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## The Knee



## Management of septic arthritis after arthroscopic anterior cruciate ligament reconstruction using a standard surgical protocol

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## ABSTRACT

**Background:** To report the incidence of septic arthritis after anterior cruciate ligament (ACL) reconstruction and management of this complication using a specific treatment protocol.

**Methods:** All primary ACL reconstructions performed in our institution between January 2002 and January 2014 were included in this study. Time to presentation, clinical symptoms, and culture results of all infected patients were analyzed. According to our protocol, an arthroscopic debridement and irrigation of the knee joint was performed immediately after a diagnosis of infection was made. In case of recurrence, knee irrigation with hardware and graft removal and later re-implantation was performed. Patients were evaluated with the Lysholm knee score, International Knee Documentation Committee (IKDC) Form, KT 1000 arthrometer and radiographic evaluation.

**Results:** Postoperative septic arthritis occurred in seven of 1242 patients (0.56%). After initial arthroscopic debridement, infection recurred in six out of seven cases (85%). Graft and hardware removal was performed in these patients. Graft re-implantation was performed in four patients at an average five months after infection. At the final follow-up (mean 6.3 years) all patients had full range of motion, while in patients with graft re-implantation the mean Lysholm score was 92, and the mean IKDC score was 87. Radiographs demonstrated that three patients had normal knees and one patient had a grade one, knee arthritis according to Kellgren–Lawrence classification.

**Conclusions:** Management of septic arthritis after ACL reconstruction using a specific surgical protocol which includes graft removal in case of infection recurrence with later re-implantation, can provide good and excellent results.

**Level of evidence:** Level IV, case series.

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### 1. Introduction

Infection after anterior cruciate ligament (ACL) reconstruction is a rare complication with a reported incidence between 0.15% and 1.72% [1–15]. Because of its rare incidence there is no consensus regarding appropriate management of this complication. According to the literature, most of the authors recommend arthroscopic irrigation with retention of the graft followed by intravenous antibiotic therapy. In almost one third of these cases, infection persists, and a repeated arthroscopic debridement and irrigation is performed by the vast majority of the authors until eradication of infection [9]. The overall success rate (defined as

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graft retention) of this procedure is almost 85% [9]. However, many of these patients managed with this protocol, suffer from persistent pain, knee stiffness and dysfunction, and development of arthritis [5,15,16]. Probably, this is because the infected ACL graft serves as a “continuing nidus of infection” and even after debridement, it is leading in cartilage destruction, pain and stiffness.

Very few surgeons recommend graft removal immediately or after failure of the initial arthroscopic debridement and later re-implantation [3,15]. Burks et al. [3] reported excellent results similar to primary ACL reconstruction after immediate removal of the infected graft and early re-implantation. Definitely, this is a high cost, staged operation but probably an effective treatment in case of infection after ACL reconstruction. In contrast, arthroscopic debridement is a more attractive option for both the surgeon and the patient but carries the risk of an inferior result especially after repeat irrigation [9].

We do believe that an immediate arthroscopic debridement and knee irrigation should be performed in case of infection after ACL reconstruction but if infection persists, graft and hardware removal should be performed to avoid further damage to articular cartilage and sequelae, like stiffness and pain.

The purpose of this study is to report the incidence and management of septic arthritis after ACL reconstruction using a specific protocol.

The protocol described herein first addressed affected patients using irrigation and debridement with graft retention. Patients were then observed. Those patients who demonstrated persistent signs of infection during the first week following surgery were then treated with repeat irrigation and debridement along with graft and hardware removal. Patients who underwent graft removal were eligible for graft re-implantation after successful eradication of the infection. Our hypothesis was that management of an infected ACL with this protocol could produce similar results to a primary ACL reconstruction regarding knee function.

