



Outcome of screw post fixation of neglected posterior cruciate ligament bony avulsions



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ARTICLE INFO

Keywords:

Neglected PCL
Bony avulsions
Spiked washer
Screw post
Functional outcome
Tegner–Lysholm score

ABSTRACT

Background: Contrary to acute posterior cruciate ligament (PCL) bony tibial avulsions, surgical management of chronic injuries is technically challenging and appears to be controversial. We sought to assess the outcome of a novel screw post augmentation technique in neglected cases.

Methods: 16 patients were followed up in a tertiary single-center retrospective study. The bony fragment was fixed using a lag screw with a spiked washer and an additional screw post through an open posterior approach. The pre- and postoperative knee range of movement (ROM), laxity, and modified Tegner–Lysholm (TL) scores were compared.

Results: The median time from injury to surgery was 10 weeks (range, 3–260). The mean clinical follow-up time was 24.25 ± 9.21 months. At the final follow-up, the mean knee ROM flexion was $130^\circ \pm 11.55^\circ$ with no extension lag. 3 patients had grade 1 laxity. The TL grade was predominantly excellent, and the overall median score improved from 76 preoperatively to 95 postoperatively ($p < 0.0004$). Bony union was achieved in all cases.

Conclusion: The described screw post fixation technique results in an excellent outcome for these rare injuries. **Level of evidence:** Level IV, case series.

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Introduction

Posterior cruciate ligament (PCL) injuries are rare with an overall reported incidence of 3–20% of all knee injuries [1,2]. They are seemingly more common in the developing world owing to the higher incidence of motor vehicle accidents [3–8]. Avulsion fractures account for a small number of PCL injuries [5,9,10]. These injuries are often missed in an acute setting and patients may present late with disabling symptoms such as anterior knee pain and instability [10–13]. The long-term sequelae of PCL injuries is undetermined, though increased incidence of knee articular cartilage degeneration, patellofemoral and medial compartment arthritis have been reported in cases left untreated [14,15].

In contrast to intra-substance tears and femoral detachment injuries, surgical management of bony avulsions has consistently shown good results [4,6–8,16,17]. Fixation methods described include use of K-wires, suture anchors, screws, bone staples, stellate and toothed plates [4,6,16,17]. However these

studies were done predominantly for acute injuries within 3 weeks.

Surgical fixation of chronic PCL avulsions is technically challenging as the ligament may be retracted and fibrosed [11]. An open approach allowing good exposure would be ideal to adequately dissect out the ligament, restore its length and mobilize it onto its footprint. Failure to achieve stable anatomical reduction of the avulsed fragment would result in a non-union with residual knee symptoms and laxity. Though some have reported poor results with delayed surgery [3,18], fixation following sustained intraoperative ligament traction [11], stab incisions [8,11] and augmented iliac crest bone grafting [10] have been reported with acceptable outcomes. However, the overall need for and efficacy of surgical fixation in chronic injuries is still controversial with limited available literature [4,8,10,11,19,20]. Therefore, our study aimed to evaluate the functional outcome of a novel screw post fixation technique in chronic PCL bony avulsions.

Materials and methods

Study design and setting

A retrospective cohort of all treated bony PCL tibial avulsions presenting beyond 3 weeks of injury (from January 2013 to

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December 2015) were analysed at a tertiary care center. Data was collected by two independent reviewers using a specially designed computerised table that included the patient demographics, injury characteristics and treatment outcomes. Audit of the other reviewer's data was carried out in turn to minimise errors in the data entry. Patients with concomitant ipsilateral ligament injuries or fractures around the knee joint were included as well. The predominant symptoms were anterior knee pain and instability. The diagnosis was confirmed in the outpatient department based on clinical examination with a positive posterior drawer, sag test and radiographic evidence of the avulsed fragment. The preoperative knee range of movement (ROM), laxity and modified Tegner-Lysholm (TL) scores were obtained from clinical records. All cases had a routine preoperative Magnetic resonance imaging (MRI) scan to confirm the diagnosis [21] and to rule out concomitant ligament injuries, meniscal involvement and occult intra-substance PCL tears. The indications for surgery were persistent anterior knee pain and instability.

