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Knee joint infection after ACL reconstruction: prevalence, management and functional outcomes

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Abstract
Purpose Septic arthritis after an ACL reconstruction is a rare but serious complication. Functional outcomes of these patients have not been studied in depth in large series. The aim of this study was to determine the prevalence and management of knee joint infection following ACL reconstruction and to assess the functional outcomes.
Methods A retrospective assessment of knee joint infections occurring after arthroscopically assisted ACL reconstructions done from 2006 to 2009 in two hospitals by the same surgical team is presented. Patients with signs and symptoms of joint infection along with blood and synovial effusion laboratory parameters suggestive of infection were considered as septic arthritis. All the patients were treated with antibiotic therapy according to antibiotic sensitivity and had at least one arthroscopic lavage. Final outcomes were assessed and compared with a control group using the KT-1000 arthrometer, functional testing and radiological examination.
Results Fifteen (1.8 %) out of 810 patients included in the study were considered as a joint infection. Microbiology showed that coagulase-negative *Staphylococcus* was present in 10 patients, *Staphylococcus Aureus* in three patients (2 MSSA and 1 MRSA) and *Propinebacterium* sp. in one patient. In one patient, the micro-organism was unknown. At a mean follow-up of 39.3 ± 13 months, the Lysholm score was 77.7 ± 15.3, the IKDC score was 70.4 ± 19.5, and the KT-1000 compared to the non-injured contralateral knee showed a mean difference of 1.3 ± 2 mm. Functional outcomes in the control group were slightly better than those obtained in the infected group (Lysholm score; 90.7 ± 9.4, $p = 0.007$. IKDC score; 86.6 ± 6.8, $p = 0.004$). All but one patient retained their reconstructed ACL.
Conclusions The prevalence of septic arthritis after an ACL reconstruction in this series was 1.8 %. Arthroscopic lavages along with antibiotic treatment led us to preserve all but one graft. Functional outcomes in the infected patients were not as good as those obtained in patients without infection.
Level of evidence Therapeutic case series, Level IV.

Keywords ACL reconstruction · Joint infection · Septic arthritis · CRP · ESR

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Introduction

Infection after arthroscopic anterior cruciate ligament reconstruction (ACLR) is a rare complication with reported prevalence ranging from 0.14 to 1.7 % [4, 11, 13, 17, 28–30]. It is important for the surgeon to understand both the risk factors and the natural history of this complication due to its potentially devastating consequences for the knee joint. Those complications include graft failure and articular cartilage loss, among others [8, 10].

Early diagnosis and treatment have been found to be the most critical factors in the healing process and avoiding its later sequelae. Since the pioneering work of Ballard, the

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treatment for septic arthritis has been based on a combination of open debridement and joint irrigation [1]. Riel et al. [21] reported on one of the first series of septic arthritis patients treated arthroscopically instead of with open lavage after ACLR that had successful outcomes. Since then, this technique has been adopted worldwide by the orthopaedic community [24].

Another issue is whether or not a reconstructed graft can be preserved in a post-operatively infected joint. While there is general agreement in the current literature as to the beneficial effects of early antibiotic therapy in the preservation of healthy articular cartilage, there is still some controversy with regard to graft preservation. In 1998, Matava et al. [15] conducted a survey on infected joints after ACLR that was directed to orthopaedic fellowship programme directors. Most of them agreed that preserving the graft and repeating arthroscopic lavage as many times as necessary would be the best policy. However, some authors still believe that graft removal is an essential part of the healing process [4]. The lack of conclusive evidence makes it difficult to get a consensus relative to the best practices in the management of this important condition. Furthermore, the only outcome measured is the healing of the infection that leaves the functional outcome of the joint unobserved in some studies.

The purpose of this study was to determine the prevalence and how to manage post-operative knee infection after ACLR as well as the functional outcomes of these patients. The initial hypothesis of this study was that early diagnoses and specific antibiotic treatment combined with aggressive arthroscopic management might prevent graft removal and bring about a good functional outcome.