## 2. Materials and methods

Between January 2003 and January 2014, 1242 primary ACL reconstructions were performed in our department. Procedures were performed in two operating theatres, by three different surgeons, including the senior surgeon (M.E.H.) who performed the vast majority (80%) of the reconstructions. Bone patellar tendon bone autograft was used in 311 (25%) patients while hamstring tendon autograft was used in the rest of the study population. Absorbable or metal interference screws were used on the femoral and tibial sides for graft fixation for the patellar tendon grafts, while for hamstring tendon graft fixation a button in the femur and a bioabsorbable interference screw and a post-fixation bicortical screw were used in the tibial side. Seven (0.56%) patients developed septic arthritis and a retrospective analysis of these patients was performed. Autologous hamstring tendon graft was used in all these patients. Symptoms like knee pain, effusion and fever, consistent with septic arthritis were present in almost every patient. In all these patients, a knee aspiration was performed before any other intervention, and an urgent arthroscopic debridement and knee irrigation was performed if more than 10,000 cells/mL were present, followed by intravenous antibiotic therapy, empirical initially, and then according to culture sensitivity. Time to presentation, laboratory results, synovial fluid analysis and culture results of all infected patients were analyzed. An extensive joint lavage combined with debridement of infected tissues, using at least 12–15 L of normal saline was performed. If symptoms (knee pain, effusion and fever) persist or did not resolve within three to five days after arthroscopic debridement, another arthroscopic debridement with graft and hardware removal was performed. Intravenous antibiotics were continued until resolution of symptoms and normalization of laboratory values such as C-reactive protein (CRP).

All patients who underwent graft removal, were offered subsequent graft re-implantation three months after the last operation. Requirements for graft re-implantation were normal knee motion, no knee effusion, and normal laboratory values. An ipsilateral patellar tendon graft was used in these cases for ACL reconstruction.

At the final follow-up clinical evaluation of the knee was performed using the KT-1000 arthrometer, the Lysholm, and International Knee Documentation Committee (IKDC) knee scores. Radiographic evaluation consisted of standing antero-posterior and lateral radiographs. All patients gave their informed consent to being included in the study; the study was approved by the local ethical committee.

A matched control group formed by 20 patients who underwent primary uncomplicated ACL reconstruction was used to compare functional results between groups. Matching criteria were age, sex, body mass index, side affected, limb dominance, associated meniscal injury, and time of follow-up.

One-way analysis of variance (ANOVA) was used to examine the differences between the control, and the infected group in baseline patient characteristics, functional scores and KT-1000 measurements. The Student t test was performed in order to identify differences in infection rate between the two graft types. The level of significance was set at  $p < 0.05$ .

## 3. Results

Seven out of 1242 (0.56%) patients during the study period developed septic arthritis after primary ACL reconstruction. All patients were male and autologous hamstring tendon graft was used in all cases. The infection rate was statistically significant higher ( $p < 0.05$ ) for the hamstring tendon grafts in comparison to the patellar tendon grafts. The average time to presentation of infection was 13 days (nine to 24). All but one patient developed an acute infection (less than two weeks after reconstruction). Knee effusion and pain as well as painful range of motion were present in all patients (Table 1). A concurrent partial medial meniscectomy was performed in three patients.

Knee aspiration was performed immediately and the aspirated knee joint fluid revealed an average of  $53.4 \times 10^9/L$  (range  $20.5\text{--}106.2 \times 10^9/L$ ) with 90% polymorphonuclear cells. Aspiration revealed a turbid synovial fluid in all cases. The mean CRP

**Table 1**  
Baseline characteristics of infected patients.

Case	Age	Sex	Duration of surgery (min)	Time to diagnosis of infection (days)	Symptoms	No. of procedures after infection	Hospital stay (days)
1	28	Male	45	11	P/E/F/W	2	30
2	36	Male	50	9	P/E/F	2	27
3	24	Male	50	10	P/E/F	2	31
4	19	Male	60	14	P/E/F	2	29
5	22	Male	45	24	P/E/F	2	34
6	28	Male	55	11	P/E/F	1	13
7	25	Male	50	13	P/E/F/W	2	28

P: knee pain/E: effusion/F: fever >38 °C/W: warmth.

level was 9.6 mg/mL (range 7.2–13.4 mg/mL). The mean peripheral white blood cell was  $8.9 \times 10^9/L$ . There was no delay of diagnosis and management, since all patients received treatment within 24 h of their presentation in our department.

