Risk and Outcome of Infection After Different Arthroscopic Anterior Cruciate Ligament Reconstruction Techniques

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Purpose: Infection after arthroscopic anterior cruciate ligament (ACL) reconstruction is reported to be rare but can cause significant morbidity. The purpose of this study was to test the null hypothesis that there is no difference in infection rates between techniques and no difference in outcome of different techniques after treatment of this complication. **Methods:** From a consecutive case series of 1,231 patients who underwent ACL reconstructions with 3 different techniques from 1988 through 2006, we report 6 patients who developed postoperative infection. Time to presentation, clinical symptoms, patient demographics, and surgical and management details were obtained from patient charts. All 6 patients were re-examined with physical and radiographic evaluation, functional testing, KT-1000 (Medmetric, San Diego, CA), and Lysholm scales. **Results:** Six patients (0.49%) were identified including 2 infections for each technique with incidence of 0.86%, 0.29%, and 0.64%, respectively. The graft was retained in all 6 patients and treated with debridement and continuous antibiotics. Metallic implant was removed in 5 cases. Patients were followed up for an average of 102.5 months. The average modified Lysholm score was 81.1. The average maximum manual KT-1000 value was 2.7 mm. A Kruskal-Wallis test was used for statistical analysis, and no significant differences were noted in incidence, mean Lysholm scores, or KT-1000 difference ($P > .05$). **Conclusions:** Aggressive surgical debridement, hardware removal, and appropriate antibiotic therapy have proven effective in eliminating postsurgical infection along with graft retention and preservation of knee stability after ACL reconstruction performed with 3 different techniques. Although it was a small case series, the incidence and outcome after treatment of ACL infection in our study is similar, supporting the hypothesis that treatment outcomes were similar by using different surgical methods. **Level of Evidence:** III, retrospective comparative study. **Key Words:** Anterior cruciate ligament reconstruction—Techniques—Complication—Infection—Outcome.

Arthroscopic anterior cruciate ligament (ACL) reconstruction is rarely complicated by infection, but it is a potential complication as with any other surgical procedure, with the incidence being reported as less than 1%.[1,2] Despite low incidence, it is important to recognize that infection and treat it without

delay because of devastating consequences such as loss of hyaline cartilage and arthrofibrosis.[3,4] There were many algorithms suggested for treatment, but there is no consensus about the best treatment modality.[5-7] Many authors advocated either open or arthroscopic debridement together with intravenous antibiotic therapy, but there is considerable controversy about graft retention.[8,9]

The heterogeneity of the reports about this situation and lack of well-documented guidelines for the diagnosis and treatment cause further confusion. Therefore, we have performed a retrospective study to review our experience with postoperative infections and to determine if there is a difference in incidence and outcome depending on the primary procedures that has been used for ACL reconstruction. Our hypothesis was that the reconstruction technique used for ACL

reconstruction was not a relevant variable in determining outcome.

METHODS

A retrospective review was conducted of the records of all 1,231 consecutive arthroscopic ACL reconstructions performed by the senior author over 18 years (1988 to 2006), which revealed 6 cases of postoperative infections. The inclusion criteria were (1) development of infection after arthroscopic ACL reconstruction, (2) clinical signs of infection (drainage and knee effusion) supported by positive cultures or laboratory results (erythrocyte sedimentation rate, C-reactive protein), and (3) have at least 1 debridement procedure. Exclusion criteria included superficial wound problems that recovered with simple wound care and oral medication. These 6 patients were asked to return for follow-up examination. All of them were evaluated with a detailed physical examination (Lachmann test and range of motion), KT-1000 arthrometer (Medmetric, San Diego, CA), and a modified Lysholm score. The time from operation and presentation, clinical symptoms and findings, patient demographics, graft type, length of hospital stay, operation time, causative microorganism, number of procedures required, and clinical management necessary to eradicate the infection including antibiotic therapy and surgery were obtained from patient files. Radiologic evaluation at final follow-up included preoperative anteroposterior, lateral, and Merchant patellar view. Magnetic resonance imaging was used in cases of resistant signs of infection and suspected areas of bone involvement on direct roentgenograms during the course of treatment. In the double-incision ACL reconstruction technique, patellar bone–tendon–bone autografts were used, and femoral tibial ends of the graft were fixed with Kurosaka interference screws (9 × 30 mm and 9 × 25 mm) (Depuy, Warsaw, IN) via tibial and femoral incisions. This technique was used more commonly between 1988 and 1992. In the single-incision technique, patellar bone–tendon–bone autograft was fixed with interference screws (9 × 20 mm and 7 × 20 mm) placed intra-articularly for the femoral side and under direct vision for the tibial side via tibial incision. Reconstruction with hamstring tendons was performed more recently (1999 to 2006). Femoral fixation of the graft was performed with EndoButton (Acufex, Mansfield, MA) and tibial fixation with a fixation post screw. A standard rehabilitation including immediate partial weight bearing, range of motion, and quadriceps strengthening exercises was applied to all patients. The Kruskal-Wallis test was used for statistical analysis.

