Septic Arthritis After Anterior Cruciate Ligament Reconstruction

Clinical and Functional Outcomes Based on Graft Retention or Removal

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Background: There remains a debate over whether to retain the index anterior cruciate ligament (ACL) graft in the setting of septic arthritis.

Purpose: To evaluate and compare clinical outcomes for the treatment of septic arthritis after ACL reconstruction (ACLR) in those with and without early graft retention.

Study Design: Case series; Level of evidence, 4.

Methods: The Military Health System was queried for all ACLR procedures performed between 2007 and 2013. Inclusion criteria required active military status, primary ACLR with secondary septic arthritis, and minimum 24-month surveillance. Demographic, clinical, and surgical variables were evaluated using descriptive statistics and regression analysis for factors influencing selected outcomes.

Results: Of 9511 ACLR procedures, 31 (0.32%) were identified as having secondary septic arthritis requiring urgent arthroscopic irrigation and debridement and intravenous antibiotics (mean, 6.3 weeks). The majority (62%) were treated in the subacute (2 weeks to 2 months) setting. Index ACLR was performed with a hamstring autograft (n = 17, 55%), soft tissue allograft (n = 11, 35%), and patellar tendon autograft (n = 3, 10%). The graft was retained in 71% (n = 22) of patients, while 29% (n = 9) underwent early graft debridement. At a mean 26.9-month follow-up, 48% of patients (n = 15) had returned to the military. Graft removal was not predictive of return to active duty ($P = .29$). The presence of postoperative complications, including symptomatic postinfection arthritis (22.6%) and arthrofibrosis (9.7%), was the only variable predictive of inability to return to duty (odds ratio, 27.5 [95% CI, 3.24-233.47]; $P = .002$). Seven of 9 patients who underwent graft debridement underwent revision ACLR, and all 7 had stable knees at final follow-up compared with 68% (15/22) in the graft retention group.

Conclusion: Arthroscopic debridement with early graft removal and staged revision ACLR remains a viable option for restoring knee stability (100%), although the rate of return to active duty was low in the graft resection group (33%). The risk of knee laxity did not differ based on early graft retention. Time to presentation with graft retention was not associated with a decreased rate of graft laxity.

Keywords: anterior cruciate ligament; anterior cruciate ligament reconstruction; septic arthritis; laxity

Septic arthritis is a rare but devastating complication after anterior cruciate ligament (ACL) reconstruction (ACLR), with an incidence ranging from 0.14% to 1.8%.[#] Early diagnosis and decisive management are essential to ensure the best functional outcomes without graft laxity or retears. The vast majority of postoperative infections after ACLR occur within 30 days of the procedure.[20] Several investigators[11,20,22,26] have reported inferior functional outcomes in patients with postoperative infections compared with uninvolved patients; however, inconsistent reporting and conflicting results may limit the utility of these findings.[13] In addition to surgical morbidity, the known sequelae of septic arthritis after ACLR may be severe and can include instability, chondral degeneration, pain, arthrofibrosis, and the need for additional surgery.[11,13]

The current recommended treatment of septic arthritis after ACLR includes surgical irrigation and debridement

[#]References 1, 2, 4, 6–8, 10, 11, 13, 16–18, 20, 22, 25, 26, 29, 30.

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(I&D) with concomitant intravenous antibiotics.[15] However, given the conflicting clinical evidence, the decision of whether to remove the graft continues to be debated.[19,22] More recently, authors have proposed standardized surgical protocols detailing whether to remove the graft and associated hardware or retain the graft.[9,23] In 3 recent systematic reviews, graft retention rates ranged from 78% to 100% following treatment for an infection after ACLR.[12,13,28] Despite these high graft retention rates, many patients still experience pain and report fair/poor results on patient-reported outcome measures.[13,25] In contrast, in a small retrospective case series, early graft removal and revision were shown to achieve excellent Lysholm scores and full symmetric knee range of motion.[6]

The purpose of this study was to compare clinical outcomes for the treatment of septic arthritis after ACLR with graft retention or revision. The secondary purpose was to determine if time to presentation was associated with inferior outcomes. The authors hypothesized that patients with early graft removal would have superior clinical and functional outcomes (presence of ligamentous laxity, revision ACLR, and return to duty) compared with patients with retained grafts.