All patients underwent a knee arthroscopy with extensive lavage using at least 12–15 L of normal saline and debridement of infected tissues. In all cases ACL grafts were found stable with normal appearance. The articular cartilage was not affected in any case according to arthroscopic appearance. Intravenous antibiotics were used after lavage according to culture results based on samples received from joint fluid and synovium. According to microbiology results coagulase-negative *Staphylococcus* was cultured in five cases and *Staphylococcus aureus* in the rest two cases. After initial debridement, symptoms (fever, pain and effusion) resolved in all patients. However, symptoms (after initial resolution or improvement) recur in six out of seven patients at approximately two to six days after debridement. A repeat arthroscopic debridement with graft, hardware removal and tunnel curettage in both sites (femur and tibia) was performed in these patients. Although CRP and Erythrocyte Sedimentation Rate (ESR) levels were elevated in all cases, the decision for a re-operation, was mainly a clinical decision. Intravenous antibiotics were used after second debridement surgery for approximately three weeks or normalization of ESR and CRP. A passive and active knee motion physical therapy program was prescribed for all patients followed by a knee strengthening program. Weight bearing gradually increased until resolution of symptoms. At the three month follow-up all six patients had normal knee motion, no knee effusion, normal laboratory values, and a positive Lachman-test.

Four out of six patients underwent graft re-implantation with ipsilateral bone patellar tendon bone, at an average five months (four to nine) after infection while the remaining two patients elected not to have an ACL reconstruction.

The mean follow-up time was 6.3 years (four to nine years). At the final follow-up the mean Lysholm score was 92 (87–95), the mean IKDC score was 86 (83–89) while the mean side to side difference in anterior tibial translation (KT-1000) was 1.4 mm for patients with graft re-implantation (Table 2). The mean Lysholm score was 58 (56 and 60), the mean IKDC score was 52 (50 and 54) while the mean side to side difference in anterior tibial translation (KT-1000) was 5.6 mm for the two patients without graft re-implantation.

Radiographs demonstrated that three patients had normal knees (Figure 1) and one patient had a grade one, knee arthritis according to the Kellgren–Lawrence classification. For the non-implanted patients radiographs demonstrated a grade one, knee arthritis according to the Kellgren–Lawrence classification. However these patients did not participate in athletic activities.

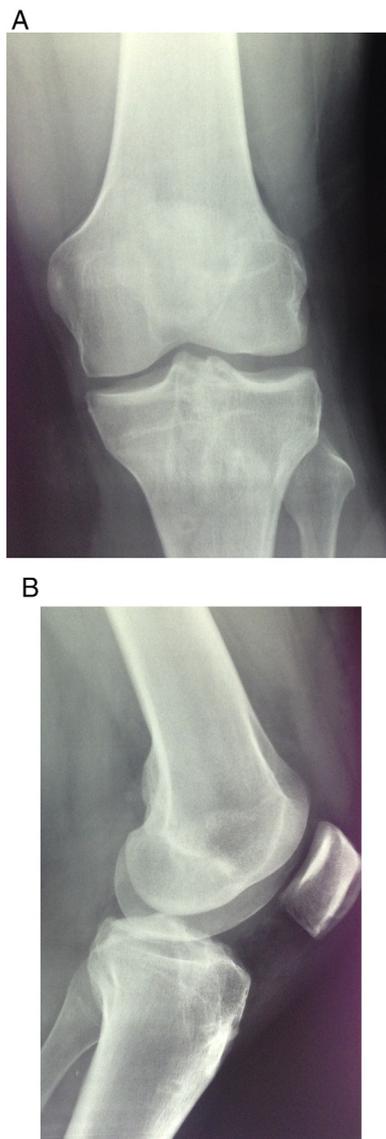
According to statistical analysis there were no differences between patients with graft re-implantation and patients with primary uncomplicated ACL reconstruction regarding the Lysholm score ( $p = 0.165$ ), the mean IKDC ( $p = 0.211$ ) and the mean side to side difference in anterior tibial translation ( $p = 0.267$ ).

#### 4. Discussion

According to our protocol, septic arthritis after ACL reconstruction, was managed with an arthroscopic debridement and irrigation of the knee joint initially, and graft/hardware removal in case of persistence of the infection. We believe that early diagnosis and treatment could eradicate infection, thus the first step of our protocol was arthroscopic debridement and irrigation. However, this treatment was effective only in one (15%) out of seven cases. Since our main concern is to protect the articular cartilage and knee function and not the graft, we elected to proceed with graft and hardware removal in these cases to maximize infection treatment. This is because we believe that an avascular tissue and foreign material within the joint will serve as a nidus and continue to promote infection since initial arthroscopic debridement was not effective. Perhaps biofilm formation around the devascularized graft and fixation

