



Case report

Knee-Spanning External Fixation for Recurrent Traumatic Anterior Prosthetic Knee Dislocation With Associated Vascular Injury

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ABSTRACT

Traumatic anterior prosthetic knee dislocation after total knee arthroplasty is a rare event. We report the case of an 88-year-old female who presented with right traumatic anterior knee dislocation and concurrent popliteal artery injury requiring an emergent bypass graft. Postoperatively, the patient had redislocated her prosthetic knee, requiring urgent re-reduction and stabilization with an external fixator. We review her case, as well as additional reported cases of anterior knee dislocation. We also review the clinical considerations surrounding arterial injury, vascular bypass, and external fixation as a proposed management in unstable cases refractory to bracing.

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Introduction

Traumatic anterior knee dislocation after total knee arthroplasty (TKA) is a rare event, isolated to case series and case reports in the literature. Our patient is an 88-year-old female who presented with right traumatic anterior knee dislocation and concurrent popliteal artery injury requiring an acute revascularization procedure. Postoperative examination revealed recurrent dislocation with intact neurovascular examination. This required operative management in the form of re-reduction and application of knee-spanning external fixator. Given the need for re-reduction in the setting of a fresh vascular bypass graft with the associated risks and complexity, we found this unique compared to most reported cases that are amenable to closed treatment with bracing. Informed consent was obtained from the patient's family before the writing of this article.

Case history

Our patient is an 88-year-old female with a history of a previously well-functioning cruciate-retaining TKA performed 10 years

prior at an outside institution. She has a past medical history significant for congestive heart failure, atrial fibrillation on apixaban, stage 3 chronic kidney disease, chronic obstructive pulmonary disease, and a body mass index of 35 kg/m². On the morning of presentation, at approximately 10:00 AM, the patient fell onto a flexed knee while making her bed at home. She was brought to an outside emergency department where her right knee was evaluated. Her neurologic function was intact, but there was concern about her dorsalis pedis and posterior tibial arteries. Pulses in both arteries could not be palpated and had no Dopplerable signals. Radiographs demonstrated an anterior dislocation of her right prosthetic knee (Fig. 1). Orthopedic surgery was consulted to perform reduction and bracing, and at approximately 12:00 PM, her knee was manually reduced with a confirmatory radiograph. However, her foot remained pulseless and cold. CT angiogram revealed popliteal artery occlusion (Fig. 2). The patient was transferred to our tertiary facility in a hinged knee brace, locked in extension, for emergent revascularization.

At 6:00 PM, the patient was taken emergently to the operating room by vascular surgery. She underwent an above-knee popliteal artery to below-knee popliteal artery bypass using reversed ipsilateral great saphenous vein autograft. Postoperatively, Dopplers demonstrated biphasic right dorsalis pedis and posterior tibial signals. She did not require lower leg fasciotomies. She was admitted to the surgical intensive care unit for volume resuscitation with hourly

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neurovascular and compartment monitoring. Her brace was reapplied postoperatively with a plan for an x-ray to confirm knee reduction in the postoperative care unit. When a portable knee x-ray was performed, it showed redislocation of her knee (Fig. 3). Her neurovascular examination remained stable. The timing of redislocation was unknown although it may have occurred before or during the vascular procedure. In order to perform reduction in a controlled manner, and to protect her vascular repair, she was taken back to the operating room emergently for a closed reduction under general anesthesia with full paralysis and vascular surgery on standby. Her knee was reduced with a combination of gentle axial

traction and posteriorly directed force on the tibia [1]. Doppler pulses were confirmed at that time. She was taken through a range of motion, where she continued to be unstable and her knee dislocated between 10 degrees and full extension. Her knee remained reduced between 30 and 90 degrees but had significant laxity with varus and valgus stresses, indicating global instability with no palpable defect of her extensor mechanism. Given her persistent instability and concern about her fresh vascular bypass, a knee-spanning external fixator was applied with her knee in 30 degrees of flexion (Fig. 3), and reduction was confirmed under fluoroscopy. Pulses were again confirmed before leaving the operating room.