TABLE 1
Data Points Collected From Patients' Electronic Health Records

Characteristics of initial surgery
Patient demographics
Graft choice
Concomitant procedures
Infection variables
Bacterial speciation
Available laboratory markers
Time from index procedure to presentation
Time from presentation to surgical intervention
Infection treatment regimen
Total course of antibiotics
Mean number of surgical procedures
Graft retention or resection
Clinical outcomes
Subjective stability of knee
Physical examination findings
Need for revision anterior cruciate ligament reconstruction
Separation from military because of associated disability

METHODS

Institutional review board approval was obtained for this study. The US Military Health System Management Analysis and Reporting Tool (M2), which encompasses a closed health care system of approximately 9.5 million beneficiaries, was queried for all arthroscopic ACLR (Current Procedural Terminology [CPT] code 29888) procedures performed between October 2007 and May 2013. Resulting patients were then cross-referenced within the M2 database for any subsequent arthroscopic treatment of the knee using CPT code 29871 (arthroscopy, knee, surgical; for infection, lavage, and drainage). A subsequent retrospective chart review was performed within the military electronic medical records to confirm all identified cases of septic arthritis after ACLR. Inclusion criteria were active-duty military patients with septic arthritis after primary ACLR during the study period with a minimum of 24-month clinical surveillance. A diagnosis of septic arthritis after primary ACLR was determined based on the criteria of the individual treating physician. All patients received preoperative intravenous antibiotics before knee aspiration. However, the diagnosis was confirmed by the presence of a synovial white blood cell count over 50,000, frank purulence, and/or positive synovial fluid cultures after knee arthrocentesis.[14] Exclusion criteria were index ACLR performed outside the military system, revision ACLR, ACL repair, synthetic graft use, noninfectious indications (eg, sterile effusion or hematoma), superficial or localized soft tissue infections, incomplete health records (insufficient follow-up within the closed military health care network <12 months), and/or absence of supporting laboratory studies.

The complete list of data points obtained from the review of patients' electronic health records can be found in Table 1. The primary outcome of interest was clinical failure, defined as persistent knee laxity or instability, revision ACLR, or the inability to return to military function. ACL laxity was defined subjectively by documented patient reports of instability or laxity, or objectively as an abnormal Lachman test finding (ie, grade $\geq$2B), positive pivot-shift test finding, or an annotation of instability during a physical examination documented by an orthopaedic surgeon.

Statistical Analysis

Descriptive statistics were used to report demographic and surgical variables. Chi-square analysis and the Fisher exact test were used to compare categorical variables. Patient, surgical, and infection treatment variables were analyzed with regard to clinical success or failure at the

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completion of treatment using a univariate regression analysis, with odds ratios (ORs) and 95% CIs reported. Secondary analysis was performed comparing these variables with graft retention to identify variables associated with this surgical treatment decision. Statistical significance was considered as $P < .05$ across all models (SPSS Statistics version 23.0; IBM).

RESULTS

A total of 9511 ACLR procedures were performed between October 2007 and May 2013 in the US Military Health System. Among these cases, 31 patients (0.32%) were treated surgically for a diagnosis of postoperative septic arthritis after arthroscopic ACLR from 26 different surgeons. The mean age of the population was 26.8 ± 4.5 years (range, 19-40 years). Male patients represented 90% (n = 28) of the population. Concomitant procedures at the time of index ACLR were performed in 22 patients (71%). Knee joint aspiration and culture were performed preoperatively or intraoperatively in all cases. Synovial fluid cultures were positive in 52% of the cases (n = 16). The mean number of surgical debridements was 2.3 (range, 1-4), and the mean duration of intravenous antibiotics was 6.3 weeks (range, 3-12 weeks). The mean time from index ACLR to the first arthroscopic lavage and debridement procedure was 55.1 days (range, 5-477 days). A complete description of demographic and surgical variables can be found in Table 2.

TABLE 2
Demographic, Operative, and Postoperative Descriptive Characteristics of Patients After Anterior Cruciate Ligament Reconstruction[a]

