Femoral Avulsion of the Anterior Cruciate Ligament in a Multiligament Setting: A Unique Case

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Anterior cruciate ligament (ACL) femoral avulsions are a rare entity mainly seen in children. We describe a unique case of a bony ACL avulsion with a medial collateral ligament (MCL) and lateral meniscus (LM) tear in a 37-year-old patient who sustained a two-wheeler accident. The ACL femoral avulsion was fixed arthroscopically using a Knee Scorpion and a FiberTape fixed over a suture disc on the lateral cortex. The MCL was repaired with an internal brace using a FiberTape and two SwiveLocks and the torn LM was repaired using all-inside sutures. At 2 years of follow-up, the fragment was united, knee range of motion was 0° to 130°, and Knee Society Score was 98. This is the first case report of a femoral avulsion of the ACL combined with an MCL injury and a meniscus tear where all three were repaired with a unique technique and good results were obtained.

Keywords: Knee, Anterior cruciate ligament, Avulsion, Arthroscopy, Repair

Received November 7, 2018; Revised (1st) December 10, 2018; (2nd) December 25, 2018; Accepted January 2, 2019
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2) Portals

A high anterolateral viewing portal, a medial working portal for passport cannula (Arthrex, Naples, FL, USA) and a far medial drilling portal for the ACL footprint were created (Fig. 2).

3) Diagnostic arthroscopy

Diagnostic arthroscopy was carried out: a femoral avulsion of the ACL was observed (Fig. 3A); an undersurface LM tear was seen in the posterior horn in the red white zone (Fig. 3B); and there was a >10 mm opening of the medial compartment, suggesting an MCL tear (Fig. 3C).

4) Lateral meniscus repair

The tear was rasped with a meniscal rasp and repaired using a Knee Scorpion (Arthrex) loaded with 2-0 FiberWire (Arthrex) and taking a bite from the superior and inferior surfaces of the meniscus to approximate the tear. The two ends were then tied with a SMC knot. The three sutures were passed at 0.5-cm intervals (Fig. 4).

5) ACL stump refixation

(1) Preparation of femoral footprint

The ACL footprint on the femur was identified and the center was drilled over a guidewire using a 4.5-mm drill bit with the knee in hyperflexion and an Ethibond (Ethicon, Somerville, NJ, USA) loop was passed through the tunnel (Fig. 5A–C). The ACL was then isolated from the posterior cruciate ligament by shaving the intervening fat pad (Fig. 5D). Through the medial portal, a Knee Scorpion loaded with 2-0 FiberWire was inserted to take a bite from the proximal 1/3 of the ACL (Fig. 5E). The 2-0 FiberWire acted as a suture shuttle to place the FiberTape (Arthrex) through the proximal part of the ACL stump (Fig. 5F); two equal arms of the FiberTape passed through the stump were delivered through the passport cannula. The FiberWire was again loaded to shuttle one end of the FiberTape through the bony fragment. Then, the FiberWire was passed through the other end of the bony fragment to shuttle the other end of the FiberTape such that a figure of eight configuration (crisscrossing) of the FiberTape on the ACL stump was established (Fig. 5G). The two ends of the FiberTape as well as the Ethibond loop were delivered through the passport cannula (Fig. 5H). The two ends of the FiberTape were then shuttled to the lateral cortex using the Ethibond loop.

(2) MCL internal bracing

Internal Bracing of the MCL was done by loading a FiberTape on two SwiveLocks (Arthrex) that are inserted into the medial epicondyle and 2 cm below the joint line on the tibia, through 1-cm incisions under C-arm guidance at 30° of knee flexion after
fixing the ACL over a suture disc.

6) Final fixation
An incision was made on the lateral aspect of the femur and the two ends of the FiberTape were tied over the suture disc (Fig. 6C). In arthroscopy, the ACL was in position and taut (Fig. 6A) and the medial compartment was opened <5 mm (Fig. 6B). In radiography, the suture disc was sitting on the bone (Fig. 6D).

2. Postoperative Rehabilitation
The patient was kept partial weight bearing from 6 weeks postoperatively, with knee bending allowed till 90° of flexion in a hinge knee brace. The brace was kept locked in extension while walking. Closed chain quadriceps strengthening exercises were begun from day 1 postoperatively. At 6 weeks after surgery, the brace was removed and the patient was allowed to walk full weight bearing with full knee flexion. Return to sports was advised at 6 months postoperatively.

CT scan and MRI were done at 3 months postoperatively, which revealed the ACL was in continuity and the bony fragment healed to the lateral aspect of the notch (Fig. 7). The LM had healed completely and the MCL had healed too on MRI. At 3 months and one year postoperatively, the knee was stable with a negative anterior drawer test and a negative valgus stress test. At one-year follow-up, the patient had a visual analogue scale of 0 and had returned to recreational sports.

Discussion

In children, epiphyseal chondral and osteochondral ACL avulsions are not uncommon because of relatively elastic connective tissue and correspondingly weaker bony structures. Osseous avulsion of the ACL in the pediatric population occurs most commonly at the distal tibial attachment site. However, in adults, the ACL tends to tear before osseous avulsion can occur. Adult cadaveric models have demonstrated that under typical stressors, osseous avulsion of the ACL is less common than ligament disruption, and when osseous avulsion does occur, it occurs at the level of the tibial eminence.

