Paraskiing Crash and Knee Dislocation With Multiligament Reconstruction and Iliotibial Band Repair

Chase S. Dean, MD, Olivia Fernandes, MS, ATC, Mark E. Cinque, MS, BS, Jorge Chahla, MD, and Robert F. LaPrade, MD, PhD

Abstract

We describe the diagnosis, treatment, rehabilitation, and complications of a 27-year-old male paraskiier who sustained a closed high-velocity knee dislocation after colliding with a tree at a speed of 45 mph and falling 40 feet to the ground. Extensive surgery to repair and reconstruct the knee included open lateral capsular repair, open anatomical posterolateral corner reconstruction with split Achilles tendon allograft, open iliotibial band reconstruction with Achilles tendon allograft, arthroscopic anterior cruciate ligament reconstruction with bone–patellar tendon–bone autograft, and double-bundle posterior cruciate ligament reconstruction with Achilles tendon allograft for the anterolateral bundle and tibialis anterior tendon allograft for the posteromedial bundle. Follow-up surgery was performed to treat arthrofibrosis. Postoperative stress radiographs and subjective outcomes demonstrated that stability was excellent overall.

Tibiofemoral knee dislocations are uncommon injuries that have devastating complications and potentially result in complex surgeries.[1] Knee dislocations (KDs) can be classified with the Schenck system.[2] KD-I is a multiligament injury involving the anterior cruciate ligament (ACL) or the posterior cruciate ligament (PCL), and the scale increases in severity/number of ligaments involved, with KD-V being a multiligament injury with periarticular fracture.[2]

In this article, we report the case of a complex multiligament knee reconstruction performed with a midsubstance iliotibial band (ITB) repair. The patient provided written informed consent for print and electronic publication of this case report.

Case Report

A 27-year-old man presented 12 days after a paraskiing crash in which he collided with a tree at 45 mph and fell 40 feet before hitting snow. Physical examination revealed a large hemarthrosis of the left lower extremity and ecchymosis about the posterolateral aspect of the knee and popliteal fossa. Range of motion (ROM) was limited from 5° of hyperextension to 90° of flexion. Additional motion was deferred secondary to pain. Varus stress testing at 0° and 30° of knee flexion demonstrated significant side-to-side differences. The Lachman test, posterior drawer test, and posterolateral drawer test were all 3+. The dial test was 3 to 4+ compared with the contralateral knee. Valgus stress testing at 0° and 30° of flexion did not reveal any side-to-side laxity. The calf was nontender, and all compartments

Take-Home Points

- Reconstruction of a torn ITB is important in restoration of native anatomy and function given its properties in anterolateral stabilization and resistance to varus stress and internal tibial rotation.

- Restoration of posterolateral instability primarily involves reconstructing the FCL, PLT, and popliteofibular ligament.

- For combined PLC injuries, concurrent reconstruction of the cruciate ligaments in one stage is highly recommended.

- Post-surgery, a 6-week non-weight-bearing, limited flexion rehab protocol utilizing a dynamic PCL brace, such as the PCL Rebound brace, is recommended to prevent posterior tibial sag.

- Arthrofibrosis and decreased ROM can be seen following a violent knee injury which requires extensive multiligament reconstruction surgeries, occasionally requiring a secondary surgery for further restoration of knee motion.

were soft. The patient reported no neurovascular symptoms and had no neuromotor deficits other than mild common peroneal nerve dysesthesias.

