 3 displaced Posterior Cruciate Ligament (PCL) tibial avulsion fractures treated by open fixation with cancellous screws through the posteromedial approach. The pre-operative assessment was done with a magnetic resonance imaging for all the patients to confirm the fracture.
Results: Post-operative radiographs were taken, which showed all avulsed fragments are well reduced and maintained. In all the cases, healing was evident by the end of 3 months. There are no symptoms of instability found clinically. The average Lysholm knee score was 94.3 (84-97).
Conclusion: This study demonstrated treatment of White's type 2 & 3 displaced avulsion fracture of the posterior cruciate ligament by open reduction through the posteromedial approach and internal fixation using partially threaded screws gives very good functional and radiological results.

Keywords: Posterior cruciate ligament, avulsion fracture, tibial bone, joint instability, rehabilitation

Introduction

Posterior cruciate ligament (PCL) avulsion fracture is a relatively rare injury. The common modes of PCL avulsion fractures in the Indian population are due to road traffic accidents and contact sports [1]. The main mechanism involved in PCL injuries is the dashboard injury, resulting from direct trauma to the proximal tibia of a flexed knee in the anteroposterior direction [2]. In case of contact sport injuries, the underlying mechanism of PCL avulsion fracture is due to acute hyper flexion of an extended knee or fall over a flexed knee.

The posterior cruciate ligament has two major parts, a large anterior portion that forms the bulk of the ligament and a smaller posterior portion that runs obliquely to the back of the tibia. The posterior cruciate ligament attaches proximally to the posterior part of the lateral surface of the medial condyle, and, forms a segment of a circle. The tibial attachment is in a depression behind and below the intraarticular portion of the tibia, with a slip usually blending with the posterior horn of the lateral meniscus.

Tibial side insertion of the PCL is more consistent than the femoral insertion. There is no anatomical separation between the two PCL bundles on the posterior aspect of the tibia over centrally located facet~1.0–1.5 cm distal to the joint line, with the anterior border being the posterior horn of the medial meniscus. The center of the two fiber bundles is located at 48% of the mediolateral width of the tibial plateau from the medial side. In the sagittal plane, the PCL attachment is 7mm anterior to posterior tibial cortex.

Most of the cases are treated conservatively due to an apprehension that the approach to the posterior aspect of the knee is difficult [4-6]. Intra-substance tears are usually not primarily diagnosed nor treated at initial presentation. In avulsion injuries from the tibial attachment, early diagnosis is usually possible on standard radiographs where a bony fragment may be

visible, and secondly the treatment protocol is fairly standardized. Surgical fixation of the bony avulsion by either a screw or K-wire is advocated, and it has given almost uniformly excellent results [7]. Non-surgical treatment has disadvantage morbidity due to residual instability and early degenerative arthritis [8].

Materials and Methods

This is a prospective study conducted in Katuri medical college and hospital, Guntur, from September 2016 to May 2019. Total eight number of patients who came with White's type 2 & 3 displaced Posterior Cruciate Ligament (PCL) tibial avulsion fractures treated by open fixation with cancellous screws through the posteromedial approach. Pre-operatively magnetic resonance imaging is performed to all the patients for confirmation of the fracture. Those patients presenting within three weeks of injury were included in the study. The exclusion criteria are those patients presenting after three weeks and those with multi-ligamentous injuries. All the patients were managed with open reduction and screw fixation using 4.5 mm partially threaded cancellous screws of avulsed fragment.

Surgical technique

All the patients were administered with Spinal anesthesia. The surgery was performed in the prone position with exsanguination of the lower limb and under tourniquet control. The Surgical area is cleaned and draped circumferentially from the proximal thigh to midcalf. A slight curved incision, with a vertical limb overlying the medial aspect of the gastrocnemius muscle and the horizontal limb near the flexion crease of the knee. Skin and subcutaneous tissue separated. Dissection carried to deep facial layer. The medial sural cutaneous nerve that is the also called the posterior cutaneous nerve of the calf, usually perforates the deep fascia distal to the horizontal limb of the incision is protected. The medial border of the medial gastrocnemius is identified, and the interval between it and the semimembranosus tendon is developed bluntly with the finger, and the posterior joint capsule is exposed. The middle geniculate artery and the motor branch of the tibial nerve and are identified and secured. Capsule is incised vertically to expose the avulsed fragment. Now, the knee is flexed slightly by keeping a leg roll beneath the ankle to improve visualization. The avulsed fragment is identified. The bony bed of the fragment is debrided and freshened. Following this, the bony fragment is reduced on its bed and provisionally fixed with a 2 mm Kirschner wire (K-wire). The position of this K-wire is confirmed under fluoroscopy, and if satisfactory, a 4.5 mm partially threaded cancellous screw with washer is used for definitive fixation of the avulsed fragment (Figure 1). Following this, the position of the screw and the reduction is confirmed with fluoroscopy (Figure 2). Thorough wound wash is given, and the wound is then closed in layers.