**Table 2**  
Results of infected patients treated with graft re-implantation.

Patient	Lysholm	IKDC	KT 1000 (mm)
1	95/100	83/100	1.2
2	92/100	89/100	1
3	87/100	85/100	1.7
4	93/100	87/100	1.6
Total	92/100	86/100	1.4



**Figure 1.** Anteroposterior (A) and lateral (B) radiograph of the knee of a patient (No 5) seven years after graft re-implantation (bone patellar tendon bone graft fixed with absorbable screws) showing no signs of arthritis.

material was the main cause for initial treatment failure. Using this protocol, our results were similar to a primary ACL reconstruction, regarding knee function and arthritis development in a short to long-term follow-up.

Although arthroscopic irrigation and debridement is the first line treatment for the vast majority (95%) of surgeons in cases of an infected ACL autograft, it is not clear how these patients should be treated in the event of a persistent infection [9]. According to the results of a survey among sports medicine fellowship directors, only 36% of them selected graft removal in case of a persistent infection and the rest of them would go for a repeat arthroscopic debridement [8]. The overall success rate of this procedure (defined as graft retention) is almost 85% [9]. However, knee function is severely impaired and the results are inferior, when compared with patients after uncomplicated ACL reconstruction according to the published studies [9,13,21]. Many of these patients develop residual stiffness and arthrofibrosis, and arthroscopic lysis of adhesions or manipulation under anesthesia is required to overcome this problem [5,15,16]. Even after these procedures, a flexion or an extension deficit remains in 50% of these patients and it is the most common cause of unsatisfactory result in the short-term follow-up [5,15,16]. This is probably because retained microbes (in case of failure of initial debridement) promote an inflammatory reaction for prolonged period resulting in pain and stiffness. We had no restrictions in knee motion and all of our patients had a normal knee motion. We assume that, this is the result of radical infection treatment with graft and hardware removal and microbe deposition from the knee joint after failure of the initial debridement. Our results are in accordance to Burks et al. [3] who reported on eight patients with postoperative knee infection after ACL reconstruction. Immediate

graft removal was performed in seven of them with excellent results regarding knee motion. A restriction in knee joint motion was noted in the patient with arthroscopic irrigation and graft retention.

Another potential complication of infection after ACL reconstruction even in a short-term follow-up is development of degenerative changes and arthritis. McAllister et al. [16] reported that all four patients who sustained septic arthritis after ACL reconstruction, had radiographic evidence of osteophyte formation and joint space narrowing at an average three years follow-up, after repeat arthroscopic debridement (2.75 procedures) and graft retention. Although the authors stated that the “infection was successfully eradicated” the presence of persistent intra-articular bacteria that are incompletely removed can have an adverse effect on articular cartilage and can lead to articular cartilage destruction and arthritis. The long-term (17.9 years) follow-up of these four patients revealed that these patients had severe pain and limited knee function because of advanced arthritis [11]. We agree with Williams et al. [15] who reported that, “if symptoms suggestive of persistent infection continue after the initial arthroscopic debridement consideration for removing the graft could be given at subsequent irrigation”. In this way, a radical infection treatment is provided, since all avascular tissue and foreign material from within the joint are removed and cartilage breakdown is avoided. According to our results three patients had normal knees and one patient had a grade one knee arthritis according to the Kellgren–Lawrence classification, 6.3 years after graft re-implantation. Similarly, no patient had evidence of knee arthritis when an immediate graft removal and early re-implantation was performed, according to Burks et al. [3] probably because adverse effects of persistent infection in the face of a retained infected graft were avoided.

The final result of the patients with graft re-implantation was similar to patients with primary uncomplicated ACL reconstruction regarding Lysholm score, IKDC score and the mean side to side difference in anterior tibial translation. Comparable results to primary ACL reconstruction have been reported also, by Burks et al. [3] after graft removal and early re-implantation. This is in contrast with the results of the published studies describing patients treated with repeated arthroscopic debridement and graft retention [2,5,10,11]. The inferior results of these patients are mainly due to knee pain and arthrofibrosis and not because of knee instability. We believe that post-infection synovitis because of incomplete eradication of infection is responsible for these complications. As we stated earlier, the avascular graft and hardware fixation continue to serve as a nidus and continue to promote infection and synovitis, if initial arthroscopic debridement is not effective. Thus, removal of graft and hardware, eliminates infection in the same way as removal of an infected knee arthroplasty. Polymicrobial infection could be another cause of persistent septic arthritis, after ACL reconstruction, despite knee irrigation and debridement. According to Zalavras et al. [17] graft removal as well as removal of any implants and curettage of osseous tunnels is necessary in these cases to eradicate infection.

