Broken Femoral Cross Pin After Hamstring Anterior Cruciate Ligament Reconstruction

Case Report

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ABSTRACT: Two years after a quadrupled hamstring anterior cruciate ligament reconstruction using polylactic acid cross pin femoral fixation, a 32-year-old woman presented with symptoms of knee catching, locking, and stiffness. Diagnostic arthroscopy revealed a loose body in the anterior compartment of the knee which was determined to be part of the polylactic acid femoral fixation pin. The graft was intact and well fixed. After simple arthroscopic removal, the patient returned to full activities and resumed normal function postoperatively. We speculate that the fixation pins may have entered the notch and later degraded or fractured. Using axial magnetic resonance images, we provide preliminary data suggesting that pins angled posterior to the epicondylar axis may violate the notch. If pins are to be placed posterior to the epicondylar axis, maximum pin length can be estimated by the formula: $0.4 \times$ the interepicondylar distance.

INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction with hamstring autograft has become a popular method of treating ACL deficiency. Improved femoral fixation techniques have resulted in better outcomes and increased popularity of this graft. Beginning in the early 1990s, Clark et al,[3] Howell and Gottlieb,[5] and Wolf[10] independently developed femoral cross pin fixation techniques for hamstring ACL reconstruction, which have since become popular alternatives to interference screw and endobutton fixation techniques.

Few complications of cross pin fixation have been reported. Klein et al[6] reported a series of 57 patients treated with metal cross pin fixation with evidence of tunnel widening. Bottoni et al[2] reported a case of proximal migration of tibial interference screw into the knee in a hamstring reconstruction using a femoral cross pin. Cross pin break-

age using the DePuy Mitek RIGIDFIX (DePuy Mitek Inc, Norwood, Mass) has recently been reported.[4] This article presents a corroborative case in which a bioabsorbable femoral cross pin fractured or degraded and presented as an articular loose body 2 years after the index surgery.

CASE REPORT

An active 32-year-old woman fell while skiing and sustained a complete ACL injury to the right knee. On physical examination, translation was 8 mm according to Lachman testing, with no endpoint and an obvious pivot shift. Radiographs revealed no abnormalities, and magnetic resonance imaging (MRI) demonstrated a complete ACL tear with no associated injuries to the menisci, posterior cruciate ligament, medial collateral ligament, lateral collateral ligament, or articular cartilage.

The patient underwent a right knee ACL reconstruction with a four-strand hamstring tendon autograft. Diagnostic arthroscopy at that time revealed no other abnormalities. The graft was fixed on the femur using two bioabsorbable transfixing pins (RIGIDFIX). The pins were impacted easily, with no specific difficulties noted during insertion. The graft was cycled manually through approximately 20 cycles to remove creep. No slippage occurred and excellent fixation was achieved. The graft was fixed distally using an interference screw and sheath (INTRAFIX; DePuy Mitek Inc).