Operative technique

We used an open posterior approach to the knee (Fig. 1). A single senior surgeon performed the surgery for all patients. Under spinal anesthesia, patients were positioned prone and a thigh tourniquet was applied. The distal long vertical limb of the incision was made overlying the medial head of the gastrocnemius as described by Burks and Schaffer [4,11]. The middle horizontal portion of the incision was fashioned across the knee flexion crease curved proximally upwards for about 1–2 cm. The lesser saphenous vein was identified. The deep fascia was incised in line with the skin incision. The medial sural cutaneous nerve located just lateral to the lesser saphenous vein was dissected out and protected. Both these structures overlay the dissection plane of interest (between the two heads of the gastrocnemius) (Fig. 1). Blunt dissection was carried out through this interval. The middle geniculate branch of the popliteal artery was also identified and ligated. The capsule was then located and vertically incised. The avulsed PCL fragment was visualized with the knee kept in flexion to relax tension on the hamstrings and gastrocnemius.

The fracture site and PCL footprint were well exposed. Owing to the delayed presentation in all the cases, the peripheral portion of the PCL was released up to the femoral attachment to facilitate easy mobilization of the contracted ligament. The fracture bed and the PCL footprint were debrided and freshened with a high-speed burr to facilitate stable bony contact and healing. A 0 vicryl suture was taken through the root of PCL, just above the tibial bony insertion

to anchor and pull down the ligament. The knee was flexed to 90° to facilitate relaxation of the ligament and the PCL fragment was fixed with a 3.5 mm partially or fully threaded cancellous lag screw (Depuy Synthes, USA) and a ceramic (Depuy Synthes /Johnson and Johnson, USA) or titanium spiked washer (BIOTEK, India) under fluoroscopic guidance. The stitch through the PCL was tied down with an additional cancellous screw post (3.5 mm Depuy Synthes, USA) 1.5–2 cm distal to the initial lag screw (Fig. 2). The screw with washer was inserted at 45° for good cortical purchase [11]. The capsule and deep fascia were repaired with size 0 vicryl followed by 2–0 vicryl for the subcutaneous tissue and 3-0 ethilon for the skin.

Follow-up

The knee was immobilized till suture removal for 2 weeks in 20 degrees flexion. ROM exercises were started using a continuous passive motion (CPM) machine initially to 30 degrees as recommended by Nicandri et al. [17] and progressed to full or maximum tolerated ROM with daily increments of 10 degrees over 10 days. The knee was protected with a dynamic hinged knee brace at discharge and physiotherapy was continued on outpatient basis. Suture removal was done on the 14th postoperative day. The average duration of hospital stay was 3 days. Patients were advised closed chain kinetic exercises for the first 4 weeks and subsequently open chain kinetic exercises. Patients were allowed to return to their previous level of activity after 6–8 months.

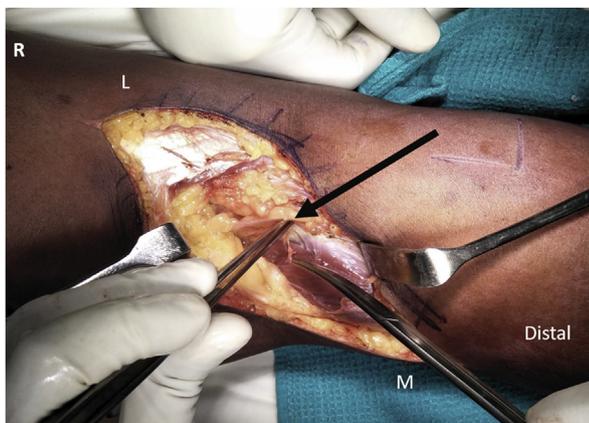


Fig. 1. Operative technique- R-Right, M-Medial, L-Lateral; Open posterior approach to the knee-Plane between the 2 heads of the gastrocnemius (arrow).