RESULTS

Of the 1,231 cases, 6 patients (% 0.49) were found to have deep infection after ACL reconstruction. There were 833 men and 398 women with the mean follow-up of 102.5 months (range, 30 to 196 months) after initial surgery. Bone–patellar tendon–bone reconstruction was performed with double-incision technique in 231 (men/women = 182/49) and with a single-incision technique in 688 (men/women = 446/242) cases. Reconstruction with hamstring tendons was performed in 312 (men/women = 205/107) knees. The incidence of infection in each technique was 0.86%, 0.29%, and 0.64% respectively. No patients were lost to follow-up. The clinical data were detailed in Table 1. The patients were all men with a median age of 24.5 years (range, 20 to 32 years). A first-generation cephalosporin was administered preoperatively to all patients. Four patients had concomitant partial menisectomy, and 2 patients had meniscus repair. There have been no reported intraoperative breaks in sterile technique. A tourniquet was inflated in some portion of the procedure and not for more than 90 minutes. There were no known risk factors for

TABLE 1. *Clinical Data Concerning the Patients*

Symptom	Knee Effusion	Symptom Period (d)	Joint Aspiration/ Arthroscopy	Microorganism	ESR/ CRP	Tunnel Debridement	Number of Debridements	KT-1000 Manual Maximum (mm)	Lysholm Score
Pain drainage femoral		14		*S. aureus*		+	5	3.3	74
Pain drainage		25		*Pseudomonas*		+	2	2.6	80
Pain drainage	+	19	+		+	+	2	3.1	75
Pain drainage		17		*S. aureus*	+	+	4	2.7	84
Pain drainage	+	35	+		+	+	2	3.0	81
Pain drainage	+	22	+	*S. aureus*	+	+	1	1.6	93

Figure 1. Direct roentgenogram of the loosened tibial fixation screw that was removed afterward.

postoperative infection in these patients such as steroid therapy or immunosuppression.

All patients had pain and wound drainage as presenting symptoms. All patients showed clinical signs of infection at an average of 22 days (range, 14 to 35 days) after the ACL reconstruction. One single-incision BTB and both of the patients whose ACL was reconstructed with autogenous hamstring graft had knee effusion in addition to discharge from the tibial incision site. One patient with a double incision had pain and persistent drainage from the femoral incision after ACL reconstruction 6 weeks postoperatively. None of the patients reported continuing signs of instability.

Before the initiation of antibiotic therapy, patients had knee aspirate or culture from drainage. Material was obtained either from the knee joint itself in 3 cases with knee swelling and from the drainage in all cases. Knee joint aspiration followed by arthroscopic debridement, and irrigation with a minimum of 15 L saline was performed in all 3 patients with knee joint effusion. Arthroscopy revealed inflammatory synovium, fibrin clots, and a stable graft in all cases with an additional loose screw in the patient with single-incision reconstruction (Fig 1). When infection was observed below the joint line capsular insertion point on the tibial tunnel incision and there was no sign

indicating involvement of the knee joint such as swelling, erythema, effusion, or decreased range of motion, samples were obtained from the drainage site to avoid contamination. They were painted with gram stain and cultured. One of the knee aspirates (hamstring) had cell counts of more than 40,000 and less than 40,000 in the other 2 cases (30 and 35,000). The granulocyte counts were greater than 90% in all aspirates.

