

Postoperative Septic Arthritis After Anterior Cruciate Ligament Reconstruction: Does It Affect the Outcome? A Retrospective Controlled Study

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Purpose: To determine whether the outcome after septic arthritis after anterior cruciate ligament reconstruction (ACLR) is inferior compared with uncomplicated ACLR when treated promptly by use of a standard protocol. **Methods:** At Capio Arthro Clinic, 4,384 primary ACLRs were performed during 2001-2009. All patients with postoperative septic arthritis were retrospectively reviewed, and 43 met the inclusion criteria. Twenty-seven patients agreed to re-examination (infection group) and were compared with 27 matched patients with uncomplicated ACLR (control group). The mean follow-up period was 60 months and 66 months in the infection group and control group, respectively. Re-examination included objective (radiographs, physical examination, functional testing, range of motion, strength, stability, International Knee Documentation Committee questionnaire) and subjective (Knee Injury and Osteoarthritis Outcome Score, Tegner score, Lysholm score, European Quality of Life–5 Dimensions, subjective satisfaction questions, Single Assessment Numeric Evaluation of knee function, visual analog scale pain rating) evaluation. **Results:** There were no significant differences in objective knee function between the groups at follow-up. For subjective knee function, no significant differences between the groups were detected with the Single Assessment Numeric Evaluation score, pain during activity, or Lysholm score. The infection group scored lower on 4 of 5 Knee Injury and Osteoarthritis Outcome Score subscales: pain ($P = .014$), function in daily living ($P = .008$), sports/recreation ($P = .015$), and quality of life ($P = .007$). The infection group scored lower versus control patients on the Tegner score ($P = .001$) and European Quality of Life–5 Dimensions scores ($P = .004$). Both groups improved over time, but the control group scored better only on the Tegner score ($P = .004$). **Conclusions:** Septic arthritis after ACLR did not result in inferior objective knee function compared with uncomplicated ACLR. Subjectively, infection patients were as satisfied as non-infection patients, but rehabilitation took longer and fewer patients returned to sports. The findings of this study suggest that anterior cruciate ligament grafts may be retained with prompt, thorough arthroscopic lavage and debridement; correct antibiotics according to cultures; and repeated arthroscopy if necessary. **Level of Evidence:** Level III, retrospective case-control therapeutic study.

The incidence of anterior cruciate ligament (ACL) ruptures in Sweden is approximately 80 per 100,000 persons,^{1,2} and about half of these patients undergo

anterior cruciate ligament reconstruction (ACLR). Arthroscopic surgery with hamstring tendon autograft is the most commonly used reconstruction method in Sweden today; only 2% of patients receive a bone–patellar tendon–bone graft.¹

Postoperative deep infection after ACLR—septic arthritis of the knee—is a rare but dreaded complication. International studies have shown infection rates of between 0.14% and 1.7%,³⁻¹⁶ and the incidence of postoperative infection in Sweden is not clear.¹

Septic arthritis of the knee after ACLR can lead to additional multiple surgical procedures and cause inferior functional and subjective results, continued instability, and prolonged recovery, as well as loss of cartilage and arthrofibrosis, if treatment is delayed.^{6,7,9-11,17-19} Treatment can include open or arthroscopic surgery. All over the world, surgeons have agreed on the importance of immediate treatment of postoperative infection

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after ACLR. However, there is no consensus regarding the type of treatment because of the rareness of this complication.^{5,7,20} Mixed results have been reported on the necessity of removing the graft.^{3,5-7,9,12,13,15}

The purpose of this study was to determine whether the outcome after septic arthritis after ACLR is inferior compared with uncomplicated ACLR when treated promptly by a standard protocol (Fig 1). Our hypothesis was that septic arthritis does not necessarily result in inferior outcomes after ACLR if detected and treated

early with repeated arthroscopic lavage and keeping the graft.

Methods

In this retrospective case-control study, all patients in whom septic arthritis developed after ACLR at Capiro Arthro Clinic during 2001-2009 were identified, and their records were retrospectively reviewed during 2010. To be eligible for inclusion, patients had to have undergone ACLR at Capiro Arthro Clinic during

