The Knee 24 (2017) 890–896

Contents lists available at ScienceDirect

The Knee

Novel techniques

A novel MIS technique for posterior cruciate ligament avulsion fractures

Ashok S. Gavaskar [a,*], Bhupesh Karthik [b], Hitesh Gopalan [c], Parthasarathy Srinivasan [d], Naveen C. Tummala [e]

[a] Department of Orthopedics, Parvathy Hospital, Chennai, India
[b] Department of Orthopedics, Sri Ramachandra Medical College, Chennai, India
[c] Department of Orthopedics, MOSC Medical College, Cochin, India
[d] Department of Orthopedics, Dr. Metha's Hospital, Chennai, India
[e] Department of Orthopedics, Swaram Hospital, Chennai, India

ARTICLE INFO

Article history:
Received 16 November 2016
Received in revised form 23 February 2017
Accepted 27 March 2017

Keywords:
Bony avulsion
Instability
Ligament injury
Mini-invasive fracture fixation
Posterior cruciate ligament

ABSTRACT

Objective: Open surgical approaches to treat tibial avulsion fractures of the posterior cruciate ligament (PCL) often use large incisions involving extensive muscle dissection and retraction. The objective of this study was to describe a new mini-invasive approach targeting the fractured zone, to minimize surgical dissection and improve recovery and rehabilitation.
Methods: The new approach was used in 15 males and seven females with isolated PCL avulsions. The length of the surgical incision, surgical time, need for conversion to open technique, visual analog scores (VAS) and duration of hospital stay were studied to assess the efficacy, learning curve and advantages of the new technique. Neurovascular complications were recorded. At the two-year follow-up, International Knee Documentation Committee (IKDC) scores were recorded to assess function.
Results: Patients were followed up for a mean of 29 months (range: 34–41). The mean length of the incision was 4.1 cm (range: 3.4 to five) measured at the end of the procedure. None of the patients required conversion to an open technique and no neurovascular complications were recorded. The mean surgical time was 40 min (range: 25–50). The mean VAS on discharge was 2.2 (range: one to four) and patients stayed at the hospital for a mean of 2.2 days (range: one to three). The mean IKDC score at one-year post surgery was 86.4 (range: 83.9–90.8).
Conclusions: The new mini-invasive targeted approach provides adequate exposure for performing internal fixation of PCL avulsion fractures without the surgical morbidity associated with conventional open surgical approaches. The procedure is safe, fast and does not require a long learning curve.

1. Introduction

Tibial avulsions of the posterior cruciate ligament (PCL) are seen in younger patients and often due to high-energy trauma. Associated knee and ipsilateral limb injuries are common. Surgical treatment is recommended for displaced avulsion fractures

* Corresponding author at: 63A, Gandhi road, Choolaimedu, Chennai 600094, India.
E-mail address: gavaskar.ortho@gmail.com (A.S. Gavaskar).

http://dx.doi.org/10.1016/j.knee.2017.03.014
0968-0160/

with a defunct PCL, in order to restore PCL function and stability to the knee joint. Several open surgical approaches [1–4] and arthroscopic techniques [5–8] have been described for treating these fractures. The open approaches involve large dorsal incisions, which often cross the flexion crease of the knee. The open surgical approaches provide access to the PCL insertion site either through midline, posteromedial or posterolateral sides. The basis for the mini-invasive approach is that the "target area — PCL insertion on tibia" is quite small and so elaborate exposure is not required. A new mini-invasive targeted approach has been developed for fixing these fractures and has successfully been used in 22 patients. The efficacy, safety and advantages of this mini-invasive approach were studied using clinician and patient-reported outcome measures.

2. Patients and methods

Fifteen males and seven females with isolated displaced PCL avulsions involving a single large fragment with retraction of the PCL on pre-operative magnetic resonance imaging (MRI) were included in the study. Patients were aged <18 and >55 years. Patients with radiological evidence of knee arthritis (>Grade I according to Ahlback classification) were excluded. The Institutional review board cleared the study and informed consent was obtained from all patients. The mean age was 34 years (range: 23–48). All patients had a positive posterior drawer test pre-operatively under anesthesia. The surgery was performed at a mean delay of five days after the injury (range: one to 14).