Staphylococcus aureus was cultured in 3, and *Pseudomonas* and *Escherichia coli* were isolated in 1 patient. In the remaining 2 cases, no specific microorganism could be isolated. The erythrocyte sedimentation rate (ESR) was obtained in 4 cases and found to be high in all (average 51, 17 to 80). C-reactive protein (CRP) was high in 4 patients (average 29.7, 17 to 42). White blood cell count was over 10,000 in all 6 patients. The average time between onset of symptoms and initiation of treatment was 3.2 days. Intravenous antibiotics (cefazolin) were administered immediately after cultures were collected and changed based on appropriate sensitivities of the microorganism identified. Intravenous antibiotics were continued for a minimum of 3 weeks. The antibiotic therapy was repeated after every recurrent debridement procedure

Figure 2. Plain radiograph of the knee of the man who was treated with a single-incision ACL reconstruction showing intra-articular localization of the femoral screw.

FIGURE 3. Magnetic resonance imaging axial reconstruction of T1- and T2-weighted images revealing the necrotic area in a femoral condyle 16 years after initial surgery in the patients who have developed femoral infection.

and continued until the signs of infection were resolved.

In both patients with single-incision reconstruction, drainage was seen in addition to loosened tibial screws, but knee effusion was observed in one of them (Fig 1). Refreshing of the wound edges and removal of necrotic infected tissue together with the loosened tibial screw was performed. The femoral screw was found to be loosened and removed arthroscopically. However, the graft was found to be stable and left in place (Fig 2). Both of the patients required repeated debridements because of unchanged clinical symptoms despite parenteral antibiotic therapy. One had complete recovery after the second and the other after 2 more debridements.

In the double-incision group, both patients (cases 1 and 2) admitted to our center with wound drainage. Debridement of the wound together with removal of the loosened screw was performed. *S. aureus* was cultured, and appropriate intravenous antibiotics were administered. One of the patients underwent another debridement because of resistant discharge from the femoral side. He was discharged after remission of the infectious parameters, but swelling of the knee persisted. Magnetic resonance imaging showed osteomyelitis of the lateral femoral condyle (Fig 3). The patient underwent 3 additional debridements including the femoral and autogenous cancellous bone grafting 1 year after the complete recovery (Fig 4). He has been followed up for more than 5 years without any sign of

infection. Another patient had complete recovery after 2 debridements including the femoral incision site, which resulted in hypertrophic scar tissue.

Effusion after ACL reconstruction was the primary complaint in both patients with hamstring tendon reconstruction. Both had drainage of a serous material from the tibial incision site during postoperative rehabilitation. Arthroscopic debridement and examination of the graft were performed, and stable grafts were observed. Relatively short hamstring grafts with intra-articular suture material and a fibrinous coating adherent to the graft were identified. The EndoButton (Smith and Nephew, Memphis, TN) was not removed; however, all tibial fixation devices were removed. The rehabilitation program was decelerated to avoid further pressure and drainage. It was thought that knee effusion developed reactive to remaining intra-articular suture material. Both patients recovered completely after 4 weeks with prompt treatment of infection.

At the end of the treatment, all patients recovered normal laboratory values, such as ESR and CRP. In the postoperative period, intermittent ice and pain medication were applied. The normal rehabilitation program was not ceased but minimized, focused on preserving range of motion. An average of 2.66 procedures (range, 1 to 5) was required to eradicate infection with an average of 19.5 days (range, 10 to 32) of hospitalization.

The Lachmann test was +1 in 4 cases and the same

FIGURE 4. Lateral plain radiograph of the same patient after complete recovery from infection and grafting of the lesion showing improved metaphyseal irregularity and osteolysis.

compared with the normal side in 2 patients. During follow-up examinations, the average loss of flexion was 6° (range, 0° to 15°). Weight-bearing radiographs revealed minimal joint space narrowing in 1 patient (case 1). The maximum manual KT-1000 arthrometer testing showed an average 2.7-mm side-to-side difference (range, 1.6 to 3.3 mm). The average modified Lysholm score was 81.1 (range, 74 to 93).