Varus stress radiographs showed increased side-to-side gapping (8 mm) of the lateral compartment of the injured knee. Kneeling posterior stress radiographs, limited because of the patient's inability to apply full stress on the injured knee secondary
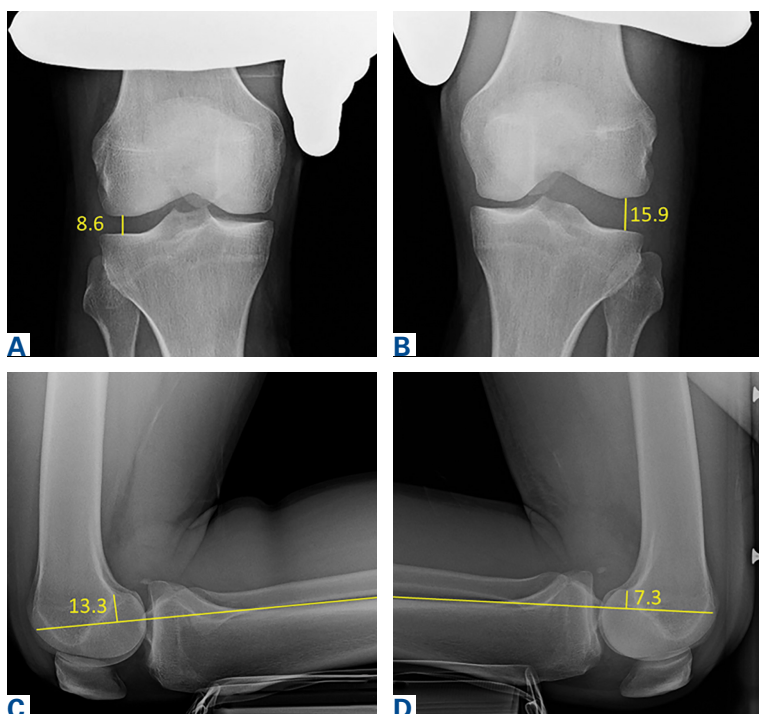

Figure 1. (A, B) Preoperative bilateral varus stress radiographs show increased gapping of lateral compartment of injured (left) knee (B) with side-to-side difference of ~8 mm. **(C, D)** Preoperative bilateral kneeling posterior stress radiographs show increased posterior tibial translation (C) of ~6 mm relative to tibia.
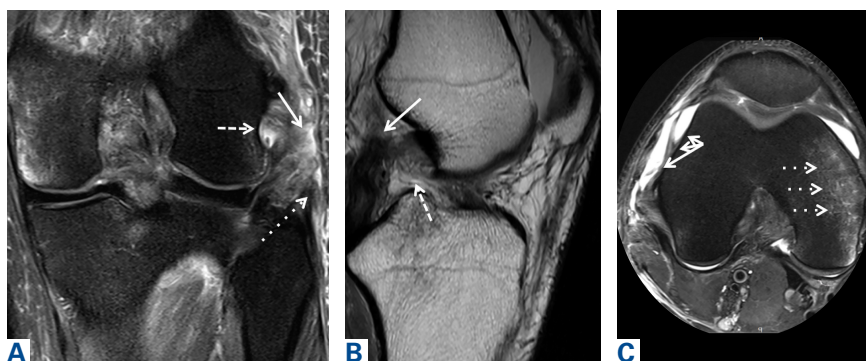

Figure 2. Magnetic resonance imaging of injured (left) knee. **(A)** Coronal image with the solid arrow pointing to the torn iliotibial band, the narrow dashed arrow pointing to the torn fibular collateral ligament, and the wide dashed arrow pointing to the torn popliteal tendon. **(B)** Sagittal image with the solid arrow pointing to the torn posterior cruciate ligament and the dashed arrow pointing to the torn anterior cruciate ligament. **(C)** Axial image with the solid arrow pointing to the torn iliotibial band and the dashed arrows pointing to bone bruising.

Abbreviations: ACL, anterior cruciate ligament; ITB, iliotibial band; PCL, posterior cruciate ligament.

to pain, showed a difference of 6 mm in increased posterior translation on the uninjured leg (**Figures 1A-1D**). Magnetic resonance imaging (MRI) showed tearing of all posterolateral corner (PLC) structures; specifically, the fibular collateral ligament (FCL) and the popliteus tendon (PLT) were completely torn, and the biceps femoris was partially torn (**Figures 2A-2C**). Also identified were a complete, retracted midsubstance tear of the ITB and a complete lateral capsule tear off of the femur. The ACL and the PCL were torn completely, but the menisci and common peroneal nerve were intact. Given the patient's extensive pathologies and activity level, surgery was deemed the best treatment option. Findings of an examination with anesthesia were consistent with the clinical examination findings, and the decision was made to proceed with the surgery.