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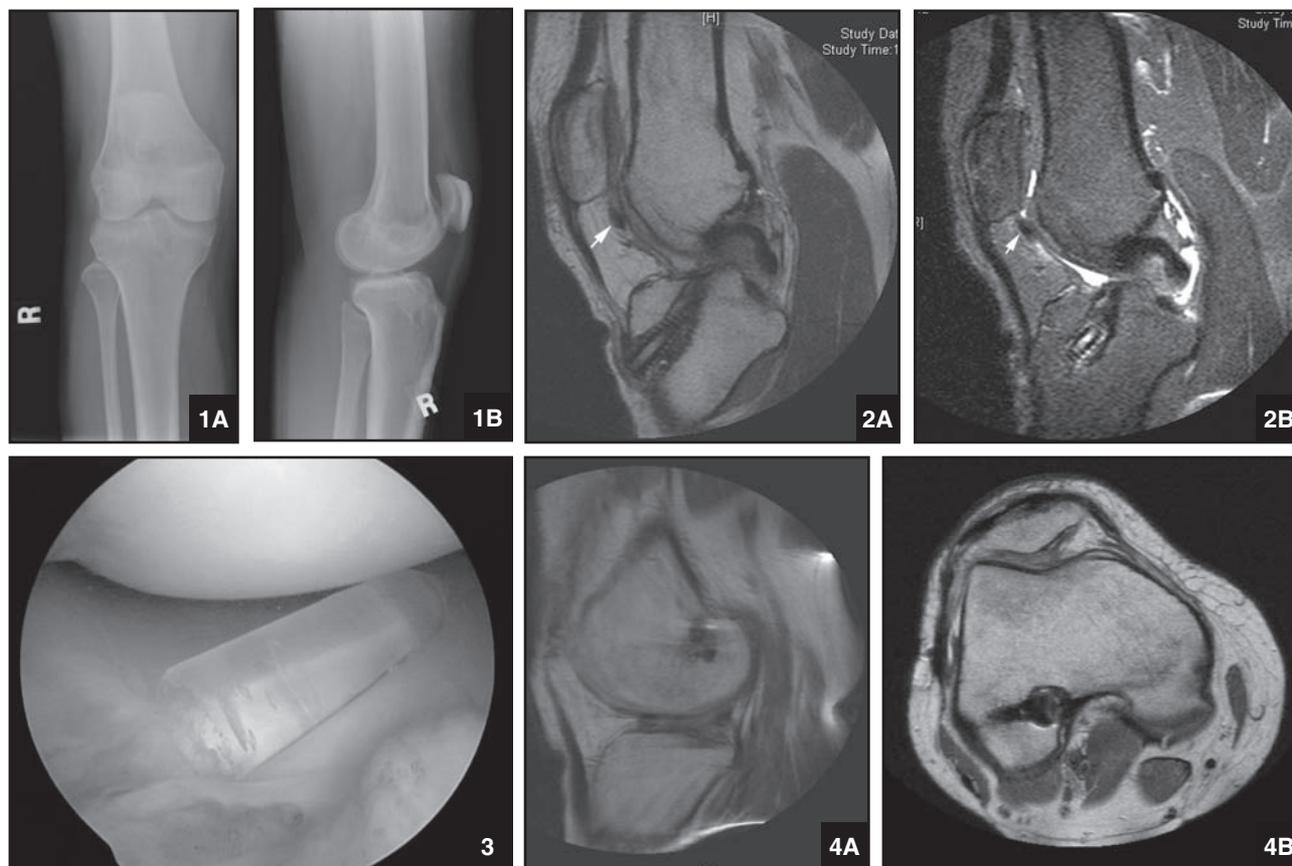
Figure 1. AP (A) and lateral (B) radiographs taken 8 months postoperatively demonstrating appropriate tunnel placement. **Figure 2.** MRI demonstrating a foreign object (white arrows) in the anterior compartment inferior to the patella, producing low intensity signal on sagittal T1- (A) and T2-weighted (B) sequences. **Figure 3.** Intraoperative arthroscopic image of broken cross pin. **Figure 4.** Sagittal (A) and axial (B) T1 MRI showing position of the pins in relation to the posteromedial cortex of the femur after the index procedure.

The patient began a standard ACL rehabilitation. She regained motion from 0°-140° by 6 weeks and had a stable Lachman on follow-up examination. By 3 months, symptoms of instability ceased and the patient began participating in nonpivoting sports. At 8 months, the patient returned to playing tennis without complication. She reported episodes of feeling as if her knee "gave way" and subjectively reported a "stiffer" knee.

One year later, the patient presented with knee clicking, catching, and locking. The patient also reported a subjective feeling of a loose body moving around her knee. She did not recall any specific trauma or incident that contributed to this. Physical examination revealed a firm endpoint on manual ACL testing and a negative no pivot shift. Radiographs were unrevealing (Figure 1). Magnetic resonance imaging (Figure 2) showed a low signal loose body and a mild increased signal in the midsubstance of the ACL graft. The tibial tunnel measured 1.3 mm in maximal diameter proximally and the femoral tunnel measured 9 mm at the joint.

The patient underwent operative arthroscopy (Figure 3). A 15-mm loose body was found in the anterior compartment of the knee. Its tapered end resembled the medial tip of the bioabsorbable femoral fixation pin. Little evidence suggested pin degradation. Grade I-II fibrillation of the distal lateral femoral condylar carti-

lage was present, with no obvious chondral injury from the pin. No obvious donor site for the pin was noted. The knee was closed in sterile fashion, and the patient began a rehabilitation program. Twelve months later, the patient remained pain free and returned to activity without limitations.