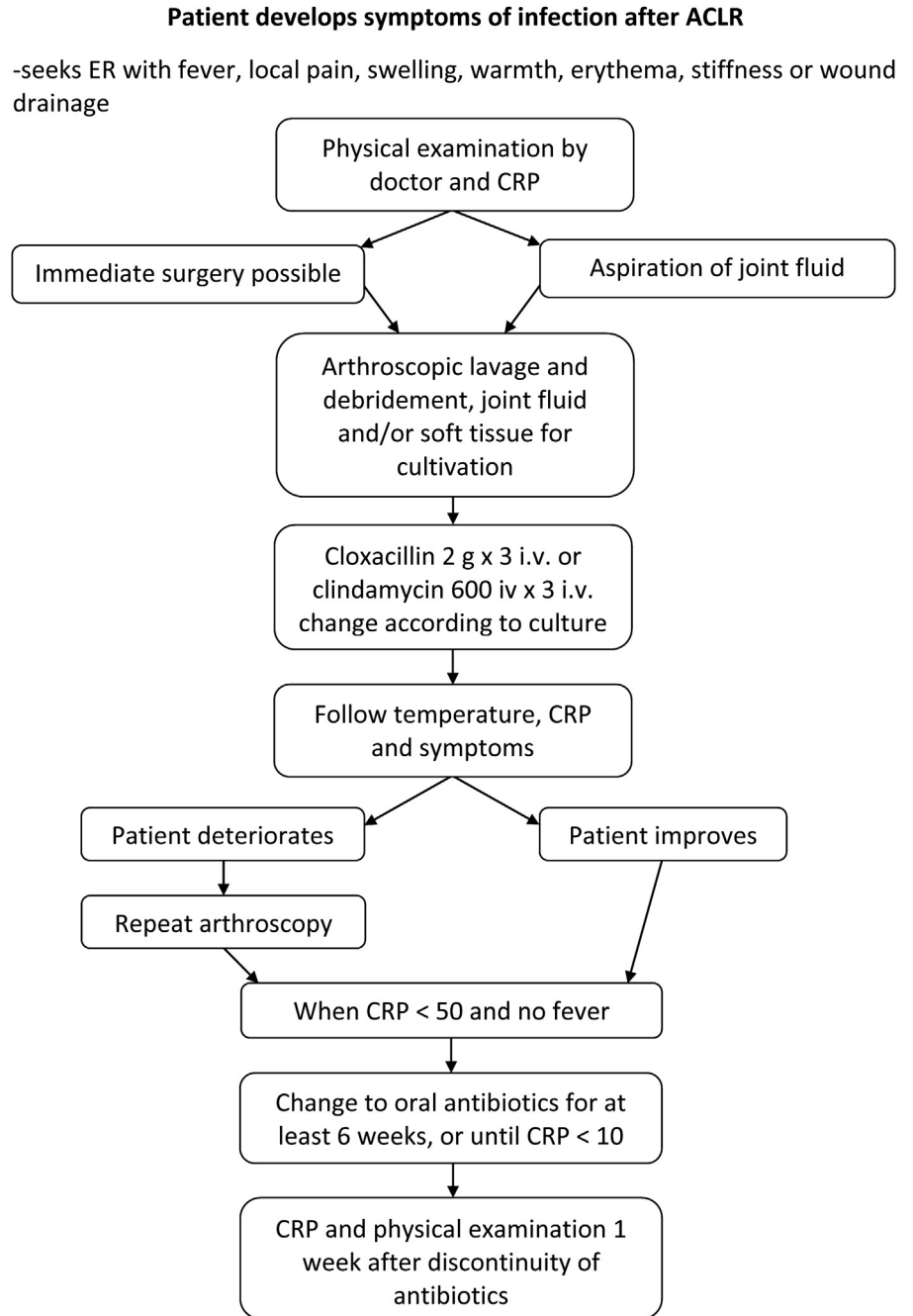


Fig 1. Standard treatment protocol for septic arthritis after ACLR at our clinic. ER, emergency room.

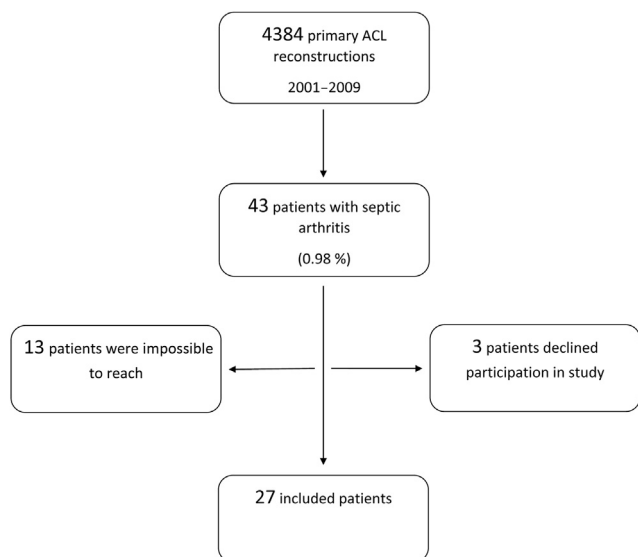


Fig 2. Flowchart for infection patients eligible for study.

2001-2009 and their rehabilitation had to be completed. A minimum of 12 months' follow-up and a positive culture from joint fluid or soft tissue from the knee were required. The exclusion criteria were malignancy, pregnancy, and negative cultures despite symptoms of septic arthritis. Of the 49 infection patients retrieved, 6 were excluded because of negative cultures despite having been treated for septic arthritis. Twenty-seven patients met the inclusion criteria and gave consent for inclusion (Fig 2). The study was approved by the Research Ethics Committee of Stockholm North (DNR 2010/1450-31/1). Written informed consent was obtained from all participating patients.