3. Surgical technique

The key point to the surgical technique is the skin incision, which is made with the patient lying prone, tourniquet inflated and the limb in neutral rotation. Two lines are drawn using fluoroscopy, with the beam centered on the knee and directed in an anterior to posterior direction to mark the skin incision. One vertical line is centered on the tibial eminence and a transverse line is one centimeter proximal to the tibial articular surface. A three to four centimeter transverse incision, depending on the size of the patient, is made centered on the intersection of the two lines (Figure 1). Skin flaps are developed both in craniocaudal and mediolateral directions. The deep fascia is incised along the line of incision and the plane between the two heads of the gastrocnemius is identified and developed by blunt dissection. The neurovascular bundle is safely retracted using a two-centimeter broad Langenbeck retractor towards the lateral side, while developing the plane between the two heads.

Once the posterior capsule and oblique popliteal ligament are identified, a self-retaining lumbar spine microdiscectomy retractor is mounted and gently distracted to get access to the posterior capsule (Figure 2). The posterior capsule is incised longitudinally and the fracture site is identified after mobilizing the capsule on either side using a periosteal elevator (Figure 3). The fracture is reduced to its bed using a long drill sleeve with the knee slightly flexed (Figure 4). A 1.2-mm threaded guide wire for a four-millimeter cannulated cancellous screw is passed, and the length measured using another guide wire of identical length. The guide wire is drilled towards the anterolateral cortex at a 45° angle to the long axis of the tibia. After confirming guide wire position under fluoroscopy, to avoid injury to the neurovascular bundle, the track is drilled with a cannulated drill bit over the long drill sleeve. A four-millimeter partially threaded lag screw is inserted and tightened over a washer. Additional screws may be used depending on the size of the fracture fragment (Figure 5). The capsule is closed and hemostasis is achieved. Finally, 20 ml of 0.5% bupivacaine is injected along the suture line and the subdermal tissues for pain control.

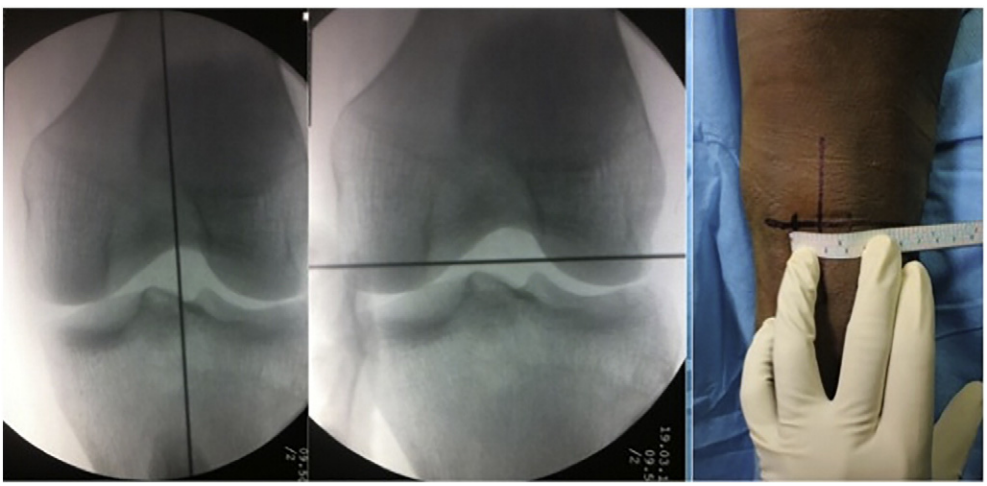

Figure 1. Placing the skin incision. Two perpendicular lines are drawn over the posterior aspect of the knee using fluoroscopy. Line 1: vertical line centered on the tibial eminence; line 2: transverse line made one centimeter proximal to the tibial articular surface intersecting line 1. The skin incision is placed centering the intersection point measuring roughly two centimeter on either side.