DISCUSSION

Bottoni et al[2] described a bioabsorbable tibial interference screw presenting as an intra-articular loose body 7 months post-ACL hamstring reconstruction with a femoral cross pin. The tibial graft remained intact and well incorporated, but the interference screw had lost its contact with the host bone. The present case also describes a fixation device failure in which a femoral cross pin fractured without fixation loss of the hamstring graft.

Two factors are likely to be involved in the failure of the device: mechanical failure and material degradation. Three in vitro studies of femoral fixation devices demonstrated that the RIGIDFIX had mean yield loads of 445-768 N with cyclical loading in various models[1,7,11];

however, Ahmad et al[1] found that grafts secured with RIGIDFIX cross pins slipped an average of 6 mm after cyclical loading. In addition, maximal loads to failure under single cycle loading ranged from means of 639-868 N for the RIGIDFIX. In all three studies, the primary mode of failure occurred by breakage of the cross pins.[1,7,11] It is conceivable that the pin broke from a force exceeding its ultimate strength.

These studies all used new fixation devices in vitro, without material degradation. The RIGIDFIX device uses two polylactic acid cross pins. Unlike other devices, there are two pins each with a smaller pin diameter. The resorption process of polylactic acid is poorly characterized and fairly unpredictable but is likely to be affected by surface area. Martinek et al[8,9] reported a case where a bioabsorbable interference screw was associated with pretibial cyst formation and another case where a polylactic acid interference screw persisted for >2 years. In the latter case, the level of screw degradation rendered en bloc removal impossible. It is possible that the polylactic acid cross pin may have partially degraded and subsequently fractured.

In the present case, it is unclear how the pin migrated to the joint cavity. The timing of the cross pin breakage raises several possible mechanisms of migration. Most likely, the pin was inserted in an oblique orientation across the femur and initially placed intra-articularly in the posteromedial compartment. Retrospective review of the MRI suggests that the implants were posteriorly located in the medial femoral condyle (Figure 4). With either time and degradation or a single traumatic event, the prominent medial and protruding end of the distal transfixing pin may have fractured and became a loose body. These femoral transfixing devices are designed for placement in an oblique orientation from the lateral femoral condyle to the medial femoral condyle. The pin will perforate if its course is too oblique. This may have been a technical error in orienting the outrigger drill guide, although the pin location was checked directly after drilling by looking into the femoral tunnel to ensure that the pins were entering the tunnel.

Another potential contributing factor may be a size mismatch between the pin length and the knee. This patient had a small knee, which may have been prone to perforation of the posteromedial femoral condyle as only one pin size was available. The dual pin fixation may be another contributing factor for two reasons: smaller diameter pins and a pin that is placed relatively distal. With single pin fixation devices, the pin diameter is larger; therefore, degradation may take longer and thus might occur and not be seen. With a dual pin fixation design, one of the pins must be placed more distally—closer to the joint surface and more likely to perforate.
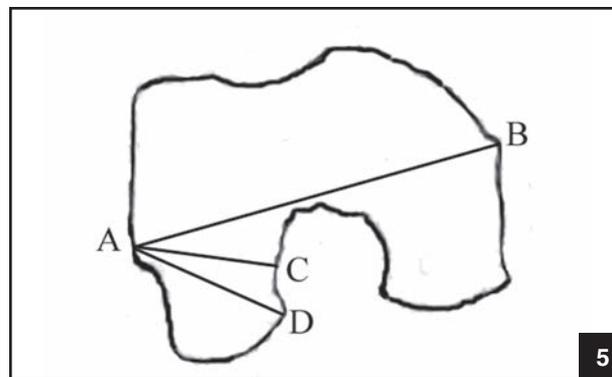
Figure 5. Schematic drawing demonstrating the interepicondylar distance (line AB), minimum distance to the notch (line AC), and danger zone (angle BAD).

Considering this complication, characterization of a region that would be at risk for notch perforation on the distal femur was attempted. Axial section MRIs of the distal femur from 10 different patients were examined. Centricity software (General Electric, New York, NY) was used to determine an angle at risk for notch perforation and a means of estimating maximal pin length—all relative to the epicondylar axis. On the axial image, distance was measured from the lateral epicondyle to the medial epicondylar sulcus. The shortest distance was then measured from the lateral epicondyle to the lateral wall of the notch. In addition, the angle formed by the epicondylar axis and a line intersecting the lateral epicondyle and the posteromedial corner of the lateral condyle was measured (Figure 5).