The infection patients (infection group) were matched with a group of 27 ACL-reconstructed patients without infection (control group) with the same sex, age, type of graft, surgeon, and follow-up time. The infection patients were individually matched with 1

patient in the control group operated on by the same surgeon within the same period. All patients received hamstring autografts, tripled or quadrupled semitendinosus tendon grafts, or semitendinosus and gracilis tendon grafts. Data from the patients charts were collected. At inclusion, no significant differences were found between the groups in terms of demographic data, duration of surgery, previous surgery in the ACL-reconstructed knee, concomitant injuries, Tegner score, Lysholm score, European Quality of Life-5 Dimensions (EQ-5D), or Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales except for the KOOS pain subscale ($P = .045$) (Tables 1 and 2). The mean follow-up time was 60 months (range, 13 to 108 months) for the infection group and 66 months for the control group (range, 16 to 114 months). There were only 3 patients with a follow-up time of less than 34 months in each group.

Clinical Evaluation

Data from the routine preoperative and 6-month postoperative visits were collected. These visits included physical examination by the patient's surgeon, 1 of the 13 different specialists in orthopaedic surgery involved, and physiotherapist, during which range-of-motion (ROM) testing, KT-1000 arthrometry (MEDmetric, San Diego, CA) testing, and isokinetic muscle torque assessment were performed. Concentric and eccentric muscle torque of the quadriceps and hamstring muscle groups was tested with a Biodex dynamometer (Biodex Medical Systems, Shirley, NY) at 90°/s. At final follow-up, all patients were individually interviewed in person, examined by the same independent orthopaedic surgeon, and tested by the same experienced physiotherapist. This visit included functional performance testing, consisting of single-legged jumps for distance, Biodex testing and evaluation of knee stability with KT-1000 arthrometry, and measurement of ROM. Both knees were assessed in 20° of

Table 1. Demographic Data of Patients Included in Study

	Infection Group (n = 27)	Control Group (n = 27)	P Value Between Groups
Female sex [n (%)]	14 (52)	14 (52)	>.99
Follow-up time [mean (range)] (mo)	60 (13-108)	66 (16-114)	.443
Age at trauma [mean (range)] (yr)	27 (16-43)	28 (14-43)	.758
Patients with manual labor employment [n (%)]	6 (22)	3 (11)	.467
Soccer players [n (%)]	14 (52)	10 (37)	.273
Time from trauma to surgery [mean (range)] (mo)	16 (1-180)	14 (2-96)	.766
Duration of surgery [mean (range)] (min)	83 (44-149)	84 (40-125)	.884
Patients with previous surgery in same knee [n (%)]	11 (41)	12 (44)	.783
Patients with concomitant injuries in knee [n (%)]	13 (48)	11 (41)	.584
Meniscal tears	10	9	
Chondral lesions	3	5	
MCL injuries	2	0	
Degenerative cartilage	1	1	

MCL, medial collateral ligament.

Table 2. KOOS, Tegner Score, Lysholm Score, EQ-5D Score, and KT-1000 Measurement Before and 6 Months After ACL Surgery

	Preoperatively			After 6 mo		
	Infection Group (n = 26)	Control Group (n = 27)	P Value Between Groups	Infection Group (n = 27)	Control Group (n = 27)	P Value Between Groups
KOOS pain	74 (36-100)	83 (53-97)	.045	86 (50-100)	90 (61-100)	.228
KOOS symptoms	73 (32-96)	80 (50-96)	.141	82 (29-100)	87 (61-100)	.258
KOOS ADL	84 (46-100)	91 (57-100)	.073	91 (65-100)	97 (84-100)	.015
KOOS sports/recreation	47 (5-95)	52 (5-90)	.504	68 (30-100)	77 (25-100)	.172
KOOS quality of life	31 (0-69)	37 (13-69)	.232	61 (25-100)	67 (13-100)	.298
Tegner	3.9 (0-9)	3.2 (0-9)	.194	4.8 (2-8), n = 24	4.9 (1-9)	.711
Lysholm	68 (28-95)	70 (40-95)	.694	83 (51-100), n = 24	88 (71-100)	.307
EQ-5D	0.808 (0.62-1.0), n = 15	0.79 (0.62-1.0), n = 14	.735	—	—	—
KT-1000 (mm)	13 (5-17)	14 (9-18)	.120	10 (5-13), n = 23	11 (6-15)	.765
Single-legged jump (% of uninjured leg)	—	—	—	92 (68-114), n = 19	96 (66-120), n = 24	.496

NOTE. The variables are presented as mean (range).

flexion, and the results were recorded in millimeters. Patients were asked when they noticed the onset of symptoms of infection.