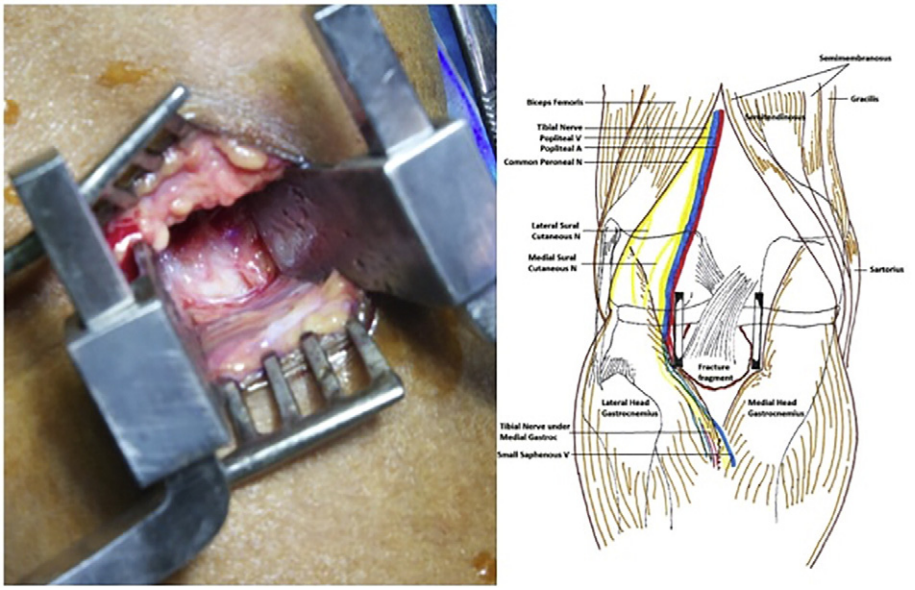

Figure 2. Intraoperative image and corresponding line diagram showing exposure of the posterior knee capsule. Once the inter-gastrocnemius plane is developed by blunt dissection, a lumbar microdiscectomy retractor is mounted, after isolating the neurovascular structures to expose the posterior knee capsule.

Postoperatively, patients were allowed to bear weight as tolerated and graduated active range of motion exercises were initiated. Closed chain strengthening exercises were started at six weeks. Patients were seen postoperatively at two, six and 12 weeks, thereafter at six and 12 months. Clinical evidence of stability using posterior drawer test, knee range of motion (ROM) and radiographs of the knee were performed at follow-up visits. All data were collected and assessed prospectively.

4. Appraisal of the new technique

The length of the incision was measured at the start and end of the procedure. Intra-operative difficulties and need for conversion to the conventional open technique were noted. Neurovascular complications were recorded. Duration of hospital stay