Pain, ability to perform daily activities or sporting activities, and symptoms of instability were questioned. Four patients stated that they had no problems with daily activities and no symptoms of instability. Two patients were performing daily activities with minimal residual limitations. Formerly, 3 patients were participating in competitive level and the other 3 patients in recreational level sports. In the competitive sports group, 1 patient (basketball) had returned to his previous level; the patient with femoral osteomyelitis had to give up competitive sports but could perform recreational activities, and the other gave up sporting activities. In the recreational sports group, 2 patients were able to perform sports with minimal residual limitations, and 1 was able to perform daily activities.

The Kruskal-Wallis test was used for statistical analysis. There were no significant differences between 3 ACL reconstruction techniques in terms of Lysholm knee scores, KT-1000 values, average number of procedures, and hospitalization periods ($P >$ .05). Considering the limitations of the limited number of cases, the technique that has been used for ACL reconstruction was not a significant factor for the outcome.

DISCUSSION

The incidence of infection after arthroscopic ACL reconstruction is low (range, 0.3% to 0.48%).[5-7,10-14] In our series, the overall incidence was 0.49%, which was minimally higher but consistent with the literature. Because of the rarity and heterogeneity of this complication, there were no standard guidelines for treatment of such patients. Most studies were case series or survey results.[14,15] Septic arthritis in adult patients can be treated by arthroscopic decompression and debridement.[16] Matawa et al.[7] stated that irrigation and debridement with graft retention followed by a course of intravenous antibiotics was the most frequently mentioned treatment method in a nationwide survey. In resistant cases, the majority of the authors favor graft removal, but some others still choose repeat debridement. We also prefer graft retention in the 3 cases with intra-articular infection and others with deep wound infections requiring debridement to avoid additional morbidity and the cost of ACL reconstruction revision.

Although clinical signs were similar to classical septic arthritis in some reports, indolent presentation of the disease was emphasized by Scollin-Borg et al.[1] They emphasize that well-known symptoms of infection may be missing, and the situation can be easily interpreted as normal postoperative findings. However, postoperative pain was supposed to last for a few days and long-lasting pain and the absence of improvement in symptoms should be suggestive for septic arthritis.[13] Our patients had indolent presentation with persistent pain, persistent drainage in all cases, and knee swelling in 3 cases. The discharge was serous from the incision over the tibial tunnel entrance and purulent from the femoral incision site. Wound edges were hyperemic with a local increase in temperature. The incision for the tibial tunnel was the most common site for deep wound infection because of its superficial anatomic location.

The aspirate was reported to be the most diagnostic test for infection.[11] One patient had cell counts more

than 40,000 and granulocyte counts greater than 90% on the aspirates in all cases. CRP and ESR were the preferred tests with their high sensitivity and negative predictive value.[5,17] But elevated levels may be attributed to surgical trauma in the early postoperative period. ESR and CRP levels were obtained in 4 patients and found to be high in all cases. All were evaluated as abnormal because of the long period of time between the initial procedure and extraordinarily high levels.

Several microorganisms were reported as causative agents such as *S. aureus* or rare agents like *Erysipelothrix rhusiopathiae*.[2] The causative agents were similar to those reported to cause arthroscopic infections of the knee. *S. aureus* was the most common isolated microorganism in previous series.[9] The high granulocyte counts, ESR, CRP levels, and clinical findings of infection were used for the diagnosis of infection in case of negative cultures. No known risk factors such as steroid usage, immunocompromised state, or previous infection were present in our patients.[10,18] Concomitant surgery was noted to be a risk factor for infection either because of increased operative time, larger incisions, or the use of suture material such as a foreign body.[14] None of our patients had a previous operation on the affected knee. Meniscus repair was performed in 2 cases. We thought that intra-articular suture materials were important factors concerning the postoperative infection. In the double-incision technique, graft material was fixed over the screws, and most of the suture material was placed inside the bone. However, in the reconstruction with hamstring grafts, the graft length was shorter, which results in increased amounts of suture material inside the knee joint.