First Surgery

1. PLC Approach. A lateral hockey-stick skin incision was made along the ITB and extended distally between the fibular head and the Gerdy tubercle. The subcutaneous tissue was then dissected, and a posteriorly based flap was developed for preservation of vascular support to the superficial tissues. The ITB and the lateral capsule had completely torn off of the femur, allowing exposure directly into the joint. The long and short heads of the biceps femoris were exposed, with about 50% of the biceps attachment torn. The FCL was torn midsubstance, and the PLT had no remnant attachment left on the femur.

2. ITB and Lateral Capsule Tag Stitched. The torn ends of the ITB were dissected and tag stitches placed in each end. Tag stitches were also placed in the lateral capsule in preparation for a direct repair.

3. Neurolysis. The common peroneal nerve was found encased in a significant amount of scar tissue, and extensive neurolysis was required. Slow, methodical dissection was performed under the partially torn long head of the biceps femoris and was continued through the scar tissue and adhesions. Distally, 5 mm to 7 mm of the peroneus longus fascia was incised as part of the neurolysis in order to prevent nerve irritation or foot drop caused by postoperative swelling.

4. PLC Tunnels. The margin between the lateral gastrocnemius tendon and the soleus muscle was identified by

blunt dissection that allowed palpation of the posteromedial aspect of the fibular styloid and the popliteus musculotendinous junction. The underlying biceps bursa was incised in order to locate the midportion of the FCL remnant, which typically is tag-stitched with No. 2 FiberWire to help identify the femoral attachment (this was not done because of the complete tear at the midsubstance of the FCL).

Subperiosteal dissection of the lateral aspect of the fibular head was performed anterior to posterior and distally extended to the champagne-glass drop-off of the fibular head. Continuing the dissection distally beyond this point can endanger the common peroneal nerve. A small sulcus can be palpated where the distal FCL inserts on the fibular head. Posteriorly, a small elevator was used to dissect the soleus muscle off of the posteromedial aspect of the fibular head, where the fibular tunnel would later be created.

A Chandler retractor was placed posterior to the fibular head to protect the neurovascular bundle. With the aid of a collateral ligament aiming device, a guide pin was drilled from the lateral aspect of the fibular head (FCL attachment) to the posteromedial downslope of the fibular styloid (popliteofibular ligament attachment). The entry point of the guide pin was immediately above the champagne-glass drop-off, at the distal insertion site of the FCL, which was described as being 28.4 mm from the styloid tip and 8.2 mm posterior to the anterior margin of the fibular head.[3] Care should be taken not to ream the tunnel too proximal, as doing so increases the risk of iatrogenic fracture. A 7-mm reamer was then used to drill the fibular tunnel. To facilitate later passage of the graft, a passing suture was placed through the tunnel, leaving the loop anterolateral.

Next, the starting point for the tibial tunnel was located on the flat spot of the anterolateral tibia distal and medial to the Gerdy tubercle, just lateral to the tibial tubercle. The tibial popliteal sulcus was identified by palpation of the posterolateral tibial plateau to localize the site of the popliteus musculotendinous junction, which is the ideal location of the posterior aperture of the tibial tunnel. This point is 1 cm proximal and 1 cm medial to the posteromedial exit of the fibular tunnel. A Chandler retractor was placed anterior to the lateral gastrocnemius to protect the neurovascular bundle. In the locations described earlier, a cruciate aiming device was used to place a guide pin anterior to posterior. A 9-mm tunnel was overreamed and a passing suture placed,

leaving the loop posterior to facilitate graft passage.