	Value
Age, mean ± SD (range), y	26.8 ± 4.5 (19-40)
Mean time to follow-up, mo	26.9
Sex	
Male	28 (90.3)
Female	3 (9.7)
Previous ipsilateral knee surgery	
Yes	2 (6.5)
No	29 (93.5)
Branch of service	
Army	13 (41.9)
Navy	8 (25.8)
Marines	5 (16.1)
Air Force	5 (16.1)
Graft selection (n = 31)	
HS autograft	17 (55)
HS allograft	11 (35)
BTB autograft	3 (10)
Concomitant procedures	22 (71)
Meniscal repair/debridement	19 (61)
Other (MAT, PLCR, MFX)	3 (10)
Median time from surgery to first debridement, d	35
Time from surgery to first debridement	
<2 wk	6 (19)
2 wk to 2 mo	19 (62)
>2 mo	6 (19)
Bacteria	
No growth	15 (48)
Methicillin-sensitive *Staphylococcus aureus*	10 (32)
Methicillin-resistant *Staphylococcus aureus*	3 (10)
Methicillin-resistant *Staphylococcus epidermidis*	2 (6)
Enterobacter	1 (3)
No. of arthroscopic debridements (graft type)	
1 (5 HS autograft/4 HS allograft)	9 (29.0)
2 (5 HS autograft/2 HS allograft/1 BTB autograft)	8 (25.8)
3 (7 HS autograft/2 BTB autograft/1 HS allograft)	10 (32.3)
4 (1 BTB autograft/2 HS autograft)	4 (12.9)
Course of antibiotics, mean ± SD (range), wk	6.3 ± 2.3 (3-12)
Retained graft	
Yes	22 (71)
No	9 (29)

[a]Data are reported as n (%) unless otherwise indicated. BTB, bone-tendon-bone; HS, hamstring; MAT, meniscal allograft transplantation; MFX, microfracture; PLCR, posterolateral corner reconstruction.

Analysis by Graft Retention

The ACL graft was resected during the early course of infection treatment in 9 cases (29%), including 4 grafts removed at the first I&D procedure. Bacteria type, choice of index graft (allograft vs autograft), age at the time of the index procedure, timing of presentation (acute, subacute, chronic), and number of debridements were not significantly associated with graft retention. Seven cases with graft resection (77.8%) underwent staged revision ACLR, resulting in a stable knee (100%). Only 3 of these patients returned to active duty (42.9%). All 7 patients who underwent early graft debridement and revision ACLR were ligamentously stable, while 15 patients (68%) of those with retained grafts who were not revised demonstrated knee stability at final follow-up. Four patients (18.2%) with retained grafts who were found to have unstable knees declined revision ACLR. The remaining 2 patients with graft resection declined revision surgery and were unable to return to active duty (Figure 1).

Three patients with retained grafts demonstrated ligamentous laxity and elected for revision ACLR. There were no significant predictors of symptomatic knee laxity in patients with retained grafts (Table 3).

A minority, 48% (n = 15) of the entire cohort, was able to return to military function, including 3 of 9 (33.3%) in the graft resection group and 12 of 22 (54.5%) in the graft retention group. Reasons for not returning to function for the graft resection group included revision ACLR with continued pain and stiffness (n = 4) and persistent instability and pain without revision ACLR (n = 2). In the graft retention group, reasons for not returning to duty included stable knees but continued pain (n = 5), an unstable knee that was revised but had continued pain (n = 1), and unstable knees that declined revision ACLR (n = 4). Graft removal had no significant effect on ability to return to duty. Of note, post hoc power analysis for the number of participants needed to show a significant 1-sided chi-square test with logistic regression, with an alpha of .05 and 80% power

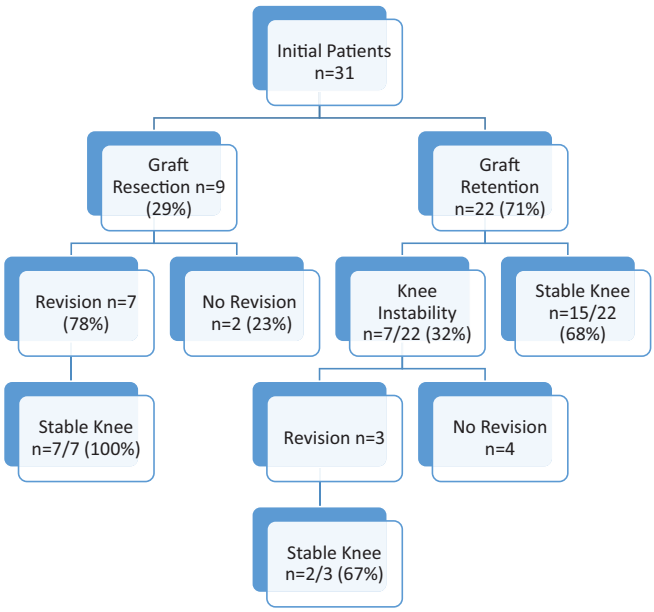

Figure 1. Clinical outcomes depicted in a decision tree format based initially on if the anterior cruciate ligament (ACL) graft was retained after treatment for septic arthritis. The graft was retained in 71% of patients, but only 15 of those 22 patients (68%) maintained knee stability without revision ACL reconstruction.