The International Knee Documentation Committee Knee Examination Form was completed during the follow-up visit. This form uses objective data from the physical examination, radiographs, arthrometer test, and functional tests.²¹

Questionnaires

At the preoperative, 6-month postoperative, and final follow-up visits, patients answered validated questionnaires, designed for self-completion. The KOOS, Swedish version, consists of 5 subscales: pain, other symptoms, function in daily living (ADL), function in sports and recreation, and knee-related quality of life. The score uses standardized answer options, and each answer is scored from 0 to 4. The result (0 to 100, where 100 is the best score) was calculated for each dimension and plotted as an outcome profile.^{22,23}

The Lysholm Knee Scoring Scale was developed specifically for assessment after knee ligament surgery. It is graded from 0 to 100, where 100 is the best score.²⁴ Activity levels were rated using the Tegner Activity Scale, which is graded from 0 to 10, where 10 is the best score.²⁵ The EQ-5D was used to measure health-related quality of life.²⁶

At follow-up, an additional questionnaire, the Single Assessment Numeric Evaluation, was completed. This consists of a single subjective evaluation score of 0 to 100, where 100 is considered to indicate normal function.²⁷ Pain in the ACL-reconstructed knee during activity was also evaluated at follow-up with a visual analog scale, which is scored from 0 to 100, where 0 indicates no pain and 100 indicates the worst imaginable pain.²⁸ Finally, patients were asked whether they would make the same choice about surgery despite having the knowledge of the outcome.

Radiologic Evaluation

All patients had bilateral radiographs taken at follow-up to determine whether there were signs of osteoarthritis present in the knee joint. The examination consisted of a weight-bearing (standing) anteroposterior view in 0° of flexion, standing lateral view in semi-flexion, and axial view of the patella (skyline view). The classification system of osteoarthritis according to Ahlbäck²⁹ was used.

Surgical Technique

All patients prepared for surgery by taking 2 showers with chlorhexidine. They were given 2 g of cloxacillin (or 600 mg of clindamycin if allergic to penicillin) intravenously (IV), 30 to 60 minutes preoperatively. Surgery was performed with patients under general anesthesia. A tourniquet was activated. The graft, semitendinosus tendon or semitendinosus and gracilis tendons, was harvested through a 3- to 4-cm-long incision at the site of the pes anserinus. ACL remnants were cleared with a shaver, and the tibial tunnel was drilled through the same incision. Graft preparation was performed on a separate graft table, tripled or quadrupled. The femoral tunnel was drilled through the tibial tunnel or an accessory anteromedial portal. The graft was pulled into position and fixated with an EndoButton CL (Smith & Nephew, Andover, MA) or Rigidfix (DePuy Mitek, Raynham, MA) device, and isometry was controlled. Distal fixation was achieved with a screw and washer (post) or Intrafix device (DePuy Mitek). The incisions were closed in layers and covered with a dressing, which was changed at the first follow-up visit, after 14 days. Patients were informed of the signs of infection and told to contact the clinic immediately if the signs occurred.

Rehabilitation

An ice bandage was used for 10 to 14 days and crutches for 2 to 4 weeks. Weight bearing, but no active extension against resistance, was allowed for the first

3 months. Muscular training with a physiotherapist lasted for 6 to 12 months, starting 7 to 10 days after surgery. Follow-up visits with the surgeon took place at 6 weeks and 6 months. Rehabilitation was considered completed when the ACL-reconstructed leg had obtained 90% of the torque in the quadriceps and hamstring muscle groups of the contralateral leg. If the goals of rehabilitation were not fulfilled at 6 months, the patients were followed up by their physiotherapist and surgeon until completion of the rehabilitation. Only then were patients allowed to return to sports.

Infection Group Testing and Treatment

Patients with postoperative infection after ACLR were treated according to the clinic's standard treatment protocol for septic arthritis after ACLR (Fig 1). Postoperative infections were classified as acute (<2 weeks, $n = 24$), subacute (2 weeks to 2 months, $n = 3$), or late (>2 months, $n = 0$).^{5,13,15}

The mean interval between ACLR and the onset of infection symptoms was 8 days (range, 1 to 22 days; median, 7 days). Patients contacted the clinic with symptoms of infection after a mean delay of 4 days (range, 0 to 11 days; median, 1 day). They were then examined urgently with laboratory tests including C-reactive protein (CRP) level, and aspiration from the knee joint was performed. If immediate surgery was possible, aspiration was refrained from, so microbiology samples of joint fluid and/or soft tissue were collected during the surgical intervention. The CRP level (normal value, <5 mg/L) was increased to a mean of 203 mg/L (range, 50 to 400; median, 179). The cell count was missing in approximately 50% of patients and is therefore not reported. Microbiology samples of joint fluid and/or soft tissue showed coagulase-negative staphylococci (CNS) in 20 patients, of whom 4 were typed as *Staphylococcus lugdunensis*, 1 as *Staphylococcus capitis*, and 1 as *Staphylococcus epidermidis*. *Staphylococcus aureus* was isolated from 5 patients, and *Klebsiella oxytoca* and *Propionibacterium acnes* were found in 1 patient each. Eight of the CNS infections were methicillin resistant.