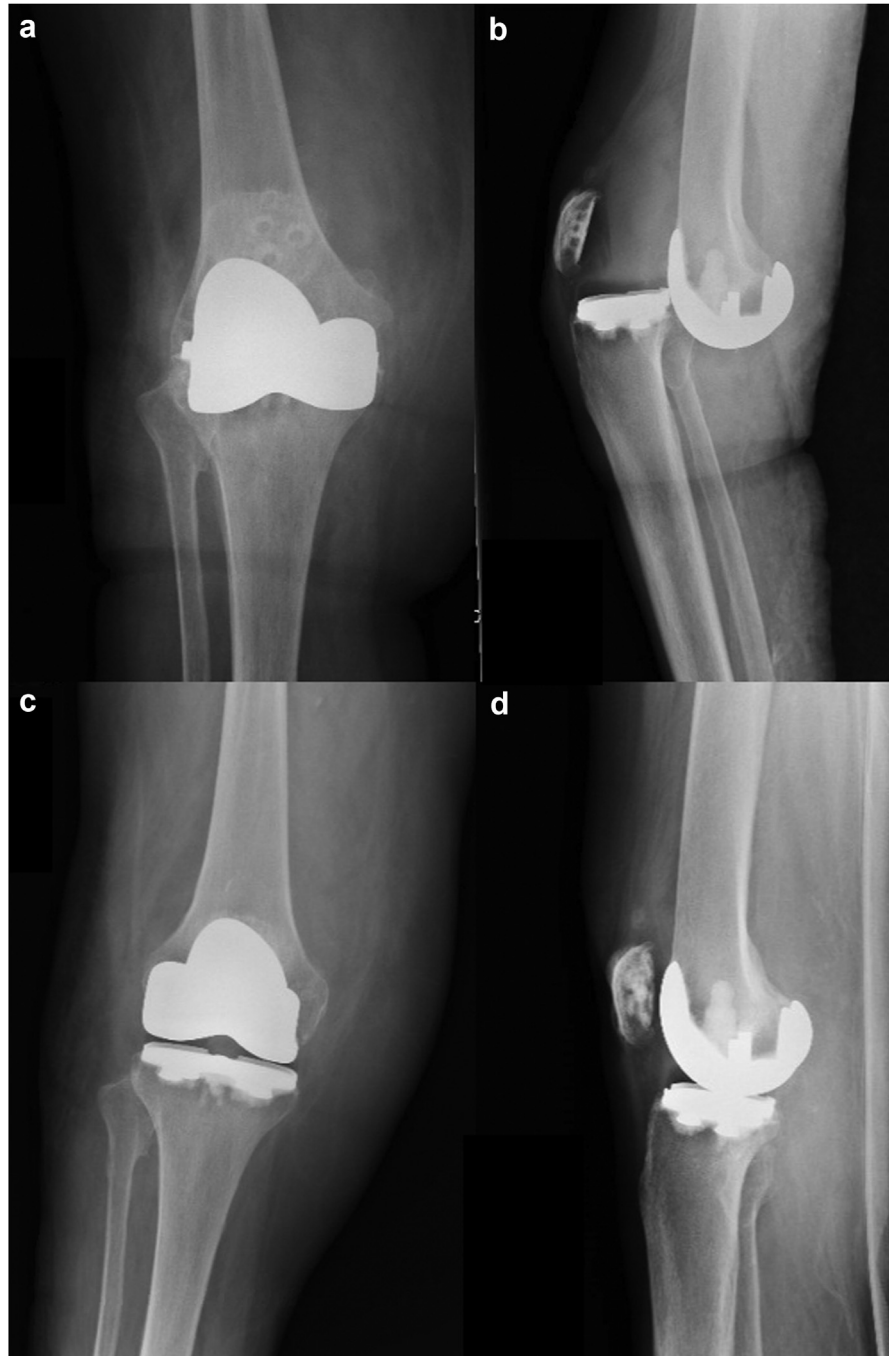


Figure 1. AP and lateral right knee radiographs demonstrating prosthetic anterior knee dislocation, before (a, b) and after (c, d) reduction. Image “d” demonstrates an intra-articular effusion with residual anterior subluxation, with likely underlying cruciate ligament injury with persistent instability.