Materials and methods

A retrospective review of 810 primary arthroscopic ACL reconstructions performed in two hospitals in the same city (434 and 376 in each one of the hospitals) between January 2006 and December 2009 was conducted. Four senior surgeons from the same surgical team performed all surgeries. Inclusion criterion was patients diagnosed with post-operative joint infection. Joint infection was defined by either a positive culture from a knee aspirate or a suggestive blood laboratory test (systemic white blood cell count (WBC) and C-reactive protein (CRP)) in patients with septic arthritis symptoms. Patients with multi-ligament injuries or those that required additional open surgical procedures were excluded. The clinical research ethics committee at our institution approved the study (11/092/1425). All the patients signed informed consent to participate in the study as well as for the evaluation and publication of their results.

Fifteen patients were diagnosed with post-operative septic arthritis. The average age was 33.5 years (SD 7.6) in the series at the time of ACL reconstruction, and most of them were male (76 %). All patients received the same antibiotic prophylaxis protocol consisting in a single dose of 2gr of endovenous cefazolin or 500 mg of vancomycin in case of penicillin allergy 30 min prior to surgery. The operations were arthroscopically assisted. A pneumatic tourniquet was inflated during the procedure. The autografts used were quadrupled hamstrings (73 %) and bone-patellar tendon-bone (BPTB) (27 %). The hamstrings were fixed with a resorbable cross-pin (Cross-Pin System®, Stryker Endoscopy, USA) on the femoral side and a resorbable interference screw (Biosteon®, Stryker Endoscopy, USA) on the tibial side in all cases. Bone-patellar tendon-bone grafts were fixed using a resorbable interference screw (Biosteon®, Stryker Endoscopy, USA) on both sides in all cases. No drains were used after surgery. All patients' operations were performed on an outpatient basis.

Diagnosis of septic arthritis was based on patient history, physical examination, laboratory parameters suggestive of an infectious process and a culture of joint aspirate. Synovial aspiration was performed as soon as the diagnosis was suspected. The fluid obtained was immediately analysed (biochemistry) and cultured for aerobic and anaerobic organisms and antibiotic sensitivity.

In patients with a suspicion of having septic arthritis, an empirical intravenous trial with a combination of ceftazidime (2 g/8 h) plus vancomycin (1 g/12 h) was immediately begun. If necessary, the antibiotic therapy was later changed according to the sensitivity of the micro-organism cultured from the aspirate. Oral antibiotics replaced intravenous antibiotics after 2–3 weeks of clinical evolution, and the blood test parameters (WBC and CRP) moved toward normal (WBC $>$ 10.000 cells/μL, CRP 0–0.8 mg/dL). Antibiotics were administered for a minimum of 6 weeks, and they were not withdrawn until complete normalization of the clinical and analytical parameters.

Once the diagnosis was confirmed by the synovial aspirate gram test as well as laboratory data, an arthroscopic procedure was carried out. The previously performed anteromedial and anterolateral standard portals were used. In some cases, a superolateral portal was added for better inflow. The treatment included extensive washout of the joint with 10–15 L of normal saline solution. Debridement of inflamed or devitalized tissue, removal of fibrin clots and old coagulated blood and synovectomy throughout the joint were carefully done. Finally, gentle removal of the fibrin layer that covered the graft surface and evaluation of its macroscopical integrity were completed. Some synovial fluid and debrided tissue were sent for new culture and antibiotic sensitivity. 48–72 h later, a new arthroscopic lavage and debridement was scheduled when clinical and laboratory parameters were not satisfactory.

When the clinical symptoms showed a move toward normalization, a physical therapy programme was initiated. In all cases the most important goals were controlling pain, the swelling, recovery of range of motion (ROM) and neuromuscular control. The rehabilitation protocol was not significantly different than the cases without infection. Two weeks after surgery, we started a graded knee-strengthening programme including quadriceps and hamstrings strength through progressive isometric, isotonic and isokinetic exercises. ROM was progressively increased until at least 120° of flexion was achieved. Weight bearing was allowed when the symptoms suggestive of infection (erythema, local temperature and drainage) disappeared.