TABLE 3
Results of Univariate Logistic Regression Analyses for the Influence of Risk Factors on Symptomatic Laxity After Graft Retention[a]

	Odds Ratio (95% CI)	*P* Value
Age (continuous)	0.33 (0.03-3.18)	.36
Sex (female vs male)	0.34 (0.01-11.61)	.55
Previous knee surgery	3.00 (0.17-54.34)	.46
Culture-positive bacteria	1.05 (0.16-7.11)	.96
Time to presentation (continuous)	0.97 (0.92-1.02)	.17
No. of debridements (continuous)	1.31 (0.59-2.91)	.50
Graft type		
HS autograft vs HS allograft	4.05 (0.51-32.02)	.19
HS autograft vs BTB autograft	1.59 (0.04-50.00)	.81

[a]BTB, bone-tendon-bone; HS, hamstring.

based on the effect size observed in the study for graft removal as a predictor of return to duty, demonstrated that 206 patients would have been needed.

The presence of postoperative complications, including symptomatic postinfection arthritis (22.6%) and arthrofibrosis (9.7%), was the only variable predictive of inability to return to duty (OR, 27.5 [95% CI, 3.24-233.47]; $P = .002$) (Table 4).

DISCUSSION

This study utilized a large, closed network database of predominantly young, active patients (N = 9511) to report a

TABLE 4
Results of Univariate Logistic Regression Analyses for the Influence of Risk Factors on Ability to Return to Duty[a]

	Odds Ratio (95% CI)	*P* Value
Age (continuous)	1.11 (0.93-1.32)	.23
Sex (female vs male)	0.92 (0.18-4.58)	.92
Branch of service		
Army	3.11 (0.28-34.42)	.35
Marines	1.75 (0.08-36.29)	.72
Air Force	1.75 (0.08-36.29)	.72
Navy	Reference	Reference
Previous knee surgery	0.93 (0.05-16.39)	.96
Time to presentation (continuous)	1.01 (0.99-1.02)	.39
Postoperative Lachman grade (0/1 vs ≥2B)	0.55 (0.11-2.86)	.48
Graft type		
HS autograft vs HS allograft	0.80 (0.08-8.47)	.85
HS autograft vs BTB autograft	0.90 (0.18-4.56)	.90
Graft removal	2.40 (0.48-12.13)	.29
Complications	27.50 (3.24-233.47)	.002

[a]BTB, bone-tendon-bone; HS, hamstring.

0.32% incidence of postoperative septic arthritis. The graft retention rate was 71% (n = 22), with 32% (n = 7) of these patients experiencing symptoms of knee laxity even after eradication of the infection. By comparison, 100% (n = 7) of patients who underwent early graft resection and revision ACLR demonstrated objective knee stability after the infection. Graft removal and time to presentation were not associated with inferior rates of return to duty. Only complications were associated with inferior rates of return to duty.

The diagnosis of septic arthritis is challenging, as classic symptoms of warmth, erythema, fever, swelling, and discomfort are not always present or easy to discern in the early postoperative course. Furthermore, positive cultures on aspiration are inconsistently found, despite infectious causes.[20] The onset of symptoms and clinical presentation for the current study were predominantly within 8 weeks of index ACLR (81%), consistent with prior reports.[3,10,26,30] Of note, 1 patient presented at 477 days after index ACLR. This patient had an indolent chronic course with negative speciation but a confirmatory cell count and acute worsening at the time of presentation.

Acute onset (within 2 weeks of the index procedure) with graft retention was not associated with a lower rate of graft laxity as compared with subacute or delayed presentation. Earlier postoperative presentation has been previously proposed as a favorable predictor of clinical and functional endpoints; however, the current study did not support these findings.[5] In fact, those presenting within 2 weeks actually had a higher rate of symptomatic knee laxity (50%) compared with those with subacute (25%) or delayed (0%) presentation, although the difference was not significant. Others have previously noted functional deficits, cartilage degeneration, arthrofibrosis, and continued instability in patients with septic arthritis after ACLR, with many of these patients presenting acutely.[10,11,16,27,30]