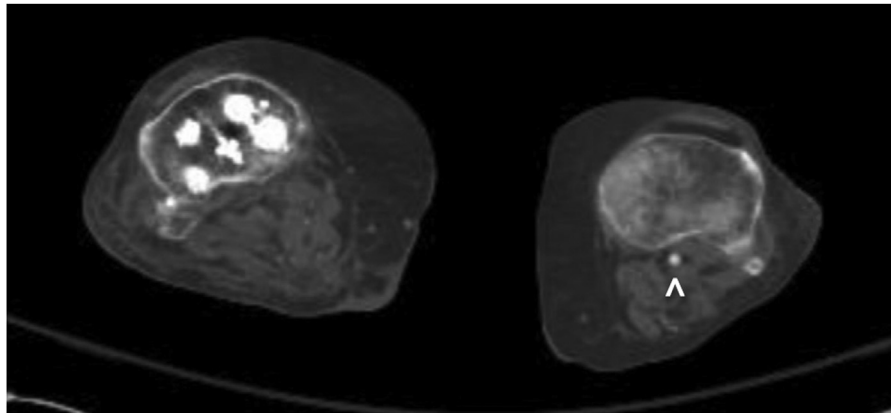


Figure 2. CT angiogram of bilateral lower extremities at the level of the tibial plateau, demonstrating a lack of filling in the right popliteal artery. The left popliteal artery enhances with contrast (white arrow head).

She had an uneventful postoperative course, and she was discharged to a short-term rehabilitation facility. She was allowed to weight bear as tolerated in her external fixator. She followed up with orthopedic and vascular surgery at 2 weeks postoperatively where her x-rays showed maintenance of reduction and hardware and a stable vascular examination. Surgical options were discussed with the patient. Revision surgery and conversion to a hinged prosthesis were discussed, but the patient declined because of her multiple comorbidities and reluctance to undergo a large surgery during the concurrent surge of COVID-19 in Massachusetts. Vascular surgery also voiced their concerns about an extensive revision surgery requiring tibial subluxation in the setting of a recent bypass graft. It was ultimately decided to remove the external fixator at 6 weeks, perform an evaluation under anesthesia, and apply a hinged brace.

At 6 weeks, she returned to the operating room. Her frame was removed, and her knee was gently ranged. From 10-90 degrees, her knee remained reduced under fluoroscopy. We were unable to achieve full extension past 10 degrees, and there was concern that further manipulating her knee could lead to fracture or instability. She did have 2+ laxity with varus and valgus stress throughout her flexion arc. Her knee was reasonably stable to anterior and posterior drawer. Her vascular examination was checked and remained intact. She was transitioned to a hinged knee brace from 20-90 degrees and discharged. She was subsequently able to ambulate short distances in the brace with a rolling walker. She was followed up at rehab by an orthopedic nurse practitioner. Our plan was to recheck stability at 3 months and to consider unlocking the brace at that time. If stable, we would have considered removing the brace at 1 year. Unfortunately, our patient decompensated and passed away from medical causes approximately 5 months after her initial dislocation.

Discussion

Traumatic anterior knee dislocation after TKA is a rare event. Posterior dislocation has occurred in prior reports in posterior stabilized designs with a combined flexion and varus moment that causes the femoral component to “jump the post.” The incidence for a posterior stabilized TKA dislocation was 1%-2%, but this has decreased to below 0.5% with redesigned components and techniques [2]. Anterior prosthetic knee dislocation is limited to several small case series and reports [3–12] and represented only 11% of all prosthetic knee dislocations in one recent systematic review [1]. It occurs by a different mechanism of combined valgus, external rotation, and hyperextension [8]. This causes medial collateral and

posterior cruciate ligament failure, resulting in anterior instability [8]. Contributing factors include flexion instability, component malpositioning, extensor mechanism dysfunction [5], and polyethylene wear [4,9,11,12]. Patient-related risk factors for instability in TKA include greater preoperative deformities necessitating aggressive ligament releases, neuromuscular pathology resulting in recurvatum (quadriceps weakness) or valgus thrust (weak hip abductors), hip or foot deformity resulting in a valgus moment on the knee, and obesity that complicates exposure, risking collateral ligament injury and component malposition during the index surgery [2,13]. Most of these injuries have been treated with closed reduction and brace treatment, and some have required revision to a more constrained implant.