The causative agent for septic arthritis in our study population was coagulase-negative *Staphylococcus* in five cases and *Staphylococcus aureus* in the rest two cases. This is in accordance with the literature since *Staphylococcus* is the most common isolated microorganism in published studies [3,9,14,15]. Probably the more virulent bacteria (coagulase-negative *Staphylococcus* and *Staphylococcus aureus*) in comparison to *Staphylococcus epidermidis* was one of the reasons for failure of arthroscopic irrigation and debridement in the vast majority (85%) of our patients. In addition, the intensity of clinical symptoms (knee pain, effusion and fever) in almost every patient in our series, could be due to the virulence of the specific bacteria.

The clinical symptoms and the synovial fluid cell count (more than  $20 \times 10^9/L$  with 90% polymorphonuclear cells in each case) were the most important factors in influencing the initial treatment. Recurrence of clinical symptoms, after initial resolution or improvement despite antibiotic therapy was the most important factor for graft and hardware removal. All patients received culture specific intravenous antibiotics for approximately three weeks and had an uneventful course and normalization of CRP at the end of the treatment. Although there is no consensus regarding time for graft re-implantation after graft removal, we elected not to perform the revision surgery earlier than three months after the graft removal and until patients had normal knee motion and normal laboratory values. The results of our series for the patients who elected to undergo graft re-implantation were excellent with no recurrence of infection. Although the number of patients was small, it seems that a three month interval for the subsequent revision is safe.

Although, one fourth of our ACL reconstructions were performed using bone patellar tendon bone autograft, all of our infected cases occurred with hamstring tendon autograft. There was a statistically higher incidence of infection when hamstring tendon grafts were utilized in our series. Maletis et al. [7] based on the results from a large registry (10,626 cases) reported that the hamstring autograft had a highest incidence of infection after ACL reconstruction in comparison to bone patellar tendon bone autografts and allografts. Probably this is due to longer graft preparation time, and more suture material along the hamstring grafts in comparison to bone patellar tendon bone grafts or allografts, which can potentially lead to graft contamination [18–22]. However, other studies reported that there was no difference between hamstring grafts and bone patellar tendon bone autografts regarding infection rate after ACL reconstruction [2]. Finally, bacterial contamination may come also from exogenous sources. Parada et al. [22] identified contamination in the cannulated portion of the screwdriver used for tibial fixation, which led to an increased rate of infection.

Except graft type it is really difficult to determine other causes of infection in our series, since no time consuming or concurrent procedures (like meniscal repair) were performed. In addition, operations were performed under stable conditions regarding surgical team, operation theatre and patient's characteristics (young and healthy patients).

This study has some limitations which must be acknowledged. First of all, the number of patients was small and therefore, our results should be interpreted within the context of this limitation. On the other hand, given the low incidence of infection after ACL reconstruction in our series (0.56%) as well as in most of the published studies, it would be extremely difficult to increase the number of patients. Another limitation was that, there was no group of patients treated with repeated arthroscopic debridement and irrigation in cases of persistent infection which could allow making a direct comparison between the two treatment options. However, this was not possible from an ethical point of view, since we decided to treat our patients using a specific protocol which could give them the

best possibility for infection eradication. On the other hand, our results are superior to those published studies with patients treated with repeated arthroscopic debridement and graft retention, although direct comparison with other series is not always possible.

## 5. Conclusion

Infection after ACL reconstruction was very rare in our series (0.56%). An initial arthroscopic debridement and irrigation of the knee joint is the first step for the management of the septic knee. However, in case of persistence of the infection, knee irrigation with hardware and graft removal should be performed and a later (more than three months) graft re-implantation is recommended. Using this protocol, similar results to a primary ACL reconstruction regarding knee function could be obtained according to our series.

## Abbreviations and acronyms

ACL	anterior cruciate ligament
IKDC	International Knee Documentation Committee
CRP	C-reactive protein
ESR	Erythrocyte Sedimentation Rate

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