Graft infection following arthroscopic anterior cruciate ligament reconstruction: a report of four cases

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INTRODUCTION

Septic arthritis after arthroscopic anterior cruciate ligament (ACL) reconstruction is rare and may result in severe morbidity, prolonged hospitalisation, and poor clinical outcome. Its incidence is 0.3 to 1.7%, whereas the postoperative intra-articular infection rate is 1.5%. Early diagnosis and aggressive treatment minimises the risks of graft failure, damage to intra-articular hyaline cartilage, and arthrofibrosis, and thus is vital in eradicating the infection, preserving the graft, and achieving good functional outcomes. Delay in treatment can lead to osteomyelitis, diffuse chondral thinning, full-thickness osteochondral defects, and rapid degenerative osteoarthritis. We report on 4 patients who developed septic arthritis following arthroscopic ACL reconstruction.

CASE REPORTS

Records of 3 men and one woman aged 22 to 35 years who developed acute (<2 weeks, n=3) or subacute (2 weeks to 2 months, n=1) septic arthritis following arthroscopic ACL reconstruction by a single surgeon between July 2007 and June 2012 were retrospectively reviewed (Table). All patients underwent emergency...
knee washout and debridement with graft retention within 24 hours, together with a course of intravenous antibiotic therapy. All the patients achieved eradication of their infections (with intact ACL grafts) and satisfactory functional outcome at a mean follow-up of 32 (range, 25–45) months.

### Patient 1

In November 2008, a 28-year-old man presented with pain and instability of the right knee following a soccer injury 12 months earlier. He was diagnosed to have tears of the ACL and medial meniscus, and underwent arthroscopic ACL reconstruction and partial medial meniscectomy 3 months later.

On the day of surgery, a 2-cm superficial wound with an overlying dry scab was noted at the proximal tibia, around 3 cm distal to the lowest pes anserinus insertion site. Although there was no evidence of wound infection, the increased risk of postoperative infection was a concern. Nonetheless, the patient declined postponement of the surgery owing to work commitments.

The right lower limb was cleaned with iodine and draped. The scab was covered with Ioban adhesive drape wrapped circumferentially around the leg. A transtibial technique with a 4-stranded semitendinosus and gracilis autograft was used. The graft was fixed with an Endobutton CL loop for the femur and a GTS interference screw for the tibia. Partial medial meniscectomy was also performed. The patient was scheduled for follow-up in 2 weeks and instructed to return earlier if he became feverish, unwell, or noted increasing knee pain, swelling, or discharge from his wounds.

On day 10, he became feverish, but did not return for earlier review. On day 13, he presented to the emergency department with discharging haemoserous fluid from the proximal tibial wound. A large, warm effusion was noted, with erythema.

#### Table

<table>
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<tr>
<th>Parameter</th>
<th>Patient 1</th>
<th>Patient 2</th>
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<th>Patient 4</th>
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<td>Subclinical left femoral intramedullary nail infection, previous knee surgery, hamstring autograft</td>
<td>Previous knee surgery, allograft, concomitant meniscectomy</td>
<td>Concomitant meniscectomy, hamstring autograft</td>
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around the wound. The previous scab had peeled off. His white blood cell (WBC) count was 10.0 x10⁹/l, the C-reactive protein level was 314.5 mg/l, and the erythrocyte sedimentation rate (ESR) was 92 mm/hr. The seropurulent fluid was positive for Gram-positive cocci, and cultures grew methicillin-sensitive *Staphylococcus aureus* (MSSA). Intravenous amoxicillin/clavulanic acid was started, and later switched to intravenous cloxacillin (based on culture and sensitivity results).

He immediately underwent arthroscopic debridement and washout of the tibial wound. Seropurulent fluid and pus was expressed from the proximal tibial wound after removal of stitches. There was severe synovitis of the joint. The ACL graft was structurally intact though it had some slough on its surface. Two days later, pus was still expressed from the wound and thus a second arthroscopic debridement and washout was performed. Another 2 days later, a third debridement and washout was performed because the CRP level remained high at 323.3 mg/l, and the ESR rose to 115 mm/hr. Nonetheless, specimens from the 2nd and 3rd washouts were all culture negative. Four days later, the CRP level had decreased to 24.1 mg/l, and the ESR to 73 mm/hr. Six days after the first washout, the proximal tibial wound was sutured, and the drains were removed when the wound discharge became minimal. The patient was discharged at day 16. He received oral cloxacillin for 6 weeks. The CRP level became normal (3.4 mg/l) 5 weeks after the first washout. Clinical examination revealed grade-1 ACL laxity with a firm end-point. At the 45-month follow-up, the patient reported no major knee pain or instability, and was able to jog and engage in recreational sports.