Post-operative management

Postoperatively, the patients were advised to start the range of motion of the operated knee, which was advanced as per pain tolerability and taking account of other associated injuries. The hinged knee brace was advised to all the patients. The patients were advised Non-weight bearing for 1st three weeks with active Quadriceps and Hamstring exercises. Following 3 to 6 weeks, all of them advised Partial weight-bearing and complete weight-bearing after six weeks. Range of motion for the knee was restricted between 0-30 in the 1st two weeks, 30-60 in the next 2-4 weeks, 60-90 in 4-6 weeks and >90 after six weeks. Post-operative rehabilitation was done with a physiotherapy program for the range of movements twice a week. Quadriceps strengthening exercises were done daily, and active hamstring exercises were avoided for two months. All the patients are followed up at three weeks, six weeks, twelve weeks, six months, and one year. At the time of the first visit, only range of motion and condition of the surgical wound was addressed, and subsequent visits included thorough clinical and radiological assessment. Clinical examination included the posterior drawer test, and radiological assessment was done with anteroposterior and lateral radiographs of knee. Bony union, meaning the bony consolidation, which was seen on radiographs, and absence of pain with stable knee, was achieved in the majority of cases between two to three months. After bony union, strengthening exercises were carried out and a most of the patients had returned to their previous occupation within six months.

Results

In our study, the functional outcome was assessed with clinical and radiological parameters like the range of motion, ligamentous laxity, crepitus, subjective measurement, radiographic findings, activity levels, and functional strength. The results were evaluated using Lysholm scoring.

Patients were asked to fill the Lysholm questionnaire and were subjected to clinical and radiological examination. The clinical examination was performed and along with with it the Lysholm scoring. Range of motion was recorded using goniometer and stability of posterior cruciate ligament (PCL) is evaluated by stress test that is the posterior drawer test and radiologically. The PCL laxity recorded on radiological examination was considered for final evaluation. They were also subjected to stress radiograph of both knees with active hamstring contraction as described by Chassaing *et al.* [9]

The PCL laxity was classified as grade I in case if the laxity was less than 5mm, grade II with the laxity ranging between 6 to 10 mm and grade III in cases with the laxity being more than 10 mm. There was only one case with grade II PCL laxity, seven cases with grade I laxity and none with grade III laxity.

The mean period of follow up was 12.30 ± six months. The mean Lysholm score was 91.85±3.58 in 8 patients (Range 84 to 97). All the patients had a bony union at the final follow up. The associated injuries (Bony and ligamentous injuries) were treated in a single stage, or PCL bony avulsion was treated at a later stage. There were no hardware-related problems and the need for implant removal. The Comparative functional outcomes of Pre-Op and Post Op Lysholm Scores of various studies performed over the years is shown in table 1.

Table 1: Shows the comparative functional outcomes of Pre-Op and post Op lysholm scores of various studies performed over the years

Study	Preop lysholm score	Post OP lysholm score
Marcos *et al.*	15.8	96
Wei Chen *et al.*	25.3	93.6
Sachin Joshi *et al.*	3	97
Chen *et al.*	43	95
Our Study	18	94.3

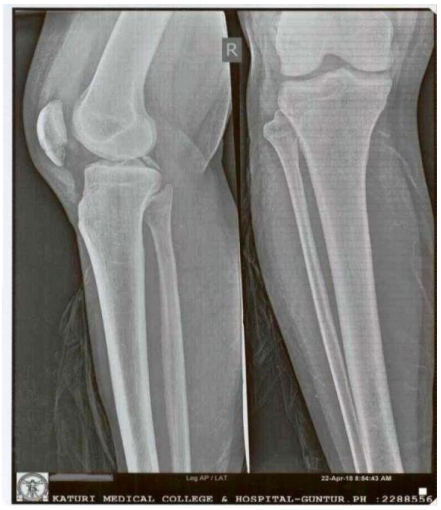

Fig 1: x-ray showing PCL avulsion fracture with transverse fracture of inferior pole patella