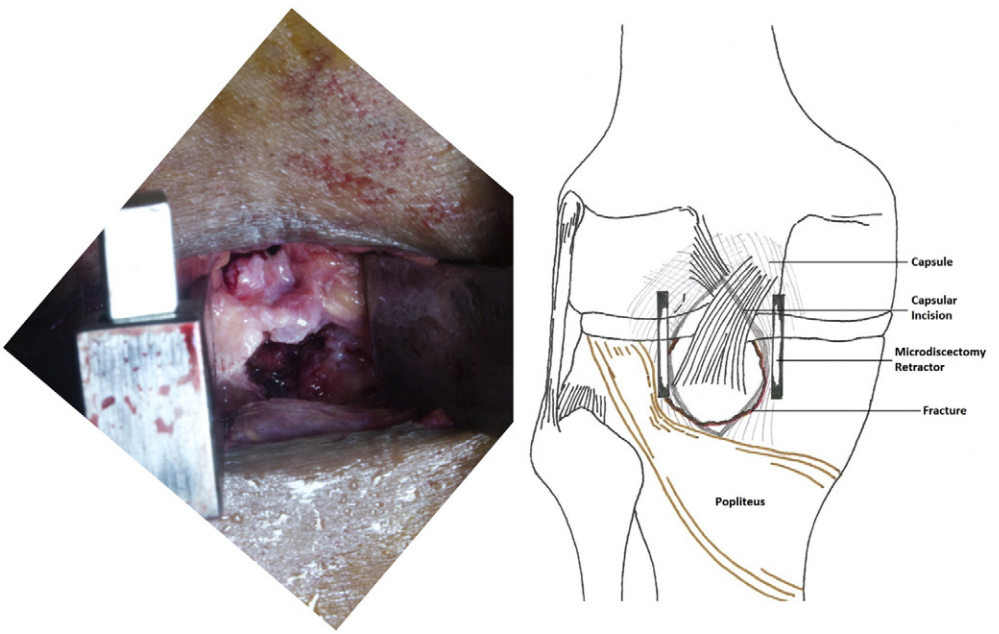

Figure 3. Intraoperative image and corresponding line diagram illustrating the capsular incision and exposure of the fracture site.

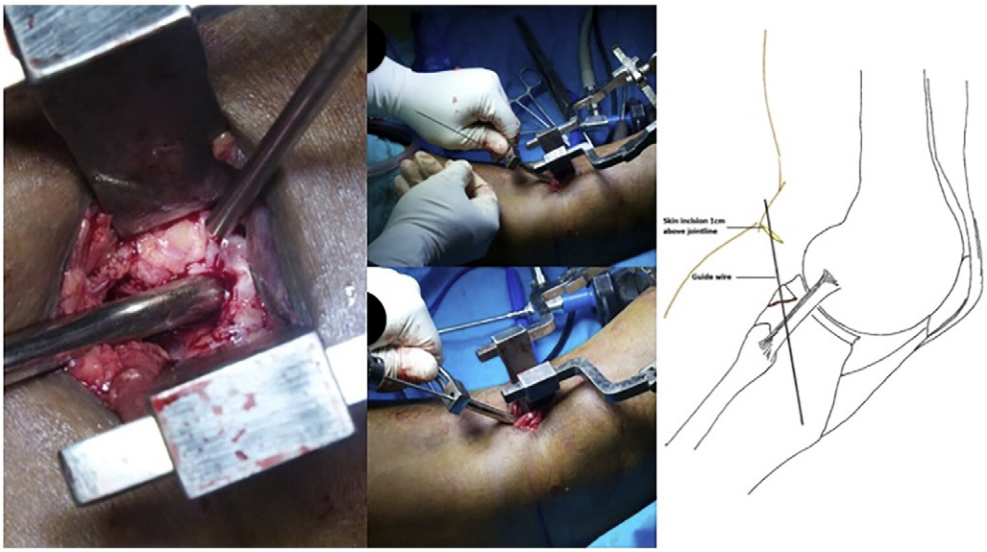

Figure 4. A long drill sleeve with a serrated end is used to hold the fractured fragment reduced during drilling for a four-millimeter cancellous screw. The guide wire is directed towards the lateral cortex anteriorly. Corresponding line diagram shows the trajectory of screw insertion.

and post-operative visual analog scores (VAS) on day 1 and at discharge were recorded. A computed tomography (CT) scan at six months follow-up was performed to assess fracture union. At six months, patients were asked to rate their satisfaction regarding the appearance of the scar on a scale of one to 10. All patients filled out an International Knee Documentation Committee (IKDC) questionnaire at the one-year follow-up [9].

5. Results

All patients had completed at least two years of follow-up. The mean follow-up was 29 months (range: 34–41) without any loss of patients. The mean body mass index (BMI) was 28.7 (range: 22.2–33). None of the patients required conversion to a conventional open technique due to intra-operative difficulties. No evidence of neurovascular compromise was encountered during and after surgery. All fractures had united on the follow-up CT scan (Figure 6). No screw loosening, breakage or back out was seen. Stability testing showed Grade 0 laxity in 14 patients and Grade I laxity in eight patients on posterior drawer test at last follow-up, but no symptomatic instability was noted. Range of motion testing did not show >10° difference in either flexion or extension compared with the opposite normal limb. The mean IKDC score at last follow-up was 86.4 (83.9–90.8). Details of surgical outcome are discussed in Table 1.