The femoral insertions of the FCL and the PLT were then identified. ITB splitting was not necessary, given the complete midsubstance tear of this structure. The FCL attachment was identified 1.4 mm proximal and 3.1 mm posterior to the lateral epicondyle.[3] Sharp dissection was performed in this location, proximal to distal, exposing the lateral epicondyle and the small sulcus at the FCL attachment site. A collateral ligament reconstruction aiming sleeve was used to drill a guide pin over the FCL femoral attachment site and out the medial aspect of the distal thigh, about 5 cm proximal and anterior to the adductor tubercle.

The femoral attachment of the PLT was reported located 18.5 mm anterior to the FCL insertion, in the anterior fifth of the popliteal sulcus.[3] Although arthrotomy is usually required in order to access the PLT attachment, it was not necessary in this case, given the lateral capsule tear. A guide pin was inserted at the PLT attachment site, parallel to the FCL pin. After proper placement was verified, a 9-mm reamer was used to drill the FCL and PLT tunnels to a depth of 25 mm (socket), and a passing suture was placed into each tunnel to facilitate graft passage.

5. ACL Graft Harvest. The central third of the ipsilateral patellar tendon was harvested for use in the ACL reconstruction. Included were a 10-mm × 20-mm bone plug from the patella and a 10-mm × 25-mm bone plug from the tibial tubercle. The patella defect was then bone-grafted, and the patellar tendon closed side-to-side.

6. Graft Preparation. For the PLC, we used a split Achilles tendon allograft that had two 9-mm × 25-mm bone plugs proximally and were tubularized distally. For the PCL, we used an anterolateral bundle (ALB), which consisted of an Achilles tendon allograft that had an 11-mm × 25-mm bone plug proximally and was tubularized distally, and a posteromedial bundle (PMB), which consisted of a tibialis anterior allograft that was tubularized at both ends. For the ACL, we used a bone–patellar tendon–bone autograft 10 mm in diameter with a 20-mm femoral bone plug and a 25-mm tibial bone plug distally.

7. Arthroscopy. We created standard anterolateral and anteromedial parapatellar portals and performed arthroscopy, including lysis of adhesions. Cartilage and menisci were lesion-free.

8. PCL Femoral Tunnels. The ALB attachment was identified and outlined with a coagulator between the trochlear point and the medial arch point, adja-

cent to the edge of the articular cartilage. Similarly, the PMB attachment was marked about 8 mm or 9 mm posterior to the edge of the articular cartilage of the medial femoral condyle and slightly posterior to the ALB tunnel.[4]

In the anterolateral tunnel, an acorn reamer 11 mm in diameter was used to score the entry point of the ALB femoral tunnel. An eyelet pin was then drilled through the reamer anteromedially out the knee. Then a closed socket tunnel was reamed over the eyelet pin to a depth of 25 mm. A passing suture was pulled through the tunnel in preparation for graft passage.

With use of the same technique, a 7-mm reamer was placed against the outline of the PMB attachment site, and an eyelet pin was drilled through this reamer and out the anteromedial aspect of the knee. Again, a 25-mm deep closed socket was reamed. A bone bridge distance of 2 mm was maintained between the 2 femoral PCL bundle tunnels.

9. ACL Femoral Tunnel. The femoral ACL attachment was identified and outlined. An over-the-top guide was used to determine proper placement of the 10-mm low-profile reamer. A guide pin was drilled through the center of the reamer. The reamer was used to create a 25-mm deep closed socket tunnel, and a passing stitch was placed.

