# Distal Femoral Fracture After Double-Bundle Anterior Cruciate Ligament Reconstruction Surgery

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Anterior cruciate ligament (ACL) reconstruction surgery is one of the most commonly performed orthopaedic procedures.[3] Common complications of ACL surgery include arthrofibrosis, graft stretching, and graft failure.[9] Bony fractures of the femur are rare complications of this surgery. It has been hypothesized that the multiple femoral tunnels used in the reconstruction may act as stress risers that lead to fractures in the future.

A search of the literature yielded 16 case reports of femoral fracture after ACL reconstruction. Of these, most were either femoral condylar or supracondylar fractures, and only 2 reports involved femoral shaft fractures. No studies so far have reported the incidence of femoral fractures after double-bundle ACL reconstruction surgery. We report the first case of a peri-ACL fracture after double-bundle ACL reconstruction.

## CASE REPORT

A 35-year-old man with a 1-month history of left knee pain after a twisting injury to the knee from an awkward fall while playing soccer was examined. He had heard a "pop" at the time of injury, and his knee swelled up almost immediately. He was able to ambulate but experienced significant pain and instability on walking, especially on pivoting activities. He is an aircraft mechanic and enjoys sports such as cycling and playing soccer in his free time. He was previously healthy and has no significant medical or surgical history. He exercises regularly and does not smoke or drink alcohol.

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The patient was 175 cm tall and weighed 86 kg at the time of examination. On examination, no swelling or deformity was seen in the left knee; there was also no obvious malalignment of bilateral lower limbs. The anterior drawer test, Lachman test, and pivot-shift tests were all positive. No posterior sag or laxity was seen on varus or valgus stress, and there was no tenderness of the joint line. The range of motion was 0° to 110°

Radiographs were obtained, which showed only mild osteoarthritis (Figure 1). The diagnosis made at the time was a torn ACL. A magnetic resonance imaging (MRI) scan was subsequently performed in another institution, which confirmed that the patient had a ruptured ACL and a tear of the lateral meniscus.

The patient subsequently underwent an arthroscopic double-bundle ACL reconstruction with use of hamstring autografts. The femoral tunnels were drilled via a transportal technique. The remnant ACL footprint was identified, and the individual footprints were marked out by use of radiofrequency ablation. The posterolateral (PL) bundle footprint was marked at the femoral-tibial contact point, and the anteromedial (AM) bundle footprint was marked 20° cephalad to that. The semitendinosus and gracilis tendons were used to reconstruct the AM and PL bundles, respectively. For the AM bundle, tunnels of 9.5 and 8.5 mm were drilled in the tibia and femur, respectively; for the PL bundle, tunnels of 7.5 and 7.0 mm were drilled in the tibia and femur, respectively. Endobutton fixation (Endobutton CL 15-mm loop for the PL, 40-mm loop for the AM bundle; Smith & Nephew) was used for fixation of the graft on the femoral side. Both grafts were secured around a tibial anchor (Acufex Spiked Washer/Tibial Anchor; Smith & Nephew), with the PL bundle tensioned in extension and the AM bundle tensioned in 30° of flexion. On arthroscopic survey of the joint, a lateral meniscus tear was also discovered, which was debrided.

The patient was discharged with a knee brace (T Scope Post-Op Knee Brace; Breg) and crutches and was given weekly physiotherapy appointments for rehabilitation. At the last follow-up 3 months after ACL reconstruction, his range of motion was 0° to 100°; the strength of knee flexion

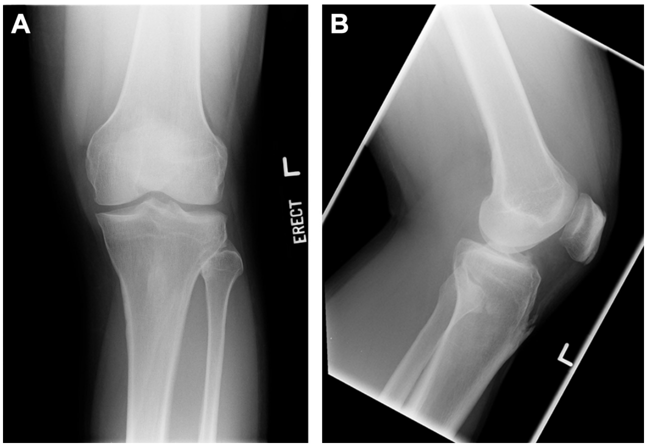


**Figure 1.** (A) Anteroposterior and (B) lateral radiographs of the left knee at the time of the anterior cruciate ligament injury.