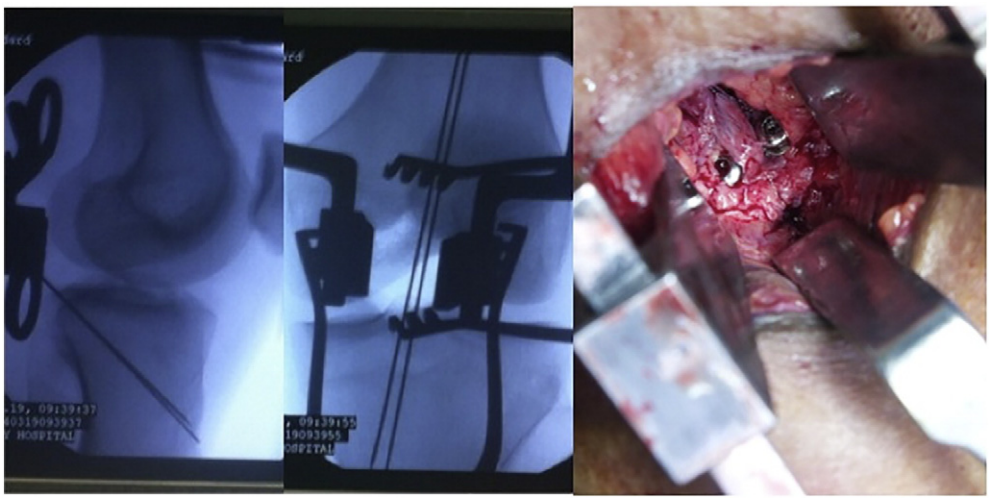

Figure 5. The position of the wires is confirmed using fluoroscopy in both planes before drilling and screw insertion. Fixation is completed using a four-millimeter cannulated cancellous screw tightened over a washer. More than one screw can be used, depending on the size of the fragment.

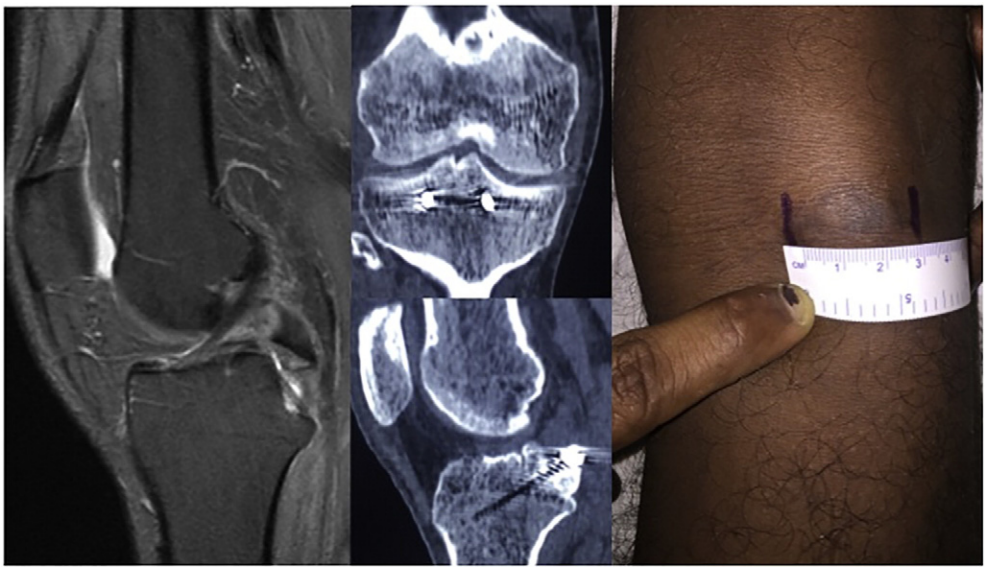

Figure 6. Case of a 20-year-old male with an isolated posterior cruciate ligament avulsion fracture. The MRI shows displacement >2 mm with retraction of the PCL. A CT scan six months after surgery using the minimal invasive technique shows evidence of sound union. The scar at six months measures 3.6 cm and is almost inconspicuous.

6. Discussion

The objective of this study was to develop a new mini open-targeted approach, which would allow exposure and reduction of the displaced PCL attachment in a safe manner without the need for large incisions crossing the knee flexion crease, and release or excessive retraction of the bulky posterior compartment muscles of the knee.

