Introduction

Isolated posterior cruciate ligament (PCL) injuries are uncommon and often go undiagnosed in acutely injured knees. The PCL, being a strong ligament, presents more commonly with avulsion fractures of its tibial attachment unlike the anterior cruciate ligament whose tears commonly present as isolated lesions. Avulsion injuries differ from other PCL injuries in that they are easily diagnosed on standard radiographs where a bony fragment may be visible. Traditionally, surgery of PCL injuries was deferred due to an apprehension that the approach to the posterior part of the knee is difficult. However, surgical fixation of avulsion injuries is recommended to avoid morbidity associated with nonunion of the fracture.

Repair of avulsion injuries can be done with an open or arthroscopic technique. Biomechanical studies have also demonstrated comparable results of screw fixation using open or arthroscopic means. However, arthroscopic repair is technically more challenging, requires specialized equipment and has a long learning curve. Thus, it unsuitable to perform in primary centers. Open reduction and internal fixation using screws has been considered a favorable method to manage PCL avulsion injuries producing satisfactory results. In addition, a simplified posteromedial approach described by Burks and Schaffer, which is...
useful for avoiding difficulties associated with previous posterior approaches to the knee, has become the standard approach to the PCL.

There is currently a wide variety of materials available for internal fixation, including lag screws, steel wires, absorbable screws, suture anchors and straddle nails\(^1\).\(^2\).\(^13\)) Fixation with screws has shown favorable results; however, no one technique has been considered a gold standard for avulsion fractures of the PCL. In this study, we present our experience with fixation using cannulated cancellous screws, which is a good implant to achieve compression needed to fix avulsion fractures and is easily available. The approach we used was also simple and helpful in avoiding the neurovascular bundles unlike other posterior approaches.

The purpose of our study was to evaluate the clinical and functional outcome after open reduction and internal fixation of tibial avulsion injuries of the PCL using cannulated cancellous screws. We hypothesized that the technique would provide improved clinical and functional outcome with use of an easily available implant and a simple approach.

**Materials and Methods**

Twenty-one patients with PCL avulsion fractures were enrolled for the study from December, 2012 to November, 2015. Patients aged between 18 and 60 years with a duration of injury less than 12 weeks were included in the study. Patients with any other associated ligament injury of the same joint, any other bony injury of the same limb or any medical comorbidity precluding the surgery were excluded from the study. Patients in whom the avulsed fragment was too small (<20 mm\(^2\)) to be fixed using a screw were also excluded. After excluding 7 patients based on the above criteria, 14 patients having isolated PCL avulsion fracture were ultimately included in the study.

All patients underwent thorough clinical examination. All the cases were clinically assessed by the senior author using the drawer test to confirm PCL injury. Anteroposterior and lateral radiographs including the posterior stress view (Fig. 1) of the knee were taken to confirm the injury. A computed tomography scan...
Fig. 2 was done for patients in whom the injury could not be defined well on radiographs. Magnetic resonance imaging (MRI) (Fig. 3) was done for every patient in order to confirm associated ligament injuries of the knee.

After informed consent was obtained, patients were operated using the modified posterior approach described by Burks and Schaffer. The approach (Fig. 4) uses an inverted ‘L’ incision starting on the medial border of the gastrocnemius and curving along the flexor crease of the joint towards the lateral side. The fascia is incised in the line of skin incision. The capsule is exposed using the interval between the semimembranosus and gastrocnemius, which is then incised longitudinally to expose the joint at the site of the avulsed fragment. The avulsed fragment was debrided if needed and reduced using a clamp. It is of note that the reduction was achieved by slight flexion of the joint. The avulsed fragment was fixed using one or two 4 mm cannulated cancellous screws according to the size of the fragment (Fig. 5). A washer was used when compression was not achieved with the screw alone.

Postoperatively, the limb was kept immobilized using a long knee brace for 6 weeks. Quadriceps strengthening was started from the 2nd postoperative day. Passive knee bending was started after suture removal (10–12 days after surgery) and active knee mobilization was started 3 weeks after surgery. Partial weight bearing was allowed after 6 weeks and full weight bearing after 12 weeks when the brace was also discarded. Return to heavy activities, such as running and sports, were allowed only after 6–9 months.