10. PCL Tibial Tunnel. With use of a 70° arthroscope for visualization, a posteromedial arthroscopic portal was created, and a shaver and a coagulator were used to identify the tibial PCL attachment, located distally along the PCL facet, until the proximal aspect of the popliteus muscle fibers were visualized. A guide pin was drilled starting at the anteromedial aspect of the tibia, about 6 cm distal to the joint line and centered between the anterior tibial crest and the medial tibial border. The pin exited posteriorly at the center of the PCL tibial attachment along the PCL bundle ridge, which was reported located between the ALB and the PMB on the tibia.[5] Pin placement was verified with intraoperative lateral and anteroposterior radiographs. On the lateral radiograph, the pin should be about 6 mm or 7 mm proximal to the champagne-glass drop-off at the PCL facet on the posterior aspect of the tibia. On the anteroposterior radiograph, the pin should be 1 mm to 2 mm distal to the joint line and at the medial aspect of the lateral tibial eminence. A large curette was passed through the posteromedial arthroscopic portal both to retract the posterior tissues away from the reamer and to protect against guide-pin protrusion The guide pin was then overreamed with a 12-mm acorn reamer.

A large smoother was passed proximally up the tibial tunnel and then pulled out the anteromedial portal with a grasper. The smoother was gently cycled to smooth the intra-articular tibial tunnel aperture to remove any bony spicules that could interfere with graft passage. The smoother was then pulled back into the joint, passed out the anterolateral arthroscopic portal, and secured with a small clamp.[4]

11. ACL Tibial Tunnel. The ACL tibial attachment site was identified and cleaned of soft tissue. A guide pin was placed and then overreamed with a 10-mm acorn reamer.

12. PCL Femoral Fixation. The PMB graft was passed into its tunnel and secured with a 7-mm × 23-mm titanium screw. Next, the ALB was secured to the femur with a 7-mm × 20-mm titanium screw. The smoother was used to pull both grafts down through the tibial tunnel.

13. ACL Femoral Fixation. A 7-mm × 20-mm titanium screw was then used to fix the ACL autograft inside the femur. Traction was applied to the 3 cruciate grafts. There was no sign of impingement.

14. PLC Femoral Fixation. The FCL and the popliteus bone plugs were passed into their respective femoral sockets and secured with 7-mm × 20-mm titanium screws.

15. Lateral Capsule Femoral Anchors. Two suture anchors were placed into the femur, and the sutures were passed through the femoral portion of the lateral capsule for later repair.

16. PCL Tibial Fixation. Both grafts were fixed with a fully threaded bicortical 6.5-mm × 40-mm cannulated cancellous screw and an 18-mm spiked washer. The ALB was fixed first, with the knee flexed to 90°, traction on the graft, and the tibia in neutral rotation. Restoration of the normal tibiofemoral step-off was verified. The PMB was then fixed with the knee in full extension. A posterior drawer test was performed to verify restoration of stability.

17. PLC Fibula Fixation. The PLT graft was passed down the popliteal hiatus, and the FCL graft was passed under the remnant of the biceps bursa on the fibular head and then through the fibular head, anterolateral to posteromedial. The FCL graft was fixed in the fibular tunnel with the knee in 20° of flexion, a slight valgus reduction force, the tibia in neutral rotation, and traction on the graft. A 7-mm × 23-mm bioabsorbable screw was used.

18. Lateral Capsular Repair. The lateral capsule was directly repaired with the previously placed sutures. The sutures were tied with the knee in 20° of flexion.

19. PLC Tibial Fixation. The grafts were passed together, posterior to anterior, through the tibial tunnel. The knee was cycled several times through complete flexion/extension ROM. A 9-mm × 23-mm bioabsorbable screw was then used to fix the grafts to the tibia. During this fixation, the knee was kept in 60° of flexion and neutral rotation while traction was being applied to the distal end of both grafts.

20. ACL Tibial Fixation. A 9-mm × 20-mm titanium screw was used to fix the ACL graft with the knee in full extension. The graft was then viewed intra-articularly to confirm there was no impingement. The Lachman, posterior drawer, posterolateral drawer, dial, and varus stress tests were performed to ensure restoration of stability.

21. ITB Repair. A portion of the remaining Achilles tendon allograft was used to perform ITB reconstruction (reconstitution of the gaped portion of the ITB). Orthocord (DePuy Synthes) and Vicryl (Ethicon) sutures were used for this reconstruction. Knee stability was deemed restored, and the incisions were closed in standard layered fashion.