Devastating neurovascular injuries can occur frequently with these injuries. In native knee dislocation, incidence of popliteal artery injury ranges from 7% to 80% [14]. Vascular injury may present in an acute or in a delayed fashion after knee dislocation and initial physical examination, and Doppler ultrasound may be insufficient for diagnosis. McDonough and Wojtyś reviewed 72 native multiligamentous knee injuries that all underwent angiography and noted 8 cases with normal pulses on initial examination that were later found to have popliteal artery disruption [14]. Addevero et al. reported a case of anterior prosthetic knee dislocation that presented with symptoms of vascular compromise approximately 80 hours after injury and subsequent reduction [8]. The patient had popliteal dissection and thrombosis on CT angiography and required emergent revascularization and subsequent fasciotomies for reperfusion compartment syndrome [8]. A high degree of suspicion, serial examinations, and a low threshold for CT angiography can help prevent missed vascular injuries.

Knee-spanning external fixation is a known modality of treatment for native knee dislocation [15]. On a series of 9 acute native knee dislocations, Levy et al. performed a staged spanning external fixation with subsequent multiligamentous knee reconstruction at 3-6 weeks [15]. Indications for external fixation were significant vascular injury, gross instability with inability to maintain reduction, open knee dislocation, and inability to immobilize in a brace. In contrast to our patient, 7 of these 9 patients sustained injury in a higher energy motor vehicle collision, and mean age was 30 years.

Compared with native knee dislocations resulting from high-energy trauma, patients with low-energy prosthetic TKA dislocations are likely to be older, more frail, and medically complex. They may be at increased risk for recurrence because they may not have adequate muscle strength, endurance, or balance. They also may be noncompliant because of dementia and other cognitive problems. Similarly, their neurovascular structures may be less resilient to



Figure 3. AP and lateral right knee radiographs. Images “a” and “b” were taken after the patient’s popliteal bypass and demonstrating redislocation of the knee. Images “c” and “d” were taken after the patient’s return to the operating room for knee-spanning external fixation.

recurrent insults. With this in mind, consideration may be given to staged external fixation in this patient population to prevent subtle or global instability. However, there are theoretical concerns about pin tract infections that could migrate down the canals to the implants and potentially cause a periprosthetic joint infection.

In a recent systematic review, lobst and Liu report increased infection rates in external fixators retained for longer periods of time [16]. Although the review reports on external fixators placed in both upper and lower extremities for trauma, limb deformity, and lengthening, rates of infection ranged from 19.6% when pins or wires were removed at 42 days or less to 47.8% when retained

longer than 180 days. Notably, infection was more common in lower extremity pins and wires (31% vs 14% in the upper extremity) [16].

There is also a theoretical concern that a prior pin tract could contaminate intramedullary stems required during a future revision knee surgery. Furthermore, prior pin sites may cause a stress-riser and lead to fracture if located at the tip of intramedullary stems. With this in mind, pins should be placed far from the knee joint to ensure these are extra-articular and out of the way of future stems. Beltran et al. recommend placing anterior femoral pins at least 7.5 cm proximal to the superior pole of the patella to avoid

penetrating the joint capsule [17]. In the proximal tibia, a distance of at least 1.4 cm distal to the joint line is recommended [18]. Stem length ranges from 30 to 75 mm in metaphyseal engaging designs to greater than 75–150 mm in diaphyseal engaging stems [19]. It is important to consider placing pins beyond these lengths.

Ideally external fixation pins will be kept in place for the exact minimum amount of time to confer soft-tissue stability in a brace but also avoid possible pin tract complications. Although we did 6 weeks of ex-fix treatment in this case, this time frame was partially due to scheduling restrictions from the COVID-19 pandemic.