The conventional open approaches used for fixing PCL avulsions can be divided into three types based on the direction of access: midline, medial and lateral. Of these, the medial-based surgical approaches described by Burks and Schaffer and its subsequent modifications are the most popular [1]. In this approach, the medial gastrocnemius muscle has to be retracted to expose the PCL insertion site. This may be difficult in obese or muscular individuals. The exposure to the lateral base of PCL is limited and screw placement perpendicular to the fracture plane is difficult, which compromises fixation stability. Jazayeri described a modification of the Burks approach, which splits the medial gastrocnemius muscle to provide access [10]. This approach involves less retraction, but splitting the muscle may lead to weakness and more blood loss. The Trickey approach [4] and its modifications [11] use midline access through a long sinusoidal incision crossing the flexion crease with or without division of the medial gastrocnemius muscle. These approaches require extensive dissection, are time consuming, and have the potential for residual muscle weakness and scar contractures. Lateral-based approaches described by McCormick, Ogata and Minkoff are not very popular [12–14].

The present targeted approach gives good access to expose the entire PCL fragment, and one or two screws can be comfortably placed depending on the size and lateral or medial extension of the fracture. It also allows placing screws at a 45° angle to the long axis of the tibia, to achieve better screw trajectory and compression across the fracture. Table 2 summarizes all the open surgical approaches for PCL fracture fixation.

Arthroscopic techniques are becoming increasingly popular, mainly because of the extensile nature of the existing open surgical approaches. However, arthroscopic techniques require a considerable learning curve [15], do not eliminate neurovascular injury and are difficult to perform in the acute setting. Arthroscopic fixation techniques might also be preferable when the fracture

Table 1
Results.

Parameters	Outcome
Length of incision	Start of surgery: 3.6 cm (range: 3.1–4.5) End of surgery: 4.1 cm (range: 3.4–5)
Visual analog score	Day 1: 3.2 (range: 1–7) On discharge: 2.2 (range: 1–4)
Hospital stay	2.2 days (range: 1–3)
Surgical time	40 min (range: 25–50)
Scar satisfaction (1–10)	8.3 (range: 5–10)
IKDC score	86.4 (range: 83.9–90.8)

IKDC, International Knee Documentation Committee.

Table 2
Comparison of various open surgical approaches for fixation of PCL avulsion fractures.

Medial based		Midline access		Lateral based	
Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Burks (1990) [1]		Trickey (1968) [4]		McCormick (1976) [12] and Ogata (1980) [13]	
• Safe distance from the neurovascular (NV) structures	• Difficult exposure • Muscle retraction • Difficult screw placement	• Elaborate exposure	• Extensive dissection • Release of medial gastrocnemius • Possibility of injury to NV structures	• Safely away from the NV structures	• Involves osteotomy of the fibular neck • Taking down the popliteus tendon • Time consuming
		Gregg (2008) [11]			• May lead to instability
Jazayeri (2009) [10]	• Involves splitting of the medial gastrocnemius	• No release of medial gastrocnemius muscle	• Extensive dissection • Involves dissection of NV structures	Minkoff (1987) [14]	
• Safe distance from the NV structures				• Mini invasive	• Possible injury to lateral knee stabilizers
• No excessive muscle retraction	• Blood loss and muscle weakness		• Time consuming	• Safely away from NV structures	• Time consuming
		Current study (2016)			
		• Minimal access • Direct access to the target area			
		• No excessive retraction or release of muscle	• Involves minimal dissection of NV structures		
		• Excellent recovery			

NV,

is comminuted and the fragments are too small for lag screw fixation. The minimal access technique described in this paper reduces the surgical morbidity associated with conventional open approaches and does not require a long learning curve, unlike arthroscopy.

The present technique uses the same plane between the two heads of the gastrocnemius muscle as described previously by several authors. It has been shown that the smaller incision, if correctly placed, provides good exposure of the posterior capsule for at least 2.5 cm on either side of the midline to perform a satisfactory fracture fixation. No neurovascular problems were encountered and the procedure was not abandoned or modified in any of the patients.