Patients were treated with arthroscopic lavage, requiring a mean of 3.7 interventions (range, 1 to 11; median, 3). The first arthroscopic lavage took place at a mean of 13 days (range, 6 to 29; median, 12 days) after ACLR. This included a doctors' delay (mean, 0.8 days; range, 0 to 5 days; median, 0 days) from the patients' first visit to the emergency department. The same portals were used as during the ACLR, and the arthroscopic lavage included all compartments. Careful debridement with a shaver was carried out if the soft tissue looked necrotic. At least 9 L of lactated Ringer solution was used. The graft was visualized and evaluated as unaffected in 23 of 27 patients. In 3 patients the grafts seemed hyperemic, and 1 graft appeared somewhat roughened. All grafts were tested and shown to be

stable and were retained. Patients were admitted and treated initially with IV cloxacillin 2 g 3 times daily (or clindamycin 600 mg 3 times daily if allergic), starting after soft-tissue collection for cultivation. A specialist in infectious diseases was consulted when the cultures were final, and the antibiotic therapy was optimized according to the sensitivity of the isolated organism. The arthroscopic procedure was repeated if the patient had persistent fever, swelling, and a CRP level greater than 50 mg/L.

IV antibiotic treatment continued until the patient had a normal temperature and the CRP level was decreasing, which occurred at a mean of 10 days (range, 2 to 25 days; median, 10 days). Oral antibiotics were then continued for a mean of 7.6 weeks (range, 4 to 18 weeks; median, 6 weeks) until the CRP level was less than 10 mg/L in all patients except for 1, whose treatment was ended at a CRP level of 15 mg/L. The hospital admittance time averaged 11 days (range, 1 to 25 days; median, 10 days).

Statistical Methods

The primary outcome was the between-group comparison of the KOOS subscales at follow-up. The minimal clinically detectable change is 10 points.³⁰ The required sample size was calculated to be 17 patients in each group to detect a difference of 10 points with an α error of .05 (2-tailed test) and β error of .20 (power, 80%).

SPSS software (version 20.0; IBM, Armonk, NY) was used for statistical testing. Variables were summarized with standard descriptive statistics such as frequency, mean, and standard deviation. Categorical variables (e.g., group ν sex) were analyzed with the Pearson χ^2 method or Fisher exact test if the expected cell frequency was 5 or less. Differences between groups in, for example, age and KOOS were analyzed with the Student t test. For severely skewed variables such as latency, a nonparametric Mann-Whitney U test replaced the Student t test. Differences in the change in the KOOS score from baseline to follow-up were analyzed with analyses of variance for repeated measurements, in which differences between groups in change appeared as an interaction effect (Group \times Time). The significance level for all analyses was 5% (2 tailed).

Results

Functional Assessments

Preoperatively, the infection group scored significantly inferior to the control group on the KOOS pain subscale ($P = .045$) but not on the other KOOS subscales or any other measure (Table 2 and Fig 3). Both groups showed significant improvement from preoperatively to follow-up (all $P < .05$) (Tables 2-4).

On the KOOS ADL subscale, but not the other KOOS subscales, the infection group scored worse than the control group at 6 months postoperatively ($P = .015$).

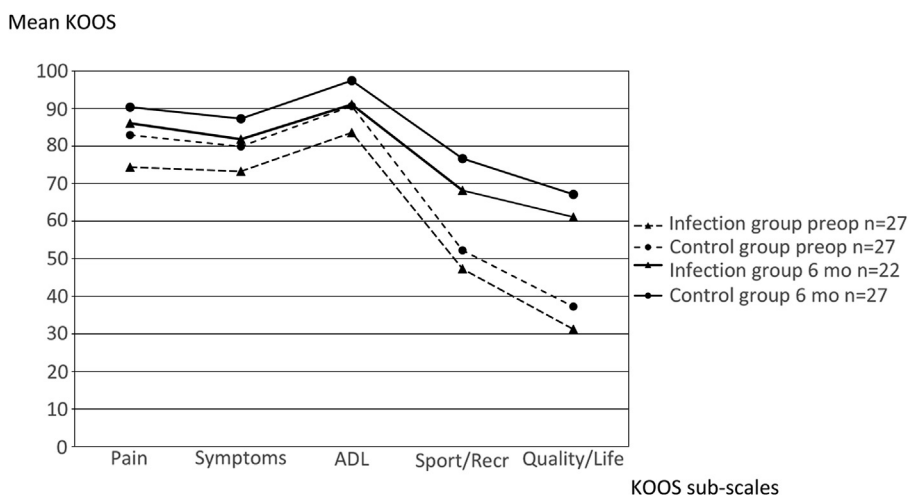


Fig 3. KOOS for infection patients and control group before surgery and 6 months after surgery. (preop, preoperatively; Recr, recreation.)