Treatment outcomes at the final follow-up that included a detailed physical examination (including the pivot-shift and Lachman tests), arthrometric evaluation with KT-1000 (MEDmetric, San Diego, California), functional scores (modified Lysholm and Gillquist scoring scale [14], the International Knee Documentation Committee (IKDC) form [12]) and radiographic evaluation (standard AP and lateral views as well as Rosenberg view) were all analysed by a previously instructed orthopaedic resident from the orthopaedic department who was not involved in the study. In the radiological evaluation, osteophyte formation and either medial or lateral joint space narrowing were assessed.

Fifteen of the patients (66.7 % males and 33.3 % women) in this series with a mean age of 34.7 (SD 7.6) who had not suffered this complication were randomly chosen to assess functional tests and compare them with those who had suffered the infection after an ACLR. The autografts used in the control group were quadrupled hamstrings (66.7 %) and bone-patellar tendon-bone (33.3 %), and the devices used to fix the graft were the same as those used in the infected group. There were no differences between both groups with regard to all those variables.

Statistical analysis

Statistical analysis was performed by using the SPSS version 15.0 (SPSS Inc, Chicago, Ill) statistical package. Continuous variables are presented as mean ± standard deviation and categorical variables as percentages. The *U*-Mann–Whitney test was used to compare independent samples with the p value set at 0.05.

Results

Fifteen (1.8 %) cases were considered a joint infection according to the previously described criteria. All the infections developed in the early post-operative period (1–5 weeks post-operative). Twelve cases were in men, and the grafts used were hamstrings in all but two cases (n.s.). A partial meniscectomy was performed during the ACLR in two patients, and a bucket-handle tear of the medial meniscus was sutured in one case. They were followed an average of 39.3 months (SD 13).

Micro-organisms observed in these 15 patients were the following: coagulase-negative *Staphylococcus* (CNS) in ten patients (66.6 %), methicillin-sensitive (MSSA) *Staphylococcus aureus* in two patients, methicillin-resistent (MRSA) *Staphylococcus aureus* in one patient and *Propinebacterium* sp in another patient. The infecting micro-organism was unknown in another patient.

At least one arthroscopic lavage was performed on all patients. The time elapsed from ACLR to the first arthroscopic lavage averaged 23.9 days (SD 14), and the mean number of lavages performed was 1.3 (SD 0.6). A second arthroscopic lavage was needed in four cases. A third arthroscopic procedure was performed on one of them. In the latter case, the graft and the fixing devices were removed due to the persistence of infection and the deteriorated appearance of the graft.

In terms of infection healing, the therapeutic protocol used was effective in all patients. The combination of arthroscopic debridement and proper antibiotic therapy permitted graft maintenance in all but one patient. The obtained functional results were rated as good from the functional point of view. However, the infected knees were not as good as the matched non-infected controls at an average of 3-year follow-up. At final follow-up, 73.3 % of the Lachman test and 80 % of the pivot-shift tests revealed no evidence of ACL laxity. The mean KT-1000 measurement side-to-side difference was 1.3 mm (SD 2), and the mean Lysholm score was 77.7 (SD 15.3), and the mean IKDC score was 70.4 (SD 19.5). Plain radiographs were assessed for all patients at final follow-up and compared with preoperative radiographs. No osteophyte formation or joint space narrowing was observed in the medial or lateral compartment in either group at final follow-up.

With regard to the control group, with a mean follow-up of 42.6 months (SD 7.5), the mean KT-1000 measurement side-to-side difference was 0.9 mm (SD 1.7), the mean Lysholm score was 90.7 (SD 9.4), and the mean IKDC score was 86.6 (SD 6.8). Differences obtained comparing infected versus non-infected groups are statistically significant relative to the Lysholm score ($p = 0.004$) and IKDC score ($p = 0.007$), but not for the KT-1000 measurement (n.s.). On the post-operative radiological evaluation, there were no significant differences between either group with regard to the femorotibial joint space measured as recorded in the Rosenberg view.