**Patient 2**

In October 2008, a 35-year-old man presented with increasing pain and instability of the left knee caused by a chronic tear of the ACL. In 2004, he had undergone retrograde intramedullary nailing for a closed, comminuted, segmental fracture of the left femoral shaft after a road traffic accident. Since July 2005, the 3 interlocking screws near the femoral condyle was found to be loose and slightly backed-out (Fig.), but there was no swelling or tenderness at the site of the interlocking screws. An option of a 2-stage procedure was provided (first to remove the retrograde nail and interlocking screws and to eradicate infection [if any], followed by ACL reconstruction later), but the patient insisted on a single-stage procedure.

The hamstring tendon was first harvested and prepared. The 3 distal interlocking screws were removed via a lateral incision to avoid interfering with femoral tunnel reaming. The retrograde nail was left *in situ* to reduce contamination of the joint. The most proximal interlocking screw was found to be loose with some surrounding granulation tissue, but no pus or slough. As the hamstring tendon was already harvested, a decision was made to proceed with ACL reconstruction. A transtibial technique was

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**Figure** Patient 2: preoperative radiograph and magnetic resonance images showing a retrograde intramedullary nail with a loosened interlocking screw and a complete tear of the anterior cruciate ligament in the left knee.
used for femoral tunnel reaming. The graft was fixed with a retrobutton loop in the femur and with a Delta screw in the tibia.

Gram stains of all intra-operative specimens were negative, as were bacterial cultures from the tissues around the loosened screws. However, a culture from the screws yielded a scanty growth of Pseudomonas aeruginosa, which was susceptible to ceftazidime but not to amoxicillin/clavulanic acid, which had been prescribed to this patient.

On day 8, the patient was readmitted with fever, increasing knee pain, and swelling for 2 days. The WBC count was 12.2 x10^9/l, the CRP level was 239.1 mg/l, and the ESR was 65 mm/hr. 80 ml of turbid haemopurulent fluid was aspirated from the knee. He was given intravenous ceftazidime and underwent an arthrotomy, washout, and removal of the retrograde nail and proximal interlocking screws, via a medial parapatellar approach within 24 hours. The ACL graft was structurally intact. The medullary canal was hand-reamed and irrigated, and the washout was completed with 9 litres of pulsed lavage. A drain was inserted prior to skin closure.

Four days after surgery, the WBC count decreased to 6.9 x10^9/l, the CRP level to 32.6 mg/l, and the ESR rose to 82 mm/hr before declining 3 days later. Gram stains and cultures of all intra-operative tissues and fluids were negative, although the WBC count was normal; this was likely due to the administration of intravenous ceftazidime before surgery.

Postoperative recovery was uneventful, and the drain was removed on day 6. Serial tests of inflammatory markers showed a steady decline, and the patient was discharged on day 18. He had received 8 weeks of intravenous ceftazidime in order to eradicate any concomitant osteomyelitis of the medullary canal, even though the CRP level returned to normal (2.0 mg/l) at week 3. At the 33-month follow-up, there was no recurrence of infection. He had mild knee pain but reported no instability. Clinical examination revealed a stable ACL with good range of knee movement.

Early osteoarthritic changes were noted in the patellofemoral and medial compartments. The tibial and femoral tunnels were freshly drilled via a transportal technique. The graft was fixed with an Endobutton CL loop in the femur and a Biosure screw in the tibia. A partial lateral meniscectomy was also performed.

At the 15-day follow-up, she had no fever, but there was a small effusion on the right knee. The surgical wounds had healed and stitches were removed. At day 28, she presented with fever for 2 to 3 days and increasing pain and swelling. A large knee effusion with increased warmth was noted. Knee aspiration yielded turbid fluid with debris.

She was immediately treated with intravenous ceftriaxone and cloxacillin, followed by arthroscopic debridement and washout. Severe synovitis of the joint and a large amount of turbid fluid and debris were noted, but the ACL graft was intact. Culture of the joint fluid yielded methicillin-sensitive Staphylococcus aureus (MSSA), for which intravenous cloxacillin was continued. The antibiotic was switched to intravenous clindamycin owing to an allergic reaction to cloxacillin.

Four days later, arthroscopic debridement and washout was repeated, as the drained fluid remained turbid, and the CRP level and the ESR had increased to 221.2 mg/l and 98 mm/hr, respectively. Culture of synovial tissue yielded a scanty growth of MSSA. Two days later, the CRP level decreased to 132.1 mg/l and 3 days later to 53.4 mg/l. The ESR increased to 118 mm/hr before declining gradually. Serial monitoring of inflammatory markers showed a steady downward trend. The patient was discharged on day 16. She had received 6 weeks of oral clindamycin. Her CRP level returned to normal (2.9 mg/l) 4 weeks after the first washout, whereas the ESR took 16 weeks to normalise. At the 26-month follow-up, she had a stable knee, with minimal pain, and was able to return to running and pivoting sports.