(Table 2 and Fig 3). No differences between the groups were observed for the Tegner and Lysholm scores. Too few patients completed the EQ-5D at 6 months (2 patients and 13 patients in the infection and control groups, respectively); therefore these results are not presented. There was no difference in KT-1000 arthrometry assessment or when comparing the ACL-reconstructed leg with the contralateral leg with single-legged jumps between the groups at this time point. However, it should be noted that at 6 months, some patients did not feel confident enough to complete the jumps; therefore data exist from 19 patients in the infection group and 24 patients in the control group. There was no difference in function assessed by average peak torque deficit between the uninjured and reconstructed legs, either in the hamstring or quadriceps muscle groups, in concentric or eccentric muscle torque at 90°/s at 6 months ($F_{1,47} = 0.44, P = .508$).

At follow-up, the infection group had significantly poorer results on the KOOS pain, ADL, sports/recreation, and quality-of-life subscales (Fig 4 and Table 3).

The Tegner and EQ-5D scores were also significantly lower for the infection group. The Lysholm and International Knee Documentation Committee scores showed no difference between groups. No significant differences in knee stability according to KT-1000 arthrometry testing or in functional tests with single-legged jumps were found. Regained strength of the ACL-reconstructed leg compared with the uninjured leg was comparable between the groups, in both the hamstring and quadriceps muscle groups, in concentric and eccentric muscle torque at 90°/s ($F_{1,52} = 0.99, P = .324$). The groups did not differ in subjective satisfaction with knee function after surgery by use of the Single Assessment Numeric Evaluation score or the visual analog scale score for pain during activity.

When comparing the improvement over time from preoperatively to follow-up, there were no significant differences between the groups in KOOS, Lysholm score, KT-1000 assessment, or functional performance with single-legged jumps (Table 4). The only significant difference was noted in the Tegner activity scale. The

Table 3. KOOS, Tegner Score, Lysholm Score, IKDC Score, EQ-5D Score, KT-1000 Measurement, Single-Legged Jump, SANE Score, and VAS Score at Follow-Up

	Infection Group (n = 27)	Control Group (n = 27)	P Value Between Groups
Follow-up (mo)	60 (13 to 108)	66 (16 to 114)	.443
KOOS pain	82 (36 to 100)	93 (56 to 100)	.014
KOOS symptoms	79 (21 to 100)	88 (46 to 100)	.063
KOOS ADL	89 (43 to 100)	98 (85 to 100)	.008
KOOS sports/recreation	65 (5 to 100)	82 (30 to 100)	.015
KOOS quality of life	61 (0 to 100)	78 (31 to 100)	.007
Tegner	5.1 (1 to 8)	6.5 (4 to 10)	.001
Lysholm	81 (46 to 100)	87 (33 to 100)	.091
IKDC (n)	13 A, 11 B, and 3 C	17 A and 10 B	.117
EQ-5D	0.765 (-0.077 to 1.0)	0.909 (0.7 to 1.0)	.004
KT-1000 (mm)	11 (4 to 23)	11 (7 to 16)	.924
Single-legged jump (% of uninjured leg)	96 (70 to 111)	100 (80 to 113)	.061
SANE	67 (7 to 98)	78 (25 to 100)	.146
Pain during activity (VAS)	13 (0 to 81)	12 (0 to 53)	.608

NOTE. The variables are presented as mean (range) unless otherwise indicated.

IKDC, International Knee Documentation Committee; SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale.

Table 4. Improvement in KOOS, Tegner Score, Lysholm Score, EQ-5D Score, KT-1000 Measurement, and Single-Legged Jump Over Time in Infection Group Compared With Control Group

	P Value Between Groups		
	Improvement From Preoperatively to 6 mo	Improvement From 6 mo to Follow-Up	Improvement From Preoperatively to Follow-Up
KOOS pain	.325	.283	.958
KOOS symptoms	.772	.603	.918
KOOS ADL	.572	.892	.908
KOOS sports/recreation	.941	.417	.226
KOOS quality of life	.998	.278	.163
Tegner	.107	.084	.004
Lysholm	.428	.900	.441
EQ-5D	Not presented because too few patients completed EQ-5D	Not presented because too few patients completed EQ-5D	Not presented because too few patients completed EQ-5D
KT-1000	.138	.711	.141
Single-legged jump	—	.304	—

control group had a significantly higher degree of improvement ($P = .004$), from a mean of 3.2 to 6.5, compared with infection group patients, who improved from a mean of 3.9 to 5.1.