Discussion

The first finding of this study confirmed that a knee joint infection following an ACLR is quite infrequent. Our second and most important finding is that it can be successfully treated with a combination of antibiotic therapy and arthroscopic debridement that preserves the graft and obtains good functional outcomes. In that sense, our hypotheses were confirmed. The reported prevalence of septic arthritis after primary ACL surgery ranged from 0.14 to 1.7 % [4, 11, 13, 17, 28–30]. Recently, Sonnery-Cottet et al. [25] reported a 0.37 % prevalence of knee joint infection following ACLR in the general population. Then again, there was subgroup of professional athletes in which the prevalence of this complication raised to 5.7 % in their series. As 23 % of these athletes had a combined lateral tenodesis, the authors concluded that being an athlete and having a lateral tenodesis at the time of ACLR are risk factors for the development of infection. In the present work, all those cases requiring additional open procedures were excluded in an effort to ascertain the true prevalence of septic arthritis in primary isolated ACL reconstructions. The encountered prevalence in the present series (1.8 %) of more than 800 consecutive patients was found to be in the higher accepted range. Although there were no statistical differences with regard to the type of graft used and the prevalence of joint infection, the fact that hamstring was the graft used in most of patients of this series could be related with the slight increase in infections observed [2].

With regard to the infecting micro-organism, *Staphylococcus aureus* and CNS, mainly *Staphylococcus epidermidis*, are the most common bacteria found in septic arthritis after ACLR [4, 11, 17, 25, 28]. In the present series, the same pattern has been found (66 % of CNS), and these findings are in agreement with many previous studies [25, 27, 29]. Conversely, in Shulz et al. [23] and McAllister et al. [17], this relationship is reversed. In any case, these two micro-organisms represent the majority of this type of infection.

Relative to the time elapsed to the onset of symptoms, there is a wide range reported in the current literature. In two different studies it ranges from 9.2 days to 3.5 weeks [7, 29]. Shulz et al. [23] reported on a series of 24 joint infections following ACLR with a mean time elapsed from this surgery to the arthroscopic lavage of 61.7 days. Only in seven patients was it possible to maintain the graft. In nine cases, the graft was removed, and the graft had been auto-digested in eight patients. One of these patients required a total knee arthroplasty 5 years later. Barker et al. [2] recently published a large series of 3126 ACL reconstructions with an infection rate of 0.58 %. In this series, hamstring autografts had a higher prevalence of infection than BPTB autografts or allograft, although this difference was not statistically significant. It is important to recognize symptoms and laboratory parameters suggestive of joint infection and treat it as soon as possible, doing this not only maintains the graft but also prevents cartilage damage. Therefore, correctly interpreting the inflammatory laboratory parameters is of critical importance. Calvisi et al. [5] investigated the variations of the CRP in patients after reconstruction of the ACL. They found that the peak value was obtained by the third day post-operatively, and the values returned to normal on the 15th and 30th day post-operatively. On the seventh day after the surgery, this value was not completely normalized, and it makes it difficult to correctly interpret this parameter when a joint infection is suspected in some cases. Margheritini et al. [16] also studied the post-operative levels of ESR. They found both parameters to be markedly increased the first week after surgery and the ESR was still not normalized at 30th post-operative day. These findings confirm the authors' opinion that the CRP is much more reliable tool than ESR to aid in early diagnosis of a joint infection after ACL reconstruction.

As far as we know, a prospective study of the optimal treatment for this complication has never been developed. Therefore, the treatment is quite varied. The treatment most commonly followed by authors is irrigation and debridement with graft retention [20, 22, 28], but other authors prefer to remove the graft from the start [7, 30]. Others removed graft only with the persistence of the infection [4, 31]. The treatment protocol that is currently applied in our department for this complication is to perform an arthroscopic washout with at least 10 litters of normal saline as soon as diagnose is confirmed through synovial laboratory data. Empirical endovenous antibiotic treatment has to be started as soon as synovial liquid samples are obtained. This treatment is modified according to the antibiotic sensitivity. It is important to repeat arthroscopic lavages as many times as necessary in case the clinical and/or analytical data are not satisfactory. High temperature, wound drainage or erythema along with a lack of CRP decline or persistent high values of WBC has caused to think on the persistence of joint infection. In this protocol, 6 weeks is the minimal period of time required for the antibiotic treatment. Mouzopoulos et al. [19] reviewed the various studies published on septic arthritis following an ACLR. This study proposed the basic principles of treatment protocol with graft retention. These principles included a parenteral antibiotic therapy over at least 4 weeks followed by oral antibiotic therapy for 2–4 weeks more. Only in patients who need more arthroscopic lavages, was an extended parenteral antibiotic therapy given. This has been the approach followed in this series. Another principle was to keep the surgical wounds open or with a continuous irrigation drain for 2 days. This last approach has not been looked into in this series as it did not use continuous irrigation drains.