While consensus exists on early surgical intervention and intravenous antibiotics in patients with an infection after ACLR,[28] the question of whether to retain or resect the graft remains a topic of debate.[24] The findings of the present study demonstrate that early debridement and secondary revision reconstruction result in a reliable rate of graft stability (100%, n = 7). In contrast, of the 22 (71%) patients with early graft retention, 32% had evidence of ligamentous instability on physical examination. Many authors have recently reported good functional outcomes of graft retention through treatment with intravenous antibiotics and arthroscopic debridement.[12,23] In patients with retained grafts, KT-1000 arthrometer measurements have been shown to be increased 1.4 mm, on average, compared with the contralateral limb.[23] Furthermore, abnormal Lachman and pivot-shift testing results were reported in 7% and 25%, respectively, of patients in a recent systematic review.[13] To further assess for the role of graft retention on clinical outcomes, Makhni and colleagues[13] directly compared studies with low rates of graft retention and all other reported studies in a separate systematic review. The authors demonstrated increased rates of ligamentous laxity in patient series with low graft retention (57% vs 13%, respectively). However, they noted that this comparison was limited by the small pool of data on ligamentous laxity. In fact, the 57% laxity rate in patients with low graft retention stems from a single study by Williams and colleagues.[30]

Additional objective variables have been compared between patients with retained grafts and those without. Specifically, the rate of abnormal pivot-shift examination findings,[30] degenerative changes on imaging,[4] and ability to perform activities of daily living[30] have all been reported as more frequent in patients preferentially treated with graft removal. Hantes et al[9] performed graft resection on 6 of 7 patients after a single arthroscopic I&D procedure failed to eradicate the infection, and revision ACLR was necessary in 67% of these patients (4/6) after a single arthroscopic I&D procedure failed to eradicate the infection. At a mean 6.3-year follow-up, the authors reported an average Lysholm score of 92, International Knee Documentation Committee (IKDC) score of 86, and KT-1000 arthrometer measurement of 1.4 mm in the 4 patients who underwent early graft resection and subsequent revision, which were not significantly different from the clinical and functional outcomes of patients with uncomplicated primary ACLR. Despite the small cohort size, the current results suggest that patients may experience improved ligamentous stability when treated with early graft resection and revision.

The majority of the existing investigations have evaluated short-term outcomes ($\leq$2 years) in patients with septic arthritis after ACLR, and a greater longitudinal follow-up is rare. Schub and colleagues[21] reported on clinical and functional outcomes of 4 patients from a large single-surgeon database at an average 17.9-year follow-up. The authors reported the progression of arthritis in all patients with a concomitant decrease in clinical outcome scores (Lysholm, IKDC, and Short Form–36), and side-to-side laxity on KT-1000 arthrometer testing increased to 4.6 mm. The progression to arthritis is a primary concern in these patients, and it was seen in a significant percentage (22.6%) in patients in the current study at a minimum 24-month follow-up. Further research is warranted to better elucidate the clinical outcomes and radiographic degenerative progression between patients with retained ACL grafts versus those opting for early resection and staged revision surgery.

Limitations

There are several limitations to this study and factors that we were not able to control for. This study utilized a large closed health care network that included patients from multiple surgeons at multiple medical centers; therefore, specific therapeutic approaches and surgical indications were not standardized. It is unknown why the graft was removed or retained, which introduces a possible selection or allocation bias that may have influenced results. There were no validated patient-reported outcome measures available for analysis. In addition, the time between the onset of patient-reported symptoms consistent with septic arthritis and formal presentation for an evaluation was infrequently recorded in the medical record and lacked sufficient detail to allow an accurate classification or analysis. Similarly, preoperative and serial postoperative erythrocyte sedimentation rates and C-reactive protein values were inconsistently available, thereby limiting a meaningful analysis according to trends in laboratory results. Return to duty may represent a multifactorial decision, and the potential for secondary gain cannot be excluded. While this data set yielded more patients than most other investigations on the topic, the number of septic arthritis cases was small, given the rarity of the complication. There is a potential for nonresponder bias in patients with <12-month follow-up. Finally, a total of 5 allografts were culture negative, and this could represent a potential nidus of acute inflammation due to a host-graft response. Despite a lack of statistically significant quantitative differences, these results may still offer substantial benefits during patient counseling and discussions about functional repercussions with graft retention or early debridement and delayed reconstruction.

CONCLUSION

Arthroscopic debridement with early graft removal and staged revision ACLR remains a viable option for restoring knee stability (100%), although the rate of return to duty (33%) was low in the graft resection group. The risk of knee laxity did not differ based on early graft retention. Time to presentation with graft retention was not associated with a decreased rate of graft laxity.

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