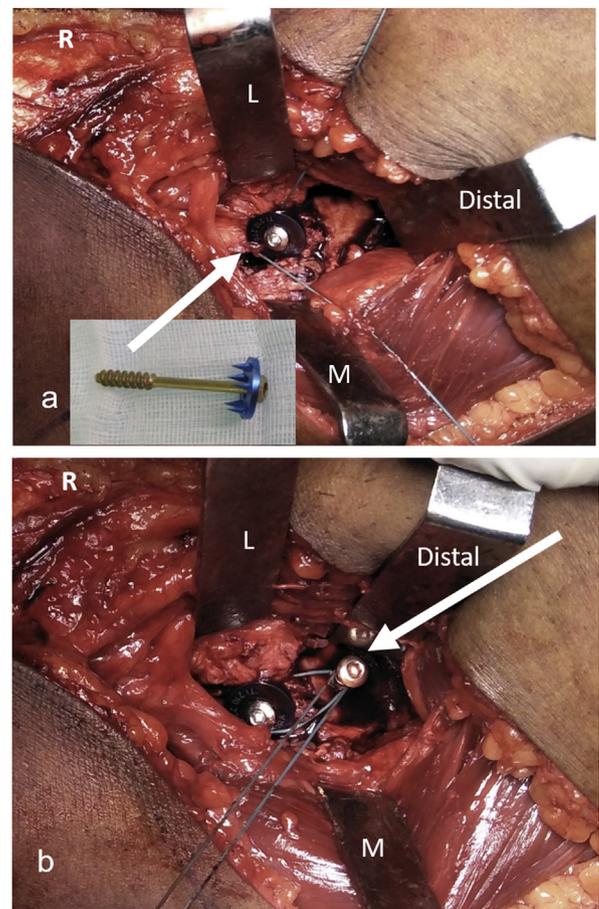


Fig. 2. Screw post fixation technique- R-Right, M-Medial, L-Lateral; **a** Cancellous screw fixation with a spiked washer (arrow). **b** Stitch through the PCL tied down with an additional screw post (arrow).

All patients were followed up as outpatients at 2 weeks, 6 weeks, 3 months, 6 months, 1 year, 2 years and thereafter as required. Only those that had a minimum clinical follow-up period of 1 year were included. They progressed from touch weight to full weight bearing over 3 months. Patients were contacted through telephone or email and asked to follow up for an additional visit. At recent follow up, each patient was subjectively assessed using the modified TL score questionnaire [22] which was compared to their preoperative score. Objective analysis was done by clinical assessment and radiological evaluation with standard knee anteroposterior and stress view lateral radiographs as described by Barros et al. [9]. PCL laxity was graded as, grade I (less than 5 mm laxity), grade II when laxity ranged between 6 to 10 mm and grade III when laxity was more than 10 mm as compared to the contralateral knee [9,23]. The knee ROM, laxity and TL scores at final follow up were documented by 2 independent observers one of whom included the senior surgeon who performed the surgery and the other, an assistant junior consultant to eliminate single observer bias.

Statistical analysis

Data was analyzed using Excel (Microsoft) and presented as mean and median with ranges. Wilcoxon signed-rank test was used for paired data to compare pre- and postoperative knee flexion ROM and TL scores. A p-value <0.05 was considered significant.

Results

16 patients were identified and their outcomes were followed up (Table 1). Majority were males, with a median age of 37 years (range, 19–51). The right side was predominantly involved (75%). The mode of injury was most often due to motorcycle accidents, except in 4 patients who had a fall from height. The median time from injury to surgery was 10 weeks (range, 3–260). The mean clinical follow up time was 24.25 ± 9.21 months.

The functional outcome at final follow up is shown in Table 2. All patients regained full knee ROM with no extensor lag. The mean knee flexion arc was 130 ± 11.55°. Only 3 patients had grade I laxity. The TL grade was excellent in 11 and good in 5 patients. The mean TL score was 94.38 ± 3.8 and improved from a median score of 76 preoperatively to 95 postoperatively ($p < 0.0004$). The median knee flexion arc also had significant improvement from 120° to 130° postoperatively ($p < 0.0054$) (Table 3) (Fig. 3). Bony

Table 1
Patient demographic characteristics, time to surgery, and follow-up time.