Fewer patients returned to their sport in the infection group than in the control group (15 patients *v* 22 patients, $P = .040$), and rehabilitation took longer (mean of 13 months [range, 6 to 42 months; median, 12 months] *v* mean of 8 months [range, 4 to 18 months; median, 7 months]; $P = .001$). Patients in both groups almost regained their preoperative ROM, lacking on average only 1° to 2° of extension (range, 0° to 10°; $P = .312$) and 3° to 4° of flexion (range, 0° to 25°; $P = .768$). With knowledge of the outcome, 22 patients (82%) would still have chosen surgery in the infection group versus 27 patients (100%) in the control group ($P = .051$).

Radiologic Outcome

The bilateral radiographs taken at follow-up showed radiologic signs of subtle degeneration in the cartilage—Ahlbäck grade 1—in 9 patients in the

infection group and 8 patients in the control group ($P = .770$). There were no signs of degeneration in the unaffected knee except in 1 patient in the infection group, who had Ahlbäck grade 1 cartilage degeneration bilaterally. No preoperative examination for comparison exists; therefore the results were not further evaluated.

Of the 43 eligible patients with septic arthritis after ACLR, 16 patients were lost to follow-up, of whom 3 declined participation in the study. Among the remaining 13, we were able to conclude by studying the patients' charts that 5 returned to their previous level of sports, all at an elite level. Four patients had satisfactory results 1 year after ACLR, 2 patients did not return to their sport, and 2 patients have not returned to the clinic and their results are therefore unknown.

Discussion

This study is, to our knowledge, the largest re-evaluation of ACL-reconstructed patients after septic arthritis to date, as well as one of the few comparisons with uncomplicated

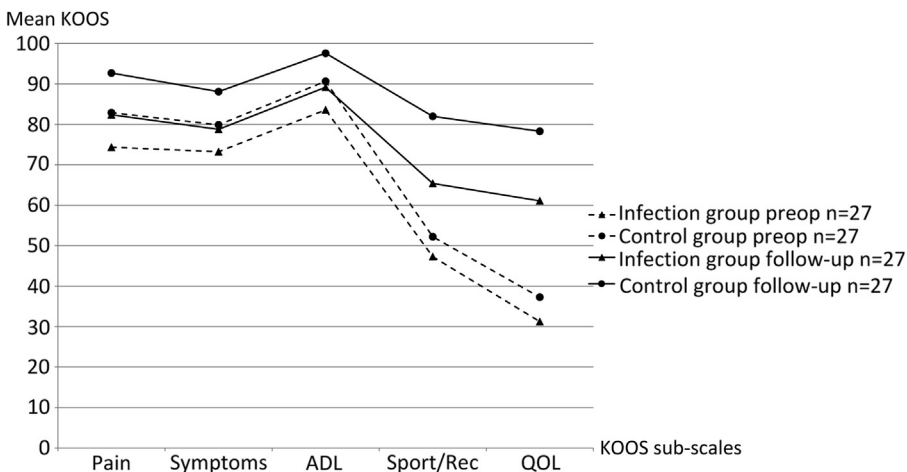
**Fig 4.** KOOS for infection patients and control group before surgery and at follow-up. (preop, preoperatively; QOL, quality of life; Recr, recreation.)

Fig 5. Incidence of infection after ACL surgery in literature.

Study	Number of ACL reconstructions	Number of infections	Incidence of infection
Burks et al	1918	8	0.42%
Fong et al	472	7	1.48%
Indelli et al	3500	5 (reports on 6)	0.14%
Judd et al	1615	11	0.68 %
McAllister et al	831	4	0.48%
Monaco et al	1232	12	0.97 %
Musso and McCormack	1094	11	1.0 %
Present study	4384	43 (reports on 27)	0.98 %
Schollin-Borg et al	575	10	1.74%
Schulz et al	?	4 (reports on 24)	0.78%
Van Tongel	1736	9 (reports on 11)	0.51 %
Viola et al	1794	14	0.78%
Wang et al	4068	21	0.52 %
Williams et al	2500	7	0.30%

cases (Fig 5). Our hypothesis was confirmed, in part, because objective knee function was not affected at follow-up. However, some subjective measures were poorer in the infection group, re-emphasizing the need to diagnose and treat infections promptly.

Most of the earlier investigations have shown inferior results for patients after a postoperative infection after ACLR.^{3,5-7,9,11-13,19} Schulz et al.¹² examined 24 patients with septic arthritis after ACLR, treated with arthroscopic debridement and lavage, partial synovectomy, and implantation of gentamicin beads. In addition to receiving the previously mentioned measures, patients with more severe infections were treated with arthrotomy and a near-total synovectomy. Fifteen grafts were taken out, and in contrast to our study, these patients had inferior clinical results compared with patients with uncomplicated ACLR. Wang et al.¹⁴ reviewed 21 patients retrospectively after septic arthritis, but there was no clinical or radiologic evaluation.