The limitations of the study included small sample size and lack of a control group. The technique relies on precise placement of the skin incision, and an incorrectly placed incision can make the procedure difficult. Since the access is through the midline, risk to neurovascular structures is possible and should always be kept in mind. The BMI of Indian patients operated in the study might be on the lower side compared to Western populations, and it might require a slightly larger incision in morbidly obese patients. It is felt that the technique is highly reproducible, given that there were no difficulties right from the first patient, with surgical times being comparable to the conventional technique used previously. Effective lag screw fixation can be performed without the need for an extensive approach using this technique, which allows for early mobilization.

To conclude, internal fixation of tibial PCL avulsions can be satisfactorily performed using this mini-invasive technique. The technique is efficient, less time-consuming, and provides adequate exposure for addressing the fracture through a small cosmetic incision. The pain relief is excellent postoperatively and can enable early rehabilitation and return to function.

Author contributions

ASG and BK: conceived the idea and performed all surgeries; NCT, PS and HG: collected all data, performed clinical and radiological assessment and helped in drafting the manuscript; all authors read and approved the final manuscript.

Acknowledgments

No external funding was received for the study.
Authors declare no competing interests.

References

[1] Burks RT, Schaffer JJ. A simplified approach to the tibial attachment of the posterior cruciate ligament. Clin Orthop Relat Res 1990;254:216–9.
[2] Hughston JC, Bowden JA, Andrews JR, et al. Acute tears of the posterior cruciate ligament. Results of operative treatment. J Bone Joint Surg 1980;62:438–50.
[3] Meyers MH. Isolated avulsion of the tibial attachment of the posterior cruciate ligament of the knee. J Bone Joint Surg 1975;57:669–72.
[4] Trickey EL. Rupture of the posterior cruciate ligament of the knee. J Bone Joint Surg Br 1968;50:334–41.
[5] Chen CH, Chen WJ, Shih CH. Fixation of small tibial avulsion fracture of the posterior cruciate ligament using the double bundles pull-through suture method. J Trauma 1999;46:1036–8.
[6] Kim SJ, Shin SJ, Cho SK, et al. Arthroscopic suture fixation for bony avulsion of the posterior cruciate ligament. Arthroscopy 2001;17:776–80.
[7] Torisu T. Avulsion fracture of the tibial attachment of the posterior cruciate ligament. Indications and results of delayed repair. Clin Orthop Relat Res 1979;143:107–14.
[8] Veselko M, Saciri V. Posterior approach for arthroscopic reduction and antegrade fixation of avulsion fracture of the posterior cruciate ligament from the tibia with cannulated screw and washer. Arthroscopy 2003;19:916–21.

[9] Hefti F, Muller W, Jakob RP, et al. Evaluation of knee ligament injuries with the IKDC form. Knee Surg Sports Traumatol Arthrosc 1993;1:226–34.
[10] Jazayeri SM, Jah AAE, Karami M. A safe posteromedial approach to posterior cruciate ligament avulsion fracture. Knee Surg Sports Traumatol Arthrosc 2009;17:244–7.
[11] Nicandri Gregg T, Klineberg Eric O, Wahl Christopher J, et al. Treatment of posterior cruciate ligament tibial avulsion fractures through a modified open posterior approach: operative technique and 12- to 48-month outcomes. J Orthop Trauma 2008;22(5):317–24.
[12] McCormick WC, Bag RJ, Kennedy Jr CW, Leukens Jr CA. Reconstruction of the posterior cruciate ligament: preliminary report of a new procedure. Clin Orthop 1976;118:30.
[13] Ogata K. Posterior cruciate reconstruction using iliotibial band: preliminary report of a new procedure. Arch Orthop Trauma Surg 1980;51547.
[14] Minkoff J, Jaffe L, Menendez L. Limited posterolateral surgical approach to the knee for excision of osteoid osteoma. Clin Orthop Relat Res 1987;223:237–46.
[15] Zhao J, He Y, Wang J. Arthroscopic treatment of acute tibial avulsion fracture of the posterior cruciate ligament with suture fixation technique through Y-shaped bone tunnels. Arthroscopy 2006;22:172–81.