Case No.	Age	Sex	Side	Mechanism of injury	Time to surgery (weeks)	Follow-up time (months)
1	35	M	R	MVA	10	25
2	47	M	R	MVA	5	28
3	39	M	R	Fall	5	26
4	20	M	L	MVA	72	20
5	19	M	L	MVA	28	18
6	51	M	R	Fall	24	15
7	49	M	R	MVA	16	14
8	29	M	R	MVA	12	16
9	26	M	R	MVA	8	30
10	32	M	R	MVA	10	32
11	40	M	L	MVA	4	30
12	19	M	R	MVA	4	18
13	41	F	R	MVA	3	48
14	29	M	R	MVA	3	24
15	41	M	L	Fall	260	32
16	40	M	R	Fall	24	12

* M-male, F-female, R-right, L-Left, MVA-motor vehicle accident.

union was achieved in all. None had any significant knee stiffness, neurovascular compromise or wound related complications.

Discussion

This study presents the outcome of fixation of neglected PCL bony avulsions with a novel screw post augmentation technique. PCL avulsion injuries are rare in clinical practice [5,9,10] and the timing of surgical fixation appears to be a matter of debate. While fixation of acute injuries have had good results [3,6,8,16,17,19], Bali et al. [3] and Torisu [18] reported poor outcomes with fixation beyond 3 and 11 weeks respectively. Bali et al in addition reported 2 chronic cases that required secondary reconstruction of the whole ligament owing to persistent instability following fixation [3]. Jang et al reported 3 successful cases of delayed fixation, done however in children [24]. Literature recommends primary ligament reconstruction in those presenting beyond 3 months of injury [8,25]. In our series, all patients presenting more than 3 weeks after initial trauma were considered as chronic cases. 7 (43.8%) patients were exceedingly delayed presentations at or beyond 3 months (range 3–60) and all had good to excellent TL scores.

Screw post fixation technique and comparison with relevant literature

Fixation of chronic injuries is technically demanding. We used an open posterior approach to the knee for the adequate visualization and dissection of the contracted ligament as opposed to minimally invasive or arthroscopic surgery [26,27]. We found that the ligament had to be released from the adjacent anterior cruciate ligament (ACL) and soft tissues in extremely delayed cases. One of our patients presented to us as late as five years following the trauma and we were still able to mobilize the ligament. This patient went on to have a good outcome. Arthrofibrosis has been a reported complication with delayed fixation [4,28] and open surgical approaches [4]. Though some of our patients had knee stiffness at 3 and 6 months following surgery, none had an extension lag or demonstrated significant loss of terminal knee flexion at final follow up. (Table 2).

Care must be taken in preparing the bed to anchor the ligament. Singla et al who advocated iliac crest bone grafting in his series of 11 patients reported a non-union in one [10]. However, apart from being an additional procedure, bone grafting considerably adds to the morbidity. We used a high-speed rotatory burr to refine and freshen the PCL footprint. We also observed that the fracture bed was sclerotic and difficult to identify in some cases. Intraoperative fluoroscopy was used to locate the footprint in these cases. The burr-drilled roughened bed exposes the underlying healthy bleeding cancellous bone and enhances stable surface contact of the avulsed fragment augmenting healing. 100% bony union was achieved in all our patients and none required bone grafting. Dhillon et al recommends sustained traction with multiple stab incisions to facilitate mobilization of the ligament [11]. Chen et al described fixation of the avulsed fragment using a toothed plate to embed the bone and increase the surface area of fixation [6]. In our series, an open approach with meticulous dissection and intra-articular release of the ligament facilitated mobilization while maintaining the knee in 90° flexion. We used a single suture around the PCL for traction reduction. As the cancellous screw is gradually advanced, the spiked washer around it shields the avulsed fragment and firmly lodges into the bone. The stitch through the PCL is used to maintain the desired ligament tension throughout the fixation and is finally tied down with an oblique secondary screw post. This is advantageous in cases where the avulsion fragment is small (<10 mm) or comminuted and serves to reinforce the fixation stability preventing screw pull-out.

Table 2

Associated Injuries, pre and post-op (operative) knee ROM, post-op laxity, and pre and post-op TL scores at final follow-up.