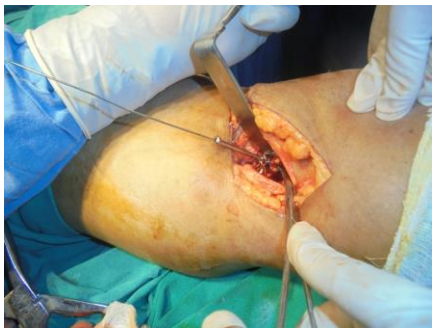

Fig 2: Image showing fixation of posterior cruciate bony avulsion injury with partially threaded cannulated cancellous screws.

Fig 3: Fluoroscopic image showing an acceptable reduction of the avulsed posterior cruciate bony fragment.

Fig 4: PCL avulsion fracture with associated patella fracture and femur shaft fracture treated with K-wire fixation and Interlocking nail respectively

Fig 5: Stress view of PCL avulsion fracture at 18 months follow up – True Lateral view and AP standing view

Discussion

There are many surgical approaches for the fixation of PCL avulsion fractures. The standard classical approach described by Abbott [10] was time-consuming, as it required handling of popliteal vessels. Later on, modifications were described by Trickey *et al.* [11], Ogata [12] and Burks and Schaffer [13] to the standard posterior approach. Trickey [12] had made some headway in decreasing the operative time but still required the division of the medial head of gastrocnemius leading to delayed rehabilitation. Ogata [13] had described the osteotomy of the fibular neck, which increased the complexity of the procedure.

Burks and Schaffer [13] simplified the procedure as it did not require medial head of gastrocnemius division or any osteotomy of fibula if required. Good functional results were obtained as the post-operative rehabilitation was accelerated. In our institute, we had used this approach in the management of all the cases of PCL tibial avulsion injury.

A high incidence of femoral shaft and patellar fractures associated with a PCL failure was seen in this series; this scenario, especially wphen seen after a motor vehicle accident should give rise to a high index of suspicion about PCL injuries. A haemarthrosis will ensue after patellar fractures, and examination of the knee is a problem. We have done a routine MRI in this injury combination, especially when there is no bony avulsion seen in the lateral radiographs, to rule out intrasubstance tears.

Another factor that plays a role in post-operative rehabilitation is the role of associated injuries patellar fractures, if comminuted may need patellectomy, and this delays early mobilization. One of our cases had an associated patellar fracture and femur shaft fracture that are treated by K-wire fixation and interlocking nail respectively, that had poorer ultimate knee flexion Figure 4). Delay in treatment was observed in all our cases, but this was not found to be a significant problem when fixing the fragment.

Many authors had recommended immobilization in a plaster cast for one and half month in cases of avulsion fracture of PCL that is treated with open reduction. They had reported stiffness as a major complication in their studies [11, 14, 15]. Nicandri *et al.* [16] had reported arthrofibrosis in only one of the ten cases when aggressive physiotherapy protocol was initiated instead of cast immobilization. They recommended the use of a functional brace and early range of motion exercises to achieve good functional results. However, the prerequisite for the same is a strong stable fixation. In our Institute, we followed the physiotherapy protocol as described by Nicandri *et al.* [16] and experienced arthrofibrosis in only one of the eight patients. Although there is controversy regarding the operative and nonoperative management of intrasubstance tear of PCL, there is a consensus regarding the treatment of PCL tibial avulsions [14, 17]. Seitz *et al.* [18] had reported excellent results in their series of 26 patients treated for PCL bony avulsion with open reduction

and internal fixation. Meyer [19] had reported the poor functional outcome in patients of bony PCL avulsion treated non-operatively.

This study had several limitations. The sample size was small, and the follow up duration was variable ranging from 12 months to 24 months. However, older studies have shown that the functional results attain a plateau after one year. So, the patients with one year follow up were also included in the study and the strength of the study was in the use of a patient-specific validated tool like Lysholm scoring to evaluate the functional results and stress radiographs to document the PCL laxity.

Conclusion

This study demonstrated treatment of White's type 2 & 3 displaced avulsion fracture of the posterior cruciate ligament by open reduction through the posteromedial approach and internal fixation using partially threaded screws gives very good functional and radiological results

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