Most previously reported orthopedic articles were in the skeletally immature patient. However, there have been four case reports using different fixation techniques in the skeletally mature. Mechanism of injury varied from road traffic accidents to sporting injuries. Fixation of these avulsions varied from open to arthroscopic techniques using suspensory devices, K-wires and screws. None of them, however, reported ACL avulsions associated with a meniscus tear and an MCL injury.
Fig. 5. Anterior cruciate ligament (ACL) refixation. The femoral footprint (A) was drilled with 4.5 mm drill bit (B). (C) The Ethibond (Ethicon) loop was delivered. (D) A shaver was used to create a space between the ACL and the posterior cruciate ligament. (E) Bite taken with a Knee Scorpion (Arthrex). (F) FiberTape (Arthrex) was passed through the stump. (G) Bites taken from the bony fragment. (H) Ethibond loop and FiberTape delivered through the passport cannula.

Fig. 6. Final fixation and arthroscopic findings. (A) Anterior cruciate ligament (ACL) after fixation. (B) Medial compartment opening <5 mm. (C) Lateral cortex femur fixation of the ACL. (D) Anteroposterior radiograph showing the suture disc.
In most reported cases, femoral avulsion of the ACL was due to high-velocity trauma where the knee was subjected to flexion, internal rotation and varus stresses, resulting in an avulsion of the femoral attachment of the ACL with a posterior horn tear of the LM.

In our case, the patient had a high-velocity injury in the form of a road traffic accident while riding a two-wheeler. The patient reported the knee was in a flexed and externally rotated position immediately after the injury. We observed bruising on the medial aspect of the anteriorly extending knee at the initial visit of the patient at the clinic. The possible mechanism, considering the injuries the patient sustained, was a flexion external rotation injury to the knee, extending from the medial aspect to the lateral aspect of the knee, also affecting the MCL, ACL and LM subsequently. The avulsed fracture fragment was not apparent on the standard anteroposterior and lateral radiographs.

Axial CT sections demonstrated the bony avulsion and exhibited continuity of the fragment with the ACL. The MRI demon-

Table 1. Review of Previously Reported Cases of ACL Femoral Avulsion and Comparison with the Present Case

| Study                          | Age (yr)/sex | Injury mode               | Fixation method                          | Operative findings                      |
|--------------------------------|--------------|---------------------------|------------------------------------------|-----------------------------------------|
| Shah et al. 1)                 | 47/F         | Road traffic accident     | 4 mm cancellous screw fixation           | Bony avulsion of ACL from femur         |
| Bengtson and Giangarra 2)      | 10/M         | Sports induced            | Mini open fixation with sutures (#2 MaxBraid) | Comminuted fragment                     |
| Wardle and Haddad 3)          | 11/F         | History of fall           | Arthroscopic fixation with tight rope     | Small size bony fragment                |
| Langenhan et al. 4)           | 14/F         | Sports induced            | Arthroscopically assisted K-wire fixation | Bony avulsion of ACL from femur         |
| Eady et al. 5)                 | 7/F          | Sports induced            | Mini open fixation with sutures woven Bunnell fashion | Granulation tissue at bony fragment, debrided |
| Zabierek et al. 6)            | 50/M         | Scuba diving              | Arthroscopically with screws              | Bony avulsion                          |
| Tharakulphan et al. 7)        | 32/M         | Sports (soccer) injury    | Arthroscopic suture loop fixation         | No bony avulsion                       |
| Tohyama et al. 8)             | 14/M         | Sports induced            | Fixed with Ethicon suture with button at lateral femur (mini open) | 6–10 mm oval osteochondral fragment of bone |
| Kawate et al. 9)              | 11/F         | Sports induced            | Arthroscopic fixation with Ethibond sutures | Osteochondral avulsion                  |
| Edwards et al. 10)            | 11/F         | Sports induced            | Lateral parapatellar approach-modified Bunnell suture repair | Displaced avulsion fracture             |
| Our study                     | 36/M         | Road traffic accident     | Arthroscopic suture pull out technique    | Osteochondral avulsion with lateral meniscus tear |

ACL: anterior cruciate ligament.
strated the intact ACL with bone-marrow edema at the lateral femoral condylar donor site of avulsion. This indicates that despite exceedingly rare, osseous femoral avulsion injury of the ACL can occur in the adult.

Most of the previously reported cases used an open or mini open technique that could potentially lead to arthrofibrosis. Only two previous studies used arthroscopic fixation techniques: one using K-wires and the other using a TightRope (Arthrex). Using a K-wire intra-articularly necessitates an additional procedure for removal. The TightRope is a relatively expensive but effective surgical treatment device. This technique was unique in that it was performed on a case of multiligament injury of the knee with a repairable meniscus tear, where all three were repaired and healed in an adult. Table 1 summarizes previous case reports in terms of patient profile, injury patterns and fixation techniques for comparison with our case.

The suture pull-out technique is a good option for arthroscopic fixation of a femoral-sided avulsion fracture of the ACL in skeletally mature patients when performed early after injury. This technique saves the natural ACL stump. The bone-to-bone healing yields a stronger construct than tendon-to-bone healing. Potential negatives include the point of fixation being away from the ACL insertion on the femur that may produce a bungee effect. Also, it is technically demanding to achieve anatomical reduction of the fragment, which may result in a loss of isometricity of the ligament.

**Conflict of Interest**

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

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