Although the distance from the lateral epicondyle to the medial epicondyle varied among patients (mean=76.6 mm; standard deviation (SD)=12.0 mm; range: 60-99 mm), the ratio of the minimum notch distance to the interepicondylar distance remained relatively constant (mean=0.40 mm; SD=0.03 mm; range: 0.36-0.42 mm). In addition, a consistent angle was noted posterior to the epicondylar axis at risk for perforation of the notch (mean=35.3°; SD=2.3°; range: 32°-39°).

In retrospect, these criteria indicate the index patient's high risk for notch perforation. The cross pins were placed 18° posterior to the lateral epicondyle, clearly in the zone of notch perforation. In addition, the patient's knee was relatively small—only 72 mm in length. Using our criteria for minimum length (0.4 × the interepicondylar distance), the estimated maximal pin length was 28.8 mm. The actual distance when measured by MRI was 27 mm. A cross pin 3 cm in length could potentially perforate the notch.

It is unclear whether technical errors in insertion, design features of this device, initial mechanical incompetence of the cross pin, material degradation of the polylactic acid, or a combination of these factors contributed to this unusual clinical presentation. In this

case, the ongoing processes of mechanical and material degradation did not manifest as a loss of graft fixation or clinical failure.

This case report could represent either an anecdotal incident or an intermediate term complication regarding cross pin ACL fixation with bioabsorbable materials. From our preliminary clinical studies, cross pinning should be avoided at angles aimed posterior to the epicondylar axis. In addition, the minimum distance to the notch can be estimated by the simple calculation: $0.4 \times$ the interepicondylar distance. This minimum distance could determine the maximum cross pin length. These useful guidelines may prevent further complications with cross pin devices.

REFERENCES

1. Ahmad CS, Gardner ME, Groh M, Arnouk J, Levine WN. Mechanical properties of soft tissue femoral fixation devices for anterior cruciate ligament reconstruction. *Am J Sports Med*. 2004;32:635-640.
2. Bottoni CR, DeBerardino TM, Fester EW, Mitchell D, Penrod BJ. An intra-articular bioabsorbable interference screw mimicking an acute meniscal tear 8 months after an anterior cruciate ligament reconstruction. *Arthroscopy*. 2000;16:395-398.
3. Clark R, Olsen RE, Larson BJ, Goble EM, Farrer RP. Cross-pin femoral fixation: a new technique for hamstring anterior cruciate ligament reconstruction of the knee. *Arthroscopy*. 1998;3:258-267.
4. Cossey AJ, Paterson RS. Loose intra-articular body following anterior cruciate ligament reconstruction. *Knee*. 2005;21:348-350.
5. Howell S, Gottlieb J. Endoscopic fixation of a double-looped semitendinosus and gracilis ACL graft using Bone Mulch screw. *Operative Techniques in Orthopaedics*. 1996;6:152-160.
6. Klein JP, Lintner DM, Downs D, Vavrenka K. The incidence and significance of femoral tunnel widening after quadrupled hamstring anterior cruciate ligament reconstruction using femoral cross pin fixation. *Arthroscopy*. 2003;19:470-476.
7. Kousa P, Jarvinen TL, Vihavainen M, Kannus P, Jarvinen M. The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction. Part I: femoral site. *Am J Sports Med*. 2003;31:174-181.
8. Martinek V, Friederich NF. Tibial and pretibial cyst formation after anterior cruciate ligament reconstruction with bioabsorbable interference screw fixation. *Arthroscopy*. 1999;15:317-320.
9. Martinek V, Seil R, Lattermann C, Watkins SC, Fu FH. The fate of the poly-L-lactic acid interference screw after anterior cruciate ligament reconstruction. *Arthroscopy*. 2001;17:73-76.
10. Wolf EM. Cross-pin ACL reconstruction (the semi-fix system). Presented at: Arthroscopy Association of North America 14th Annual Fall Course; December 7-10, 1995; San Antonio,Tex.
11. Zantop T, Weimann A, Rummler M, Hassenpflug J, Petersen W. Initial fixation strength of two bioabsorbable pins for the fixation of hamstring grafts compared to interference screw fixation: single cycle and cyclic loading. *Am J Sports Med*. 2004;32:641-649.