First Surgery: Postoperative Management

The patient remained non-weight-bearing the first 6 weeks after surgery, with prone knee flexion limited (0°-90°) the first 2 weeks. In addition, a PCL Jack brace (Albrecht) was placed 1 week after surgery and was to be worn at all times to decrease stress on the PCL grafts.

As ROM was not progressing as expected, the patient was instructed to use a continuous passive motion (CPM) machine 2 hours 3 times a day. About 4 weeks after surgery, with ROM still not progressing, the frequency of use of this machine was increased.

Despite continued physical therapy, use of the CPM machine, and pain management, ROM was limited (11°-90° of flexion) 5.5 months after left knee multiligament reconstruction. However, stress radiographs showed excellent stability. Varus stress radiographs showed a side-to-side difference of 0.3 mm less on the left (injured) knee, and kneeling PCL stress radiographs showed a side-to-side difference of 1.3 mm more on the left knee (**Figures 3A-3D**). In addition, radiographs showed good knee position with no evidence of subluxation, hardware migration, or heterotopic ossification. There was no effusion, but the thigh showed signs of regaining muscle mass. Given his postoperative arthrofibrosis and decreased ROM, the patient underwent another surgery.
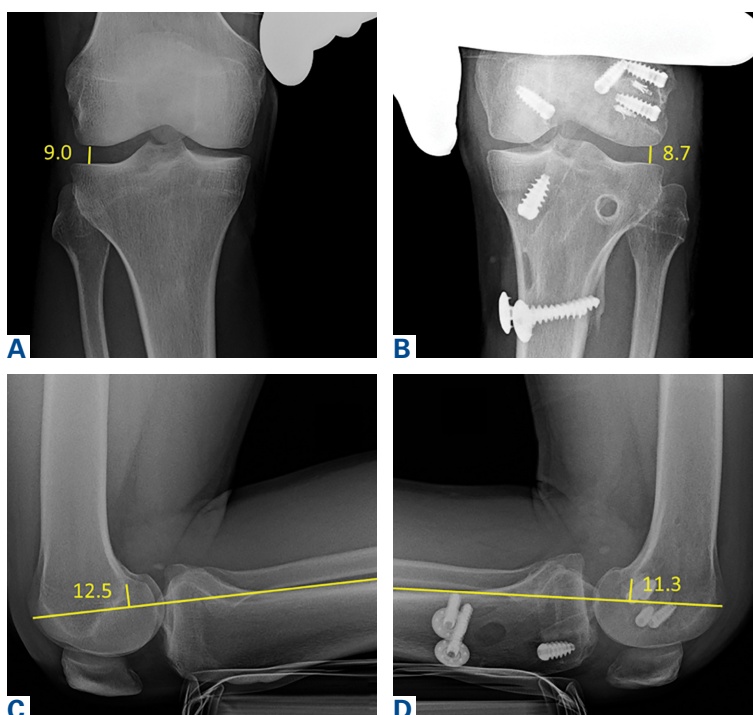

Figure 3. (A, B) Postoperative bilateral varus stress radiographs show decreased lateral compartment gapping of involved knee (B) compared with increase of ~8 mm side-to-side before surgery. **(C, D)** Postoperative bilateral kneeling posterior cruciate ligament stress radiographs show slight increased tibial translation of 1.3 mm side-to-side.

Second Surgery and Postoperative Management

As gentle manipulation under anesthesia was unsuccessful, the patient underwent knee arthroscopy, including 4-compartment lysis of adhesions, arthroscopically assisted posteromedial capsular release, and post-débridement manipulation under anesthesia. During manipulation, full extension and knee flexion up to 135° were achieved. ACL, PCL, and popliteus grafts were visualized and confirmed to be intact.

After this second surgery, the patient was to resume physical therapy and begin weight-bearing as tolerated. Active ROM was prioritized in an attempt to reach full ROM. In addition, a CPM machine was to be used from 0° to 135° of knee flexion 4 hours 3 times a day for 6 weeks.