However, not all authors have shown inferior function after infection. Our results showing no impact on objective outcomes are in accordance with those of McAllister et al.,⁹ Schollin-Borg et al.,¹¹ and Van Tongel et al.¹³ Burks et al.⁴ reported on 4 patients who were satisfied with their outcomes after infection. Viola et al.¹⁶ re-evaluated 14 knees on average 14.4 months after septic arthritis after ACLR. The results were better than those of earlier reports and, overall, similar to those of uncomplicated ACLR, although the recovery was longer. However, the diagnosis was based on clinical symptoms and laboratory results, and only 2 of 14 cultures were positive. In our study the infection group also had a significantly longer rehabilitation. Fewer infection patients than control patients in this study were able to return to sports, which is in accordance with the findings of Judd et al.⁷

An important finding of our study is that the infection can be controlled without removing the graft. Reports in the literature have shown the possibility of keeping the graft with correct antibiotics and repeated arthroscopic lavage and debridement.^{3,5,6,9,12,13} Other authors have suggested to remove the graft if the infection persists but to try to keep the graft initially.^{6,7,12,15,31} Keeping the graft or performing a re-graft surgery has previously been shown to give better clinical results.¹² On the contrary, Burks et al.⁴ concluded in 2003 that an aggressive approach with early graft removal and IV antibiotic treatment, followed by early re-graft implantation, can give excellent results. This finding was based on 7 patients, of whom only 4 went through a repeat reconstruction.

In a systematic review from 2013, Wang et al.²⁰ reported that most authors treat septic arthritis after ACLR with arthroscopic debridement and IV antibiotic therapy. They reviewed 17 articles with, in total, 196 cases of septic arthritis after ACLR. Most of the patients, 60%, were treated with a single arthroscopic debridement. Repeat debridement, with 2 to 4 procedures, was carried out because of persistent clinical symptoms, fever, or increased CRP level.

Former literature stated that the most common infecting bacteria was *Staphylococcus aureus*,^{3,5,6,9,12,15,32} followed by CNS^{7,8,10,11,13,14} or a polymicrobial infection.³¹ In our study CNS was the most frequent microbial finding, as was stated in the recent systematic review by Wang et al.²⁰ Nakayama et al.³³ investigated the status of preoperative colonization and perioperative contamination in patients undergoing ACLR. The most frequently identified organism was CNS, occurring in 93% of the positive results, in samples taken from the nose and skin preoperatively and skin intraoperatively. Several reasons for deteriorated knee

function after infection have been discussed in the literature. Bacterial toxins causing lesions in the cartilage, leading to osteoarthritis and pain,^{6,7,9,11,34} as well as arthrofibrosis^{3,7,11} or post-infectious meniscal tears,¹¹ have been suggested.

Risk factors for septic arthritis after ACLR have been identified as prior knee surgery^{7,9,32} or concomitant procedures such as meniscal repair.^{3,7,15} Other studies have concluded that concomitant procedures do not influence the outcome or rate of infection.^{10,13} Our groups were too small to perform a risk-factor analysis, although there was no significant difference between the groups in numbers of concomitant procedures or mean operating times. Reports on how different graft types affect the risk of postoperative infection have shown a preponderance of deep infections when using hamstring tendon autografts.^{3,7,14,20,35,36}

Limitations

This material represents a large series of postoperative infections after ACLR with a mean follow-up time of 60 months and a matched control group. Nevertheless, there are several limitations to this study. The retrospective design means flaws in terms of the selection of the study groups. The study population is small, and therefore there is a risk of type II error. We chose to report on all 27 patients in each group, although 3 patients in each group had, in this context, a fairly short follow-up time, because we believe their results are representative. A fair number of patients with infections were lost to follow-up, probably because of our young patients' tendency to move, nationally and internationally, for education, work, and sports. There is long-term follow-up through the ACL registry database with KOOS and Tegner questionnaires at 1, 2, and 5 years postoperatively, but the data submitted are not complete and therefore not reported in this study.

We used KT-1000 arthrometry, which is the accepted method worldwide to evaluate ACL laxity postoperatively. This method is user dependent, but in this material the same experienced physiotherapist measured all patients at follow-up. Unfortunately, the preoperative measurements with KT-1000 arthrometry were conducted by several different physiotherapists.

Conclusions

Septic arthritis after ACLR did not result in inferior objective knee function compared with uncomplicated ACLR. Subjectively, infection patients were as satisfied as non-infection patients, but rehabilitation took longer and fewer patients returned to sports. The findings of this study suggest that ACL grafts may be retained with prompt, thorough arthroscopic lavage and debridement, correct antibiotics according to cultures, and repeated arthroscopy if necessary.

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