Case No.	Ipsilateral associated injuries	Pre-op knee ROM	Post-op knee ROM	Post-op knee laxity	Pre-op TL score	Post-op TL score	Final post-op TL grade
1	Medial meniscus	0°–120°	0°–120°	None	66	94	Excellent
2	None	10°–100°	0°–140°	None	84	100	Excellent
3	LCL	0°–120°	0°–120°	None	84	96	Excellent
4	Acetabulum #	0°–140°	0°–140°	Grade 1	78	90	Good
5	None	0°–140°	0°–140°	Grade 1	74	91	Excellent
6	LCL	0°–120°	0°–140°	None	60	95	Excellent
7	ACL	0°–120°	0°–130°	None	89	90	Good
8	None	0°–140°	0°–140°	None	84	95	Excellent
9	Ankle syndesmosis	0°–130°	0°–130°	None	78	90	Good
10	None	5°–90°	0°–120°	None	69	100	Excellent
11	Patella #	20°–90°	0°–120°	None	64	96	Excellent
12	Floating knee	10°–110°	0°–140°	None	72	99	Excellent
13	None	0°–70°	0°–130°	None	84	95	Excellent
14	None	0°–90°	0°–100°	None	89	99	Excellent
15	None	0°–130°	0°–130°	Grade 1	59	90	Good
16	None	0°–140°	0°–140°	None	64	90	Good

* #-Fracture, LCL-lateral collateral ligament, ACL-anterior cruciate ligament.

Table 3

Comparison of pre- and post-op knee ROM and TL scores using Wilcoxon signed-rank test.

	Pre-op Median (IQR)	Post-op Median (IQR)	Improvement significance (p value)
TL score	76 (65, 84)	95 (90, 97.5)	<0.0004
Knee Flexion ROM* (degrees)	120 (95, 135)	130 (120, 140)	<0.0054

* IQR-interquartile range.

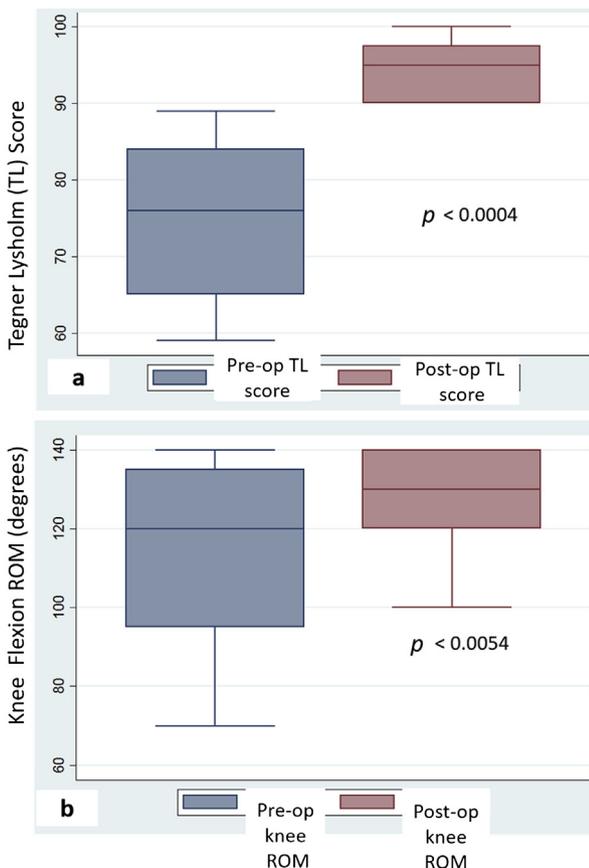


Fig. 3. Pre and post-operative comparison of **a** TL scores and **b** Knee ROM using Wilcoxon signed-rank test.

Concomitant injuries

8 patients (50%) had ipsilateral concomitant injuries (Table 2). Of these 1 had a stable medial meniscus injury which was left alone. 2 had a lateral collateral ligament (LCL) and 1, an ACL injury. The LCL was repaired at the time of the PCL fixation for both these patients and the patient who had an ACL injury was operated on 4 months later. 2 others had an acetabulum fracture and ankle syndesmosis injury primarily fixed elsewhere and presented to us at 72 and 8 weeks respectively. Of the remaining 2 patients, 1 had a patella fracture and the other a floating knee (femur and tibia shaft fracture) (Fig. 4). Both of these were acute presentations, the PCL injury was missed in the emergency department and diagnosed on subsequent clinical examination. Fixation in both these cases was carried out after a month. PCL injuries can be overlooked as examination of an acutely injured knee is difficult and the avulsion fragment, if small may not be picked up on plain radiographs [7,11,13,29]. Kim et al reported a 60% incidence of missed PCL injuries with periarticular fractures around the knee [29]. An MRI is hence recommended for routine knee screening [3,11]. As shown in Fig. 4a–c, the avulsion fragment was inconspicuous and thereupon missed with due focus on the long bone fractures. This highlights the importance of diligent assessment of traumatic knee injuries.