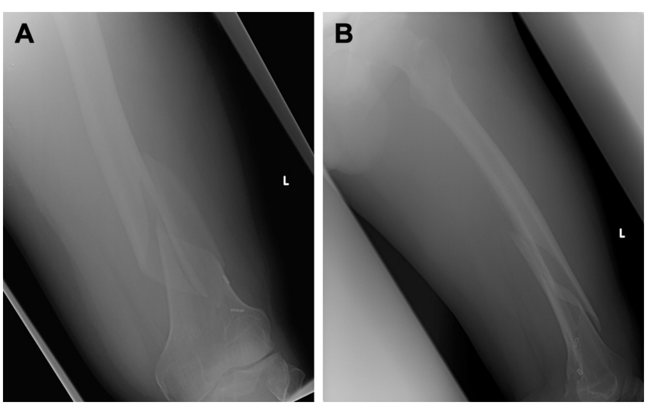


**Figure 2.** (A) Anteroposterior and (B) lateral radiographs of the left femur at the time of fracture. Fracture lines are seen running through the 2 femoral tunnels.

and that of extension were both grade 5 according to the Medical Research Council (MRC) grading. The anterior drawer, Lachman, and pivot-shift tests were all negative.

The patient returned 5 months later with left lower limb pain after a fall. He had slipped in the bathroom and had sustained a twisting injury to his left lower limb. He had distal thigh pain and was unable to bear weight after the fall. On examination, the neurovascular status of the lower limb was intact and there were no open wounds. Radiographs were obtained showing a closed, displaced, and angulated left distal femoral fracture with spiral extension proximally and a butterfly fragment (Figure 2). The fracture lines ran through the 2 femoral tunnels that were used in the double-bundle ACL reconstruction.

Intraoperatively, the fracture was found to be a comminuted distal femoral fracture with a large butterfly fragment and long coronal split to the distal metaphysis. There was no articular involvement. The fracture was reduced with a minimally invasive plate osteosynthesis (MIPO) technique and fixed with a less invasive stabilization system (LISS) plate (Figure 3). Examination under

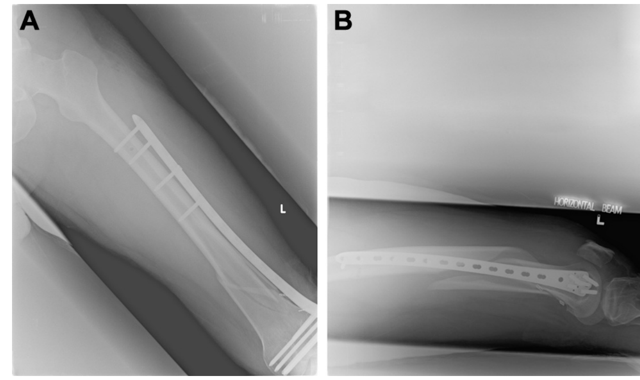


**Figure 3.** (A) Anteroposterior and (B) lateral radiographs of the left femur after open reduction and internal fixation with a less invasive stabilization system (LISS) plate.

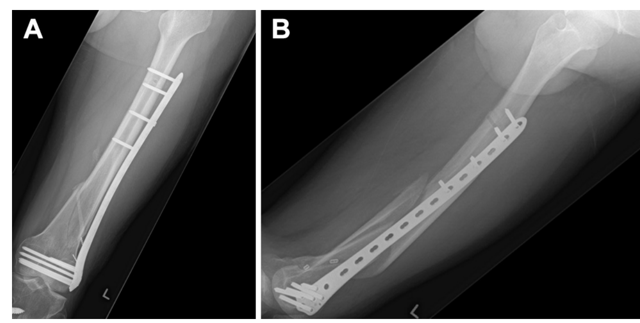


**Figure 4.** (A) Anteroposterior and (B) lateral radiographs of the left femur at 4-month follow-up. Fixation is stable and there are signs of early bony union.

anesthesia was performed after fracture fixation, and the ACL graft was determined to be clinically stable and was left alone. The patient was discharged home with crutches and weightbearing advice.

The patient was followed up 4 months postoperatively, at which point he still required the use of 1 crutch for ambulation and had yet to return to work. There was no pain over the femoral shaft, suggesting clinical union of the fracture. Physical examination of the knee did not suggest any compromise of the ACL reconstruction; the anterior drawer, Lachman, and pivot-shift tests were all negative. Knee range of motion was 0° to 100°, and strength of knee flexion and extension was grade 5 according to the MRC grading. Repeat radiographs showed the LISS plate in situ with evidence of early bony union (Figure 4).