Two weeks after surgery, the patient had continued pain, and extracapsular swelling in the left knee. However, ROM (0°-115° of flexion) was improved relative to before surgery (11°-90° of flexion), though it remained below the range on the contralateral side. Of note, the patient reported having a flexion contracture (~10°) in the immediate postoperative period. He had woken up with it after sleeping with the CPM machine the night before. The contracture delayed his physical ther-

apy for several hours and resulted in a redesign of his therapy protocol to emphasize full, active knee extension and patellar mobilization, as well as discontinuation of use of the CPM machine. Corticosteroids were initiated to help with the extracapsular swelling, and the new therapy regimen brought adequate progress in ROM. Four months after the second surgery, the patient had full extension and 135° of flexion and was transitioned into wearing the PCL Rebound brace.

Discussion

This case was unique because of the midsubstance ITB tear and simultaneous multiligament injury caused by a KD-IIIL, a KD involving the ACL, the PCL, and the PLC with the medial side intact. There is limited research on ITB repair generally, with or without KD involvement. In a retrospective review of acute knee trauma cases, ITB pathologies were seen on 45% of reviewed MRI scans, and only 3% of the injuries were grade III; in addition, only 9 (5%) of the 200 cases involved both ITB and multiligament (ACL, PCL) knee injuries.[6]

After our patient's ACL, PCL, and PLC were reconstructed, a fan piece of the Achilles tendon allograft from the PLC reconstruction was used to repair the ITB. The graft was used to reconstitute the torn gapped portion of the band in multiple locations, and this repair helped restore stability. The literature has reported numerous surgical uses for a portion of the ITB but few studies on repairing this anatomical structure. Preservation of the ITB is important to restoration of native anatomy and function. The ITB helps with anterolateral stabilization of the knee and with resistance of varus stress and internal tibial rotation.

The PLC reconstruction used in this case has been biomechanically validated as restoring the knee to near native stability through anatomical reconstruction of the PLC's 3 main static stabilizers: the FCL, the PLT, and the popliteofibular ligament.[7-9] First described in 2004,[7] this anatomical PLC reconstruction technique has improved subjective and objective patient outcomes.[10,11] For combined PLC injuries (eg, our patient's injuries), Geeslin and LaPrade[10] recommended concurrent reconstruction of the cruciate ligaments. In addition to the PLC reconstruction, the anatomical double-bundle PCL reconstruction used in this case has demonstrated significant improvements in subjective and objective outcome scores and objective knee stability.[12]

Although the stability and anatomy of this patient's injured knee were reestablished, his development of arthrofibrosis is important. Many have discussed the commonality of arthrofibrosis or decreased ROM after extensive multiligament reconstruction surgeries.[13,14] One study involving surgical management and outcomes of multiligament knee injuries found that, in more than half of its cases, restoration of full ROM required at least one operation after the initial one.[13] Therefore, it is not unusual that our patient required a second operation for decreased ROM.

Conclusion

After surgery, excellent stabilization was achieved. Although the patient had setbacks related to pain and decreased ROM, his second surgery and continued physical therapy likely will help him return to his preoperative recreational activity levels.

Dr. Dean, Mr. Cinque, and Dr. Chahla are Clinical Research Assistants, Steadman Philippon Research Institute, Vail, Colorado. Ms. Fernandes is an Athletic Trainer, Steadman Clinic, Vail, Colorado. Dr. LaPrade is an Orthopaedic Complex Knee and Sports Medicine Surgeon, Chief Medical Officer, and Co-Director of Sports Medicine Fellowship Program, Steadman Philippon Research Institute, Steadman Clinic, Vail, Colorado.

Address correspondence to: Robert F. LaPrade MD, PhD, Steadman Philippon Research Institute, Steadman Clinic, 181 W Meadow Dr, Suite 400, Vail, CO 81657 (email, drlaprade@sprivail.org).

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