Several instruments have been implicated as a source of infection such as inflow cannulas, meniscus repair cannulas, or graft boards.[1,9,17] Because the infections observed spread over a long period of time and the instruments that were used were different, there were no instruments identified as the source of infection in our series. Preoperative usage of antibiotics was suggested to decrease the postoperative infection rate by several authors.[8,19] It was found to be controversial by others because of recent infection clusters despite preoperative antibiotic prophylaxis.[9,17] All of our patients receive 1 g first-generation cephalosporin (cefazolin) preoperatively. Arthroscopic debridement and lavage was the preferred method of treatment in the majority of the series.[1,6,16]

Magnetic resonance imaging was obtained in cases with suspected areas of bone involvement on direct roentgenograms, and osteomylitis was identified in 1 case. McAllister et al.[5] suggested additional open incision and drainage of all associated wounds at the time of arthroscopic lavage to avoid extra-articular fluid collection. All 6 patents underwent debridement of the infected area, and 5 required repeat debridement despite meticulous removal of all nonvitalized tissue at the initial debridement. We observed that femoral localization was associated with a higher number of debridement for eradication of the infection. There were 2 patients who had femoral debridement; 1 had 2 and the other had 5 debridements.

ACL autografts were left inside in all patients. Williams et al.[14] believed that the ACL graft could serve as a nidus for infection but also reported eradication of infection in cases with preserved ACL grafts. They recommended preservation of graft for the first debridement and removal in case of subsequent debridements. They also suggest that concomitant procedures are risk factors for infection after ACL reconstruction. Autografts and allografts were found to be similar in respect to infection after ACL reconstruction. Both were avascular initially and responded as foreign bodies.[6] Several authors reported that graft removal does not preclude revision ACL reconstructions that can be successfully performed with allografts.[5,6] We also retain the graft because of extra morbidity and cost of revision ACL reconstruction. The persistence of skin-joint tract because of the suture is a potential site for bacterial colonization. Although recent methods are less invasive, they had their peculiar disadvantages such as effusion observed after reconstruction with hamstring tendons. The relative shortness of the graft and intra-articular remaining suture material were supposed to cause an inflammatory reaction. We believe that effusion observed after reconstruction with hamstring tendons is a risk factor for postoperative drainage and subsequent infection.

Evaluation of knee stability by KT-1000 and physical examination revealed similar results with noncomplicated cases; however, the difference in the modified Lysholm score was attributed to other factors such as postinfectious damage to cartilage. Damage to articular cartilage and artrofibrosis was stated as the cause of inferior results.[1,5,9,20] In our series, similar results were obtained in terms of average procedures required to eradicate infection (2.66), average hospitalization (19.5 days), Lysholm knee scores (81.1), and joint space narrowing rates (16.6) when compared with graft-retaining postoperative septic arthritis series of McAlister et al.[5] The patients with early hardware removal in our series were slightly more lax but it did not seemingly affect the clinical results. Better

results were reported with primary graft removal and revision in small series, but there may have been other factors that influenced the result as stated by the authors.[11] Williams et al.[14] reported all patients able to perform daily activities, and 57% of the patients returned to athletic activities after treatment of infection. Although half of the infections were extra-articular in nature, they had lower Lysholm scores that may be explained with recurrent debridements and delayed rehabilitation.

Despite different techniques used for ACL reconstruction and with the advent of new less invasive techniques, infection is still a rare but devastating complication of ACL reconstruction. The relatively high infection rate in the hamstring group was attributed to the limited case number and effusion observed after operation, which may be related to a tissue reaction caused by intra-articular suture material. A limited number of the infected cases and heteorgenous nature of the infection (intra- and extra-articular) remain as major limitations for the analysis. Kruskal-Wallis analysis was used for statistical analysis revealing no significant difference concerning the incidence of infection, objective, and subjective outcome after infection in 3 different ACL reconstruction techniques revealing no significant difference.

CONCLUSION

Although it is a rare condition, the physician should consider infection in case of absence of improving symptoms even if signs are not evident. Although graft failure and postoperative symptoms of instability were not observed, the functional results were slightly inferior in infected patients. Although it is difficult to make a comparison with a limited number of cases, the results of our series supported our hypothesis that the technique used for ACL reconstruction had no significant effect on outcome after eradication of infection in our series.

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