Limitations

Our study is limited by its retrospective nature and small sample size. However, these injuries are rare. Our clinical follow up was of short term with a mean of 24.25 ± 9.21 months. The uncertainty surrounding the outcomes of chronic injuries warrants long term follow up studies. PCL avulsions rarely present in isolation, therefore we included concomitant injuries as well in the

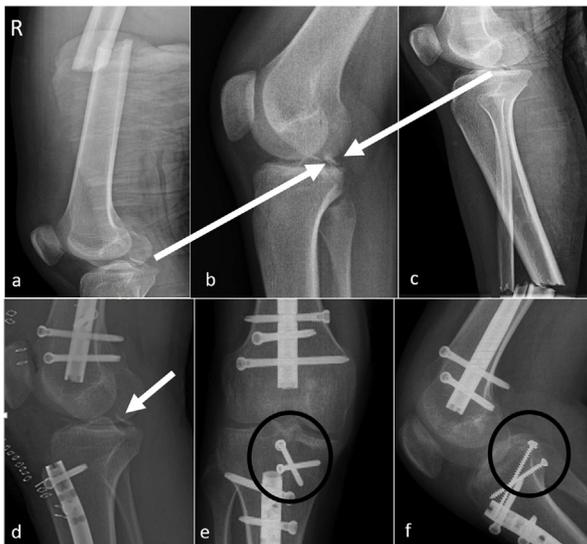


Fig. 4. Case No. 12, R-Right, Knee Radiographs of a 19 year old boy who sustained a dashboard injury with a floating knee; the long bone fractures were acutely fixed and PCL injury was diagnosed and fixed after a month. Note the inconspicuous avulsion fragment (arrows). **a–c** Preoperative radiographs of the floating knee. **d** Radiograph at 10 days following tibia and femur nailing. **e, f** Knee Antero-posterior and Lateral view Radiographs at 3 months post PCL fixation showing a healed bony fragment (encircled).

analysis. 3 patients had an additional ipsilateral ligament injury (2 LCL and 1 ACL) that required repair (Table 2). However the presence of concomitant injuries did not hinder our results and all patients had either a good or excellent outcome (Table 2). The KT arthrometer was not used to evaluate knee laxity due to non-availability. 3 of our patients had grade 1 laxity and none of them were found to have occult PCL tears on the preoperative MRI. They had an overall good outcome. Finally, we used only the modified TL scoring system which is a documented validated measure for assessment of knee ligament injuries [30]. Use of the International Knee Documentation Committee's (IKDC) and musculoskeletal function assessment (MFA) scores as well could be considered to improve validity in future studies.

Study implications and future prospects

The importance of this study is that it adds to the literature and provides evidence for surgical management of neglected PCL avulsions. Our fixation technique can be followed as it is successful in all our cases. The majority of our patients were referrals and were disabled and symptomatic as evident by their preoperative TL scores leaving a narrow margin to decide against surgery. Although literature recommends surgery only in symptomatic patients [18], the risk of long term arthritis and articular cartilage degeneration in asymptomatic patients or those with non-disabling symptoms managed conservatively is still questionable. However, a clinically stable knee with improved function is likely to arrest the progression to early arthritis in these intra-articular avulsion fractures.

Conclusion

The described novel screw post fixation technique for neglected PCL bony avulsions restores the knee biomechanics with a predominantly excellent outcome. It is replicable and results in bony union obviating the need for bone grafting or reconstruction of the whole ligament.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

The study was approved by the ethical board of our institution.

Informed consent

An informed consent was obtained from each participant included in the study.

Acknowledgements

The authors would like to acknowledge AO trauma Asia Pacific. The following paper was presented at the AO Trauma Asia Pacific 7th Annual Conference at India.

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