Matava et al. [15] asked 74 surgeons about their preferred treatment to use in a deep infection after an ACLR. Most of surgeons proposed an initial debridement with graft retention, and hardware removal was preferred only in case of resistant infection. As opposed to those authors [7, 30] who prefer to remove the graft as the first surgical option in these cases, we advocate maintaining the graft while it is functional. Only in case of a deteriorated appearance of the graft, assessed during the arthroscopic procedure, was removing it considered. In the series presented, graft removal was required only in one case. In the study performed by Matava et al. [15], 6 and 33 % of surgeons considered the graft's removal the standard for initial treatment for a septic arthritis following an autograft and allograft ACL reconstruction, respectively.

It is important to place emphasis on the functional outcomes obtained at the final follow-up. The Lachman test was positive only in four patients and the pivot-shift test in only three patients. The mean difference obtained between the KT-1000 compared with the non-injured knee was 1.3 mm, and differences with regard to the control group (0.93 mm) were not significant (p.0.581). In three patients, the KT-1000 obtained in the injured knee at the final follow-up was negative. It meant better control of anteroposterior laxity than the non-injured knee. In four out of 15, this difference was equal to or lower than 1 mm, the difference considered to be not relevant in most of studies [6, 9]. Monaco et al. [18] recently published a study assessing the functional outcomes of 14 patients at a mean of 38 months after a septic arthritis following an ACL reconstruction. The mean maximum KT-1000 side-to-side difference obtained was 2.5 mm. Binnet et al. [3] obtained similar results at 102 months of follow-up with a mean maximum KT-1000 value of 2.7 mm. There were only four patients in the series presented in which the maximal side-to-side KT-1000 difference was higher than the results obtained by these two authors. It may be suggested that if it is possible to maintain the graft after the treatment for this complication, the laxity obtained in most cases is similar to those in patients who have not suffered an infection.

With regard to knee function, the mean Lysholm score obtained in the present series was 77.7, while the mean IKDC score obtained was 70.4. These results are inferior to those obtained in a control group of non-infected ACLR analysed at the same follow-up. In this sense, the findings obtained in this series are quite similar to those of Schulz et al. [23], Schollin-Borg et al. [22] and Van Tongel et al. [27], and different from those reported by Monaco et al. [18] in which series almost all patients were able to return to the preoperative sport at the same level. A combination of glucosaminoglycan and collagen depletion from the hyaline cartilage that usually occurs after some days of joint infection [26] and some degree of arthrofibrosis, another common finding, might contribute to explaining these results.

The main limitation of this study is its retrospective design and the limited follow-up. However, the nature of the procedure makes it difficult to carry out any other design. Another limitation is caused by the absence of an MRI study to better assess the cartilage damage of the infected knees.

Although longer follow-up studies will be needed to determine the final outcome of the infected knees, the worst results obtained in the functional scores seem to foreshadow a poor long-term outcome for these knees.

Taking into account this is not an uncommon complication in the daily clinical work, it is important to recognize the symptoms and laboratory parameters suggesting knee joint infection following an ACLR. Most of these infections occur during the first month after the surgery and can be treated with success maintaining the graft if this protocol is quickly applied.

Conclusions

In conclusion, septic arthritis after ACL reconstruction can be successfully managed using the proposed protocol. The combination of antibiotic therapy and repeated arthroscopic debridement was able to eradicate the infection while maintaining the graft in all but one case. However, functional outcomes in the present series have been inferior to that of control subjects without infection.

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