Patients were regularly followed up every week for a month, then every month for the first 3 months and every 3 months thereafter for a minimum of 12 months. At every follow-up, patients were assessed clinically and radiographically. Outcomes were assessed in terms of stability and range of motion (ROM). Stability was assessed clinically by the drawer test and radiographically by lateral stress X-ray (Fig. 6). Final functional outcome was assessed using the Lysholm knee scoring system.

Statistical analysis was done using the Wilcoxon nonparametric paired test to determine the significance of postoperative improvement with respect to the Lysholm score as well as joint stability.

Results

Of the 14 patients, 12 were male and 2 were female. The mean age of the patients was 33.9 years, ranging from 22 to 54 years (Table 1). The most common mode of injury was road traffic accident (n=9) with a majority involving motorcycle accident fol-
followed by either sports-related injury or fall. Eleven patients presented to the clinic within 3 weeks of injury while three patients presented between 3 to 12 weeks after injury. The average period of follow-up was 13.5 months.

At the final follow-up, all 14 patients had achieved fracture union. At 6 weeks after surgery, the ROM was more than 90° in 9 patients. Of the remaining 5 patients, 3 patients who had presented later than 3 weeks after injury regained more than 90° of flexion after more than 6 postoperative weeks. At the final follow-up, the average flexion was 121.7°±9.18° with full extension possible in all the patients. The functional outcome assessed by the Lysholm scoring system was excellent in 11 patients, good in 2 patients and fair in one patient. The average Lysholm score was 97±7.6.

Two patients complained of residual pain in the joint while one complained of residual swelling in the joint. Two patients had superficial wound infection, which was treated with intravenous antibiotics and regular dressings. No other complications were observed.

Instability tested clinically using the drawer test and radiologically by stress X-ray was found to be mild (1+) in 4 of the patients while the rest of the patients had no residual instability.

The statistical analysis showed highly significant improvement (p<0.001) in functional outcome assessed by the Lysholm score and joint stability (p<0.001) (Table 2).

| Case | Age (yr) | Mechanism of injury | Duration of injury (day) | Follow-up (mo) | Lyscholm score Preop | Postop (functional outcome) | Clinical outcome (°) | Postop instability | Complication |
|------|----------|---------------------|--------------------------|----------------|-----------------------|---------------------------|----------------------|------------------|--------------|
| 1    | 29       | Motorcycle          | 2                        | 15             | 0                     | 100 (excellent)           | 130                  | Nil              | -             |
| 2    | 34       | Fall                | 10                       | 12             | 6                     | 99 (excellent)            | 110                  | Nil              | Superficial infection |
| 3    | 26       | Motorcycle          | 4                        | 12             | 0                     | 99 (excellent)            | 113                  | Nil              | -             |
| 4    | 48       | Motorcycle          | 3                        | 13             | 0                     | 84 (good)                 | 110                  | Nil              | Residual pain |
| 5    | 27       | Road traffic        | 1                        | 16             | 0                     | 95 (excellent)            | 120                  | Mild (1+)        | -             |
| 6    | 39       | Motorcycle          | 5                        | 13             | 0                     | 100 (excellent)           | 130                  | Nil              | -             |
| 7    | 24       | Sports related      | 8                        | 12             | 2                     | 95 (excellent)            | 128                  | Mild (1+)        | Superficial infection |
| 8    | 41       | Fall                | 46                       | 15             | 20                    | 89 (good)                 | 121                  | Nil              | Residual swelling |
| 9    | 43       | Motorcycle          | 7                        | 12             | 4                     | 95 (excellent)            | 127                  | Mild (1+)        | -             |
| 10   | 22       | Sports related      | 28                       | 17             | 15                    | 99 (excellent)            | 110                  | Nil              | -             |
| 11   | 31       | Motorcycle          | 1                        | 14             | 0                     | 100 (excellent)           | 135                  | Nil              | -             |
| 12   | 29       | Road traffic        | 2                        | 13             | 0                     | 95 (excellent)            | 130                  | Mild (1+)        | -             |
| 13   | 54       | Fall                | 38                       | 12             | 13                    | 74 (fair)                 | 110                  | Nil              | Residual pain |
| 14   | 28       | Motorcycle          | 5                        | 14             | 7                     | 100 (excellent)           | 130                  | Nil              | -             |
| Mean | 33.9     | -                   | -                        | -              | 4.8                   | 94.6                     | 121.7                | -                | -             |