**Patient 4**

In July 2010, a 26-year-old man presented with a 2-year history of pain and instability of the right knee following a soccer injury. He had a complete tear of the ACL, a tear of the medial meniscus, and partial cartilage loss in the medial compartment. He underwent arthroscopic ACL reconstruction and a partial medial meniscectomy using a 4-stranded semitendinosus and gracilis autograft via a transportal technique. The graft was fixed with an Endobutton CL loop in the femur and a Biosure screw in the tibia. At the 15-day follow-up, he was afebrile but had...
had moderate knee pain for 2 days. A large knee effusion was noted. Knee aspiration yielded 80 ml of haemoserous fluid. He declined the offer of surgery and was therefore prescribed oral amoxicillin/clavulanic acid for one week. Although the Gram staining of the joint aspirate was negative, cultures grew *Staphylococcus hominis*, which was sensitive to cloxacillin. The patient refused a knee washout despite repeated advice. On day 21, he eventually underwent extensive debridement, synovectomy, and washout. The ACL graft was intact. A drain was inserted before closure. Cultures were negative for bacterial growth, probably owing to his oral antibiotic therapy. The WBC count was 5.4 x10^9/l, the CRP level was 114.7 mg/l, and the ESR was 75 mm/hr. Four day later, the CRP level was 7.6 mg/l, and the ESR was 20 mm/hr. The patient was discharged on day 8. He had received 6 weeks of intravenous cloxacillin. He regained full range of knee motion, despite having grade-1 laxity with a firm end point. At the 25-month follow-up, he had no knee pain or instability and was able to jog and play recreational sports.

**Discussion**

Risk factors of septic arthritis following arthroscopic ACL reconstruction include (1) concomitant procedures during the reconstruction, (2) previous knee surgery, (3) allograft usage, (4) use of a hamstring grafts versus bone-patellar tendon-bone grafts, (5) peri-operative wound contamination, (6) presence of intra-articular foreign bodies, and (7) contamination of surgical equipment.2–6

**Concomitant procedures**

Previous knee surgeries and concomitant procedures during the ACL reconstruction (e.g. meniscus repair) are risk factors for postoperative infection.6 This was probably attributed to increased operation time, additional or larger incisions, longer tourniquet time, and suture materials acting as a foreign-body nidus for infection.

Septic arthritis of the knee is related to concomitant menisci repair.4 The extra posteromedial incision for an inside-out repair technique and the suture materials are all risk factors. In one series, 50% of patients with septic arthritis had undergone concomitant surgeries, compared to only 20% in those without infection.13 However, one study reported that none of the patients with an infected ACL reconstruction had a concomitant open procedure (apart from harvesting of the graft).3 The relative risk of postoperative infection was not significantly higher in patients with concomitant procedures (relative risk=0.59; 95% confidence interval, 0.25–1.4).14 In our series, concomitant partial meniscectomy might have been a contributing factor in patients 1, 3, and 4, whereas removal of interlocking screws also increased the operation time in patient 2.

**Previous knee surgery**

53 to 75% of patients who developed septic arthritis after ACL reconstruction have previous surgery to the ipsilateral knee.2,7,11,12,15 The relative risk of postoperative infections in such patients is 1.9, and increased to 5.1 if the previous surgery is ACL reconstruction.11

In our series, patient 2 had undergone retrograde intramedullary nailing for an ipsilateral femoral shaft fracture 4 years earlier. A culture from one of the distal interlocking screws was positive, indicating pre-existing subclinical infection. In addition, the intramedullary nail was left *in situ* during the ACL reconstruction and could have served as a foreign-body nidus for infection. Patient 3 had undergone primary ACL reconstruction using a hamstring autograft. The autograft later failed and was revised with an allograft. This patient therefore had 2 risk factors: a history of previous ipsilateral ACL reconstruction and the use of an allograft.