At the 2-year follow-up, the patient was ambulating well without walking aids. He was community ambulant and able to return to normal daily activities but had yet to return to competitive sport. Similar to previous follow-ups, the physical examination of the knee at 2 years did not suggest any compromise of the ACL reconstruction; anterior drawer, Lachman, and pivot-shift tests were negative. Knee range of motion was 2° to 134°, and strength of knee flexion and extension was grade 5 according to the MRC grading. There was no femoral shaft tenderness,

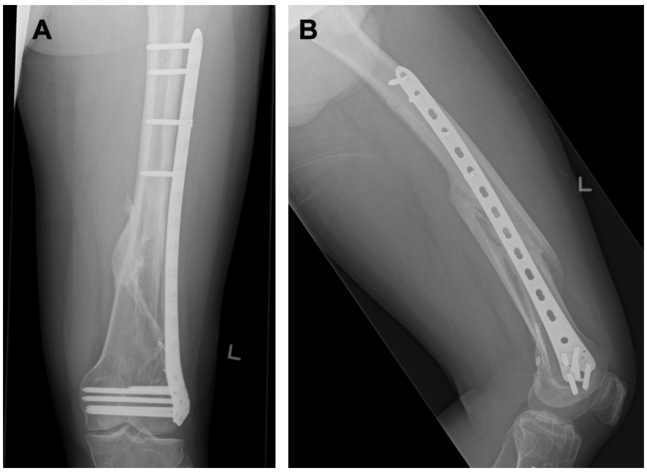


**Figure 5.** (A) Anteroposterior and (B) lateral radiographs of the left femur at 2-year follow-up, showing evidence of full bony union of the fracture.

and repeat radiographs showed bony union of the fracture (Figure 5).

## DISCUSSION

Femoral shaft fracture after an ACL reconstruction is an uncommon complication, with only isolated cases reported in the literature. This case is of interest as it is the first reported case of femoral fracture as a complication of double-bundle ACL reconstruction. Although the creation of femoral tunnels in cancellous bone may have contributed to the fracture, we hypothesized that the majority of the stress arising from a double-bundle ACL reconstruction was due to the multiple cortical violations of the far cortex when attempting to pass the Endobutton loops for fixation of the hamstring grafts on the femoral side, resulting in significant weakening of the cortex in that region.

All reported cases of peri-ACL femoral fractures in the literature so far have occurred after single-bundle ACL reconstruction. Various reasons have been proposed, such as tenodesis screw fixation,[12] use of a cross-pin[5,6,11] or staple,[8] and removal of a transverse cancellous screw.[13] Some authors believe that multiple cortical passes with a guide pin[14,17] or drill[12] may have contributed to the weakening of the bone. Vertical tunnels,[15,16] tunnel widening,[10,16] and an additional tunnel in the case of a revision surgery[2] have also been implicated. Isolated incidents with no identified risk factors as well as stress fractures have been reported. Most cases occurred within a few months of surgery; however, occurrence at 2 years[8] and even 11 years[6] after the surgery has been reported.

In the case of double-bundle ACL reconstruction, it is likely that the 2 femoral tunnels used to pass the hamstring graft cause increased stress concentration in the distal femur, resulting in propagation of the fracture.

A drill hole through the cortex of the bone weakens the bone in 2 ways. First, there is less material available to withstand applied forces; second, local stresses in the area surrounding the drill hole increase, leading to a stress concentration effect.[1] The load strength of the bone is reduced as a result of this stress concentration effect; thus, the bone requires a lesser load to fracture and the fracture lines would run through the drill hole. The stress concentration effect causes the bone to be especially sensitive to torsional forces[7]; therefore, a spiral appearance is commonly seen in these fractures.

A biomechanical study by Brooks et al[1] found that drill holes or tunnels potentially decrease bone torsional strength by up to 55% compared with undrilled bones. Brooks et al also found that on torsional loading, the bones with drill holes had fractures through the drill hole at lower forces compared with undrilled bones. This theory is especially relevant in double-bundle ACL reconstruction because larger combined diameters of graft tunnels, multiple femoral cortical violations, and reaming of multiple femoral tunnels may create areas of greater stress concentration, which might significantly compromise the torsional strength of the bone and lead to increased risk of peritunnel fracture.

A recent biomechanical study by Han et al[4] found that femurs after double-bundle ACL reconstruction surgery required significantly less energy to fracture. The investigators drilled 1 and 2 femoral tunnels from articular surface to far cortex, simulating single- and double-bundle ACL reconstruction, respectively, in fourth-generation composite femur bones and subsequently loaded them to failure. It was found that load to failure was significantly lower in femurs that had 2 tunnels compared with native femurs or femurs with only a single tunnel. This suggests that these bones with an additional femoral tunnel are more susceptible to failure from loading.

Han et al[4] also found that the fracture lines that occurred in femurs with 2 femoral tunnels always involved both femoral tunnels, whereas the fracture lines that occurred in bones with a single tunnel or no tunnel at all always involved the lateral cortex but did not always run through the femoral tunnel. This observation lends further credence to the role of multiple tunnels in undermining bone strength and predisposing to fractures.

## CONCLUSION

Double-bundle ACL reconstruction surgery may increase the chances of peri-ACL femoral fractures due to a greater stress concentration effect from the presence of multiple femoral tunnels and multiple cortical violations.

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