Preop: preoperative, Postop: postoperative.
Discussion

PCL injuries account for approximately 20% of total ligament injuries of the knee\textsuperscript{14}. The incidence is especially high in cases of high-energy trauma (motorcycle and car accidents), and athletic population involved in contact sports is especially vulnerable to PCL injuries\textsuperscript{4,10}. The most common mechanism underlying PCL avulsion fractures of the tibia in road traffic accidents is dashboard collision in which a direct force is applied to the proximal part of the tibia in an anterior-to-posterior direction, with the knee in flexion\textsuperscript{16,17}. In our series, most of the injuries resulted from motorcycle accidents because the majority of people commute by two-wheelers in India.

Though the necessity of surgical treatment of isolated PCL injuries is still controversial, fixation methods for avulsion fractures of the PCL at the tibial insertion have been suggested in different series\textsuperscript{18-23}. If left untreated, the injury leads to secondary joint changes resulting in osteoarthritis\textsuperscript{24}. Open fixation through the posteromedial approach seems to be a relatively easy procedure that can be performed at any center by any orthopedic surgeon. The posteromedial approach used in our patients was devised by Burks and Schaffer\textsuperscript{21}, which is a simple approach exposing the desired surgical area without having to disturb the neurovascular bundles as well as other approaches described by Abbott, Trickey, Ogata, and McCormick\textsuperscript{1,20,25,26}.

In this study, we performed open reduction and internal fixation of isolated PCL avulsion injuries using cannulated cancellous screws, assuming to attain good functional and clinical outcome. The most important findings of our study include that excellent to good functional outcome was obtained in the majority of patients (92.9%) and fairly good results were achieved in terms of ROM as well as stability.

In our series, we treated 14 patients with isolated PCL avulsion injuries by internal fixation using cannulated cancellous screws and the results were excellent in 78.6%, good in 14.3% and fair in 7.1% of the patients with an average postoperative Lysholm score of 97±7.6. These results were superior to those reported in previous studies. In a study by Attia and Zanfaly\textsuperscript{27} among 12 patients treated using navicular screws, excellent results were obtained in 33.3%, good results in 58.3% and fair results in 8.3%. Similarly, Piedade and Mischan\textsuperscript{28} showed excellent results in 53% and good in 47% of their cases where screws or Polyester no. 5 were used to fix the fracture. Khatri et al.\textsuperscript{29} used the same approach and technique, which resulted in a postoperative Lysholm score of 90.85±5.58. In the present study, all patients attained fair to good ROM with an average flexion of 121.7°±9.2° and full extension. Khatri et al.\textsuperscript{29} achieved normal to nearly normal ROM in 96% of the patients where as 64.3% of the patients achieved results similar to our study. Postoperative knee flexion was inferior in patients who had presented to the clinic relatively late and who did not adhere to the prescribed physiotherapy. Hence early fixation and strict adherence to physiotherapy are recommended.

Four of the patients who had mild (1+) residual instability had an intrasubstance PCL injury determined on MRI. However, this instability did not affect the functional outcome. Bali et al.\textsuperscript{10} reported that intrasubstance occult injuries were present in 15 out of 42 patients included in their study and 6 of them required a PCL reconstruction at a later stage. By contrast, none of the patients in our study had gross instability that necessitated PCL reconstruction at a later stage.

Although the technique we used in this study resulted in significant improvement in functional and clinical outcome, it is difficult to conclude that it should be the go to technique for PCL avulsion fractures due to the small sample size. Further studies with a larger sample size or case-control studies comparing different techniques are necessary to confirm our results. Nevertheless, the significance of this study is that we explored a novel and simple technique and added to the available literature on the management of PCL avulsion fractures.

Conclusions

Avulsion injuries of the PCL, though rare, should not be ignored. These injuries can be easily approached using a modified posterior approach and cancellous screw fixation with early controlled knee mobilization provides excellent to good functional results. Early diagnosis and fixation is preferred; however, fixation should not be discouraged in patients presenting late since comparably good to fair results can be obtained in such cases as well.
Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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