A cruciate retaining TKA design relies on an intact posterior cruciate and collateral ligaments for stability, and a knee dislocation will likely render multiple or all these ligaments incompetent, resulting in ongoing instability risk. An anterior knee dislocation occurs with a hyperextension moment, and knee immobilizer treatment in extension may be ineffective. Given all these factors, we propose that serious consideration should be given to initial external fixator treatment in an anteriorly unstable cruciate-retaining knee, particularly if revascularization has already been performed or is being planned. Ideally, the frame should be placed before revascularization to guarantee intraoperative length and stability. However, the leg may require mobilization for access to the deep vessels, and the frame may interfere with this. Furthermore, in delayed presentations such as ours, vascular repair may precede orthopedic stabilization [20], as further delay with revascularization beyond 8 hours can result in a high rate of amputation [21]. We recommend a thorough discussion between specialties about how to coordinate these operations safely and efficiently.

Definitive treatment to address instability requires revision arthroplasty to more constrained components. Ahn et al. report a case of traumatic anterior knee dislocation with revision to a hinged knee prosthesis [5]. The authors of this report recommended revision to more constrained implants if global instability persists after 6 weeks of immobilization. Unfortunately, the risk of recurrence is still present despite an instability-free interval. Pao and Jiang [10] reported a case of recurrent anterior prosthetic knee dislocation after initial closed reduction and brace treatment. The patient returned with a recurrent dislocation from a similar mechanism 18 months later.

There is minimal guidance about timing of revision knee procedures after revascularization. Turner et al. reported on 9 cases of TKA performed in the setting of prior vascular bypass surgery [22]. There were 2 cases of arterial thrombosis, one of which went on to below-knee amputation after failing emergent thrombectomy. Based on their experience, Turner et al. describe a protocol including (1) preoperative ultrasound of the graft to evaluate for stenosis or occlusion, with a positive result prompting angiogram and preoperative vascular surgery consultation; (2) intravenous heparin before tourniquet inflation and an additional dose after 1 hour; and (3) careful postoperative examination for ischemia, with anticoagulation on warfarin for 4 weeks [22]. Another consideration would include revision surgery without a tourniquet.

Given our patient's advanced age, comorbidities, and low-demand functional status, she was not interested in a revision surgery. Nonetheless, the question of appropriate timing for major arthroplasty revision after revascularization is not well addressed in the literature.

Treatment recommendations

Based on our experience and review of available literature, we suggest the following treatment: All patients should undergo emergent knee reduction with close serial examinations, with a high suspicion for arterial injury and a low threshold for CT angiography. In the event of injury requiring revascularization, close

communication with vascular surgery is imperative. Orthopedic surgery should be present at the time of the bypass procedure, to confirm knee reduction on fluoroscopy before determination of bypass graft length and maintenance of reduction. Based on our experience with this case, external fixation should then be considered as either a staged or definitive approach to prevent recurrent dislocation, thus protecting the bypass graft and the potential for loss of limb.

There are no definitive guidelines regarding the optimal length of treatment in the external fixator. Based on our case, 6 weeks in an external fixator in slight flexion conferred adequate stability to prevent further dislocations, but did not provide adequate coronal plane stability after removal. A cruciate retaining component may not provide adequate sagittal plane stability after this injury; one option in some systems would be for isolated polyethylene exchange to an anterior stabilized insert. If a posterior-stabilized femoral component was in place, some systems may allow for isolated exchange to a more constrained polyethylene. If these options are unavailable, single or both component revision may be necessary to increase constraint. Simple polyethylene exchange without increasing constraint has a high rate of failure [1]. Timing on safety of major revision arthroplasty surgery after revascularization is unclear. Consequently, a multidisciplinary approach with appropriate counseling and explanation of risks and benefits should precede any revision procedure.

Summary

Anterior knee dislocation after TKA is a rare but potentially devastating injury, reported in small case series and reports. Even more rare is the acutely dislocated knee in the setting of a concomitant revascularization procedure. With exponential growth of total knee replacement procedures projected, along with these procedures being performed in an obese and elderly population, the incidence of these injuries may only increase in the future. Despite the possibility of this increase, and the inherent high stakes for loss of limb and life, treatment recommendations for these injuries are sparse. Based on our experience, early multidisciplinary coordination with vascular surgery is paramount to a successful outcome. External fixation may be considered as an acute treatment to stabilize a persistently unstable knee that requires urgent vascular bypass.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Informed patient consent

The authors declare that informed patient consent was not provided for the following reason: Informed consent was obtained from the daughter of the patient, as the patient had unfortunately passed away by the time that the case report was written.

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