**Allograft usage**

In a study by the Centers for Disease Control from a single surgical center, the infection rate for both autografts and irradiated allografts is 0%, but is 4% for non-irradiated allografts.16 Most allografts are not irradiated, as radiation may cause structural weakening of the graft. In another study, allografts have a higher rate of infection than autografts (4.4% vs. 0%).17 Other studies reported no differences in the postoperative infection rates between allograft and autologous grafts for ACL reconstruction.3,18

**Type of autograft**

ACL reconstruction with a hamstring graft is associated with a higher rate of septic arthritis.3,11 It is postulated that the relatively short hamstring graft results in increased amounts of suture material inside the knee joint, which acts as a foreign body.11 Furthermore, harvesting the hamstring tendons predisposes this area to wound complications.11 Nonetheless, the postoperative infection rate is not significantly different between 3 different ACL
reconstruction techniques (using a patellar tendon graft with single- or double-incision technique, or using a hamstring graft).\(^8\)

**Peri-operative wound contamination**

Peri-operative wound contamination (including incision for graft harvesting) may be the most common source of infection.\(^7,8,11\) It is postulated that infection originates from the tibial tunnel and spreads to the knee joint.\(^7,8,11\) Haematoma collection in the pre-tibial subcutaneous tissue may serve as a nidus for infection. In our series, peri-operative wound contamination was a likely risk factor for patients 1 and 2. It is recommended that surgery be postponed when there is a dry scab near the surgical site. For patients with peri-articular implants, especially those that are loose, a 2-stage ACL reconstruction is recommended to reduce the risk of postoperative infection. Should a single-stage surgery be performed, it is advisable to remove all implants before harvesting the graft. This enables ACL reconstruction to be postponed, if there is intra-operative suspicion of infection or an unexpected fracture.

**Intra-articular foreign bodies**

Increased intra-articular foreign body load predisposes to infections.\(^7,8,11,19\) This includes suture material from hamstring grafts, implanted material from meniscal repairs, and pre-existing implants, such as intramedullary nails.

**Contamination of surgical equipment**

Increased environmental contamination (such as excessive traffic of personnel) may be a risk factor of postoperative septic arthritis.\(^5,11-13,19\) Incomplete sterilisation of inflow cannulae,\(^5\) meniscus repair cannulae,\(^20\) or graft boards\(^15\) may lead to postoperative infection. The gap between the metal part and rubber membranes on the suture clamps cannot be sterilised satisfactorily despite sterilisation attempts in certified autoclaves.\(^13\)

**Treatment**

Treatment options include long-term intravenous antibiotics, arthroscopic or open washout and debridement, constant joint irrigation, and graft retention or removal with or without reimplantation.\(^13\) The most frequently used treatment is joint irrigation and debridement with graft retention.\(^5,15,21-24\) Immediate removal of the infected ACL graft is suggested,\(^2,25\) but others advocate graft removal only in cases of persistent infection.\(^6,26\) In a survey of 74 surgeons, most propose initial debridement with graft retention, whereas 36% adopt graft removal as part of the treatment regimen for resistant infection.\(^21\)

Based on the Gaechter grading system for septic arthritis of the knee, a stage-adapted treatment protocol is proposed.\(^15\) For Gaechter grades 1 and 2, arthroscopic treatment is suggested. For grades 3 and 4, medial or lateral arthrotomy is suggested. Graft retention is based on clinical findings. This treatment protocol has achieved reliable results, with no recurrence of septic arthritis or development of osteomyelitis. However, overall results are only fair compared with patients with no complication. Early infection can be managed with arthroscopic surgery, whereas in advanced or chronic infection, a more radical approach is preferred. Clinical results are better if the ACL graft remains functional.

In our patients, aggressive, emergency arthroscopic debridement and washout, with retention of the ACL graft, successfully eradicated intra-articular infection, with no recurrence. The CRP level is the best inflammatory marker for detecting septic arthritis and monitoring infection status following knee washout. Its response at the onset of infection is rapid. All 4 patients had markedly elevated CRP levels (>100 mg/l) at presentation. Patients with persistently elevated CRP levels (patients 1 and 3) had repeat washouts, whereas those with rapidly declining CRP levels following the first washout (patients 2 and 4) did not undergo further washout. The ESR response often lagged clinical improvement and the decline of CRP levels by days to weeks; sometimes the ESR even rose temporarily. Three of the 4 patients had normal WBC count on admission and throughout the treatment period. Only patient 2 had a mildly elevated WBC count of 12.2 x10\(^9\)/l on admission. Thus, the WBC count is not sensitive enough for early diagnosis of postoperative septic arthritis and for monitoring the clinical course. The CRP level, together with inspection of the knee aspirate, is the most sensitive marker for detecting postoperative infection and for monitoring the response to treatment.

**CONCLUSION**

Aggressive early knee washout and debridement with graft retention, and a prolonged course of intravenous antibiotic therapy are recommended for treatment of graft infection following arthroscopic ACL reconstruction. The CRP level is the most
sensitive inflammatory marker for detecting postoperative infection. All our patients recovered well with reasonably good functional outcomes.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES