Original Article

# Incidence, Risk Factors, and Management of Infection Following Anterior Cruciate Ligament Reconstruction Surgery

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## Abstract

**Background:** Infection after anterior cruciate ligament reconstruction surgery (ACLRS) is a rare complication. Although there are number of studies from various Caucasian population but only few studies are available from Asian population. The aim of the study is to assess the incidence, risk factors and, clinical outcome using our treatment protocol. **Materials and Methods:** Out of 1468 arthroscopic ACLRS, 26 patients with clinical suspicion of infection were critically analysed in terms of laboratory reports of arthrocentesis, erythrocyte sedimentation rate, C-reactive protein and risk factors such as the type of graft, gender, diabetes mellitus, smoking, intraarticular steroid injection, and obesity. At final followup, all these patients were evaluated using visual analog scale (VAS), Lysholm knee score, and Tegner activity level. **Results:** In nine patients, culture did not show any growth and they showed improvement with arthrocentesis and oral antibiotics. These patients were labeled as suffering from aseptic effusion. In the remaining 17 patients, there was no clinical improvement or instead worsening of symptoms after arthrocentesis and oral antibiotics. These patients were labeled as suffering from an infection and underwent surgical debridement along with administration of injectable antibiotics. The history of intraarticular steroid injection before ACLRS was a significant risk factor for developing infection ($P$ = 0.001). At mean followup of 2.8 years, mean VAS improved to 1.18 ± 0.99 from 6.2 ± 2.3. The mean Lysholm knee score and Tegner's activity level at the final followup were 79.2 ± 10.52 and 4.8 ± 2.30, respectively. **Conclusion:** The incidence of infection was 1.2% (17/1468). The step-ladder approach of differentiating between aseptic effusion and infection and accordingly, following a treatment protocol, i.e., oral antibiotics alone or surgical debridement along with injectable antibiotics or additional debridement of graft in refractory patients, yielded satisfactory results.

**Keywords:** *Anterior cruciate ligament, infections, incidence, risk factors, treatment protocol*
**MeSH terms:** *Anterior cruciate ligament, ACL reconstruction, risk factors, surgical wound infection*

## Introduction

Postoperative infection is a rare but potentially devastating complication after anterior cruciate ligament reconstruction surgery (ACLRS). The incidence of postoperative infection after ACLRS has been reported to be between 0.1% and 2.4%.[1-5] Multiple factors including surgical technique, graft type (semitendinosus and gracilis [STG], quadriceps, bone–patellar tendon–bone [BPTB]), graft source (autograft, allograft), fixation technique (cortical fixation, bio-screws), diabetes mellitus, smoking, intraarticular steroid injection, obesity, etc., have been reported as potential risk factors for postoperative infections.[4-10] Further, there are varied treatment protocols used by various authors including conservative treatment, open or arthroscopic debridement with graft retention or graft removal.[2-5,11] However, most of these series are small case series with no well-defined guidelines.[1-7]

The majority of reports of infection after ACLRS have originated from the Caucasian population with a few reports from the Asian population.[6-12] Different ethnic populations can have varied predisposition to infections, in terms of type and virulence of organisms.[13] Thus, there is a need to have more data from different ethnic populations. To the best of our knowledge, the present study is the largest cohort from Asia which has studied the incidence, risk factors, and treatment protocol to manage infection post anterior cruciate ligament (ACL) reconstruction surgery.



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The aim of the present study was to determine the incidence and risk factors of postoperative infection after arthroscopic ACLRS in the Indian population and to report the outcome of our treatment protocol.

## Materials and Methods

This is an analysis of 26 patients, with clinical suspicion of infection, from a prospective cohort of 1468 arthroscopic ACLRS (141 BPTB graft and 1327 STG graft) performed between January 2010 and August 2015 at our center. BPTB graft was fixed with metallic interference screws on both femoral and tibial side, and STG graft with preserved tibial insertions[14] was fixed on the femoral side using an endobutton. Patients with multi-ligament reconstruction, previous knee surgery other than ACLRS and, those who underwent ACL reconstruction surgery elsewhere and later on got infected were excluded from the study. Infection was suspected when features of fever, knee swelling/effusion, local rise of temperature, pain out of proportion to the surgery, loss of regained knee movements, etc., were present after ACLRS. The data were analyzed to obtain the demographic profile, comorbidities, type of graft, clinical presentation, arthrocentesis findings, laboratory parameters (C-reactive protein and erythrocyte sedimentation rate [CRP and ESR]), and the treatment given.

At final followup, patients were evaluated with a detailed physical examination, visual analog scale (VAS) for pain, functional Lysholm and Gillquist knee score[15] and Tegner and Lysholm activity level.[16]

### Treatment protocol for the suspected infection

In cases of clinically suspected infection after ACLRS, blood tests for inflammatory markers (CRP and ESR) were performed. After arthrocentesis, synovial fluid was sent for cytology and culture sensitivity. Analgesics and oral amoxicillin + clavulanic acid 625 mg three times/day were started until the culture sensitivity reports were obtained.

If the culture reports were negative, knee aspirate was sent for extended culture. The downward trend of ESR/CRP and the patients showing clinical improvement after arthrocentesis were considered to be cases of aseptic effusion. In such cases, the oral antibiotics were continued until the patient became asymptomatic and CRP became normal.

In the patients in whom the culture report was negative at 48 h, but symptoms were continuing or worsening with raised CRP/ESR, these patients were taken up for arthroscopic debridement and administered injectable amoxicillin + clavulanic acid 1.2 g and gentamycin 80 mg twice daily. Meanwhile, the knee aspirate was sent for extended culture. These patients were monitored clinically and with laboratory parameters (ESR/CRP). In patients with clinical improvement and reduced level of inflammatory markers, injectable antibiotics were continued until patients became asymptomatic and CRP levels became normal.

In all culture-positive patients, arthroscopic debridement was performed along with administration of injectable antibiotics according to culture/sensitivity [Figure 1].

### Operative procedure

Debridement included removal of the devitalized or necrotic tissue and removal of fibrin layers, followed by extensive irrigation using at least 18 L of fluid. The graft was retained at the time of debridement. If however, the symptoms persisted after 7–10 days of first debridement and antibiotics, graft removal was considered at second debridement. If the patient had discharge from the graft area, the debridement of graft area was also performed. A closed-suction drain was placed after the debridement in all the patients for 24 h. Empirical antibiotic therapy was continued after debridement and continued until extended culture sensitivity report was obtained. Antibiotic treatment was changed if necessary. Injectable antibiotics were given for 2–4 weeks until complete cure of symptoms and normalization of laboratory parameters.

Postoperatively immediately after debridement, weight bearing and range of motion exercises were allowed, as per tolerance for pain.

### Statistical methods

The correlation of various risk factors including gender, diabetes, smoking, obesity, preoperative intraarticular steroid injection, and graft type has been studied by calculating the event rate and odds ratio (OR) in the affected and unaffected cohort. The logistic regression analysis was applied to the various risk factors to find the independent predictors of infection.

## Results

Between January 2010 and August 2015, 1468 ACLRS with 1358 males and 110 females, (141 BPTB graft and 1327 STG graft) were performed. The mean age of the patients was 27.1 years (range 21–42 years). Infection was suspected in 26 patients. There were 24 male and 2 female patients with a mean age of 27.2 years (range 23–42 years) who were suspected to have an infection.

All of the patients had symptoms of pain, swelling, and loss of the regained knee movements. Fever was present in 65.3% (17/26) of the patients. The mean interval from the index ACL procedure to the onset of symptoms was 12.4 days (range 3–21 days).

### Type of graft

In patients who had the postoperative suspicion of infection ($n$ = 26), 1 (3.85%) out of 26 was operated using BPTB graft and 25 (96.15%) were operated with STG graft. While 140 out of 1442 patients (9.70%) (who did not have

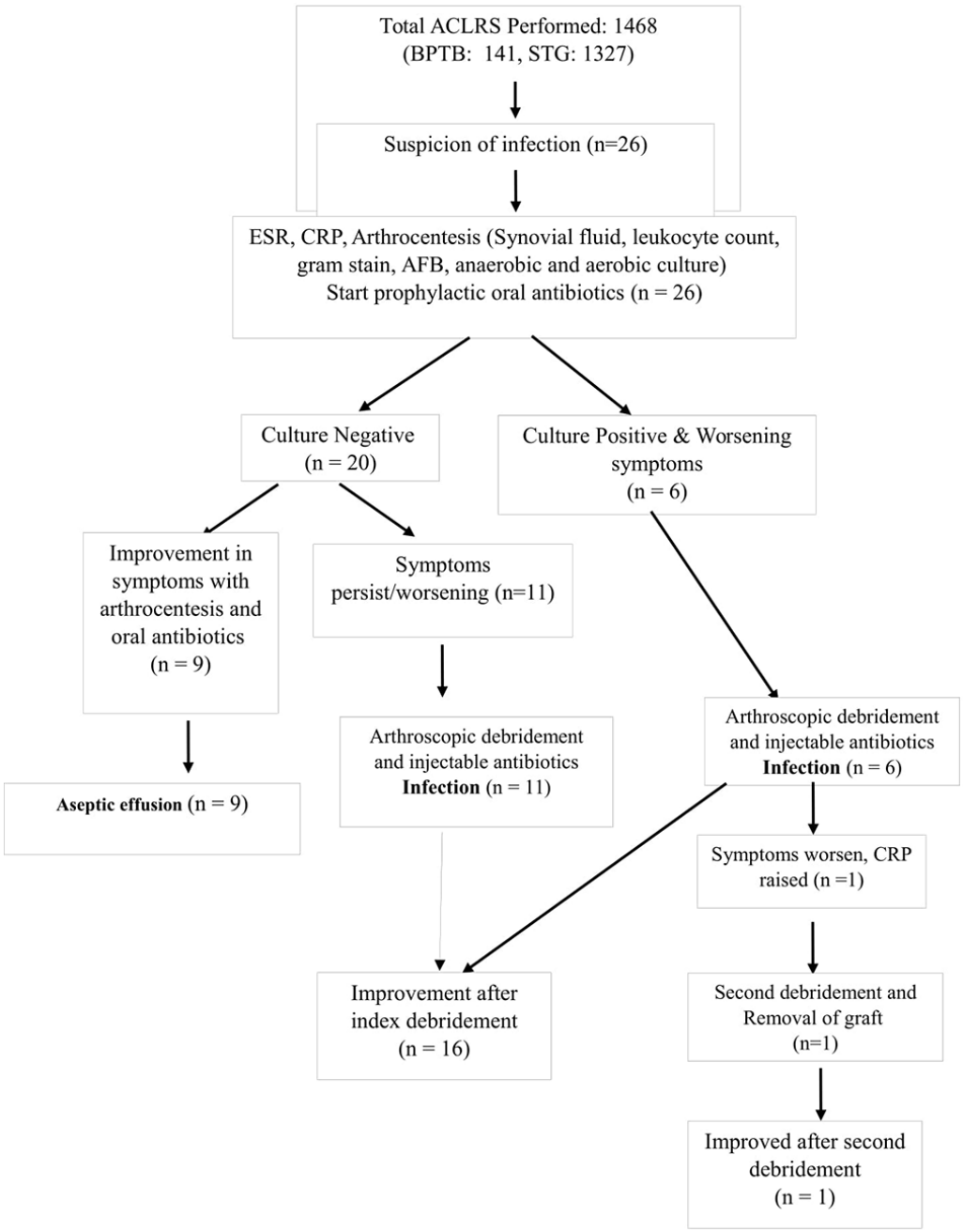


**Figure 1: Treatment algorithm in cases of suspected infection after anterior cruciate ligament reconstruction surgery**

suspicion of infection) were operated using BPTB graft and 1302 out of 1442 patients (90.29%) (who did not have suspicion of infection) were operated with STG graft. The incidence of suspicion of infection was higher in the STG group. The OR of developing infection using STG graft was 2.6 (95% confidence interval [CI]: 0.3–19.2; $P = 0.358$) [Table 1].

## Gender

24 out of 26 patients (92.30%) with postoperative suspicion of infection after ACLR were males and 2 (7.70%) were females. While 1334 out of 1442 patients (92.51%) with primary ACLR surgery (who did not have suspicion of infection) were males and 108 were females (7.49%).

**Table 1: Logistic regression analysis**

| Outcome: Postoperative infection after arthroscopic ACLRS | Regression coefficient | *P* | OR (95% CI) |
|---|---|---|---|
| Constant | 0-5.79 | 0.000 | - |
| Sex (female) | 0.573 | 0.367 | 0.6 (0.2-2.0) |
| Type of graft (STG) | 0.94 | 0.358 | 2.6 (0.3-19.2) |
| Diabetes mellitus | 1.56 | 0.162 | 4.8 (0.5-42.3) |
| Smoking | 0.520 | 0.369 | 1.7 (0.5-5.2) |
| Intraarticular injection | 1.440 | 0.001 | 4.2 (1.9-9.6) |
| Obesity | 0.614 | 0.350 | 1.8 (0.5-6.7) |

OR=Odd ratio, CI=Confidence interval, ACLRS=Anterior cruciate ligament reconstruction surgery, STG=Semitendinosus and gracilis

### Diabetes mellitus

Diabetes mellitus was present in 1 out of 26 patients with the postoperative suspicion of infection after ACLRS with an event rate of 3.84%. While 11 out of 1442 patients with primary ACLRS (who did not have suspicion of infection) had diabetes mellitus with an event rate of 0.76%. The OR of developing infection in patients with Diabetes mellitus was 4.8 (95% CI: 0.5–42.3; $P = 0.162$).

### Smoking

Four out of 26 patients with postoperative suspicion of infection were smokers with the event rate of 15.38%. While 142 out of 1442 patients with primary ACLRS (who did not have suspicion of infection) were smokers with an event rate of 9.8%. The OR of developing the infection in patients who were smoker was 1.7 (95% CI: 0.5–5.2; $P = 0.369$).

### Intraarticular steroid injection

Intraarticular administration of steroids by quacks is a prevalent practice in our part of the world. It doesn't amount to any form of treatment. The history of intraarticular steroid injection was present in 17 out of 26 patients with postoperative suspicion of infection after ACLRS with an event rate of 65.38%. While 448 out of 1442 patients with primary ACLRS (who did not have suspicion of infection) had the history of intraarticular steroid injection with an event rate of 31.06%. The OR of developing the infection in patients with a history of intraarticular steroid injection was 4.2 (95%CI: 1.9–9.6; $P = 0.001$).

### Obesity

Three out of 26 patients with postoperative suspicion of infection were obese (body mass index >30) with an event rate of 11.53%, whereas 65 out of 1442 patients with primary ACLRS (who did not have suspicion of infection) were obese with an event rate of 4.5%. The OR of developing the infection in patients with obesity was 1.8 (95% Cl, 0.5–6.7; $P = 0.350$).

Using logistic regression analysis, all the above factors were evaluated independently as a risk factor for infection after ACLRS [Table 1]. As the incidence of infection after ACLRS was higher in females and in patients who were operated using STG graft, these factors were evaluated. The history of intraarticular steroid injection before the surgical intervention was the independent significant factor for developing infection after ACLRS (OR, 4.2; $P = 0.001$).

The trends of ESR and CRP in cases with clinical suspicion of infection are summarized in Table 2.

Organisms were isolated in 6 out of 26 (23.1%) patients [Table 3]. *Staphylococcus aureus* was isolated in 5 patients while Pseudomonas was isolated in 1 patient. The cultures were sensitive to amoxicillin and clavulanic acid in 4 out of these 5 patients (66.7%) while in remaining 2 (33.3%) patients' cultures were sensitive to carbapenems, gentamycin, and amikacin.

Nine patients showed decreasing trends of the markers of inflammation (CRP and ESR) and signs of clinical improvement in 48 h after arthrocentesis and start of oral

**Table 2: Mean erythrocyte sedimentation rate and C-reactive protein levels in patients**

| Grades of clinical suspicion of infection | At onset | | After 48 h | | 1 week | | 6 weeks | |
|---|---|---|---|---|---|---|---|---|
| | ESR (mm) | CRP (mg/L) | ESR (mm) | CRP (mg/L) | ESR (mm) | CRP (mg/L) | ESR (mm) | CRP (mg/L) |
| Aseptic effusion | 31.22 | 45.2 | 24.56 | 37.6 | 18.11 | 10.0 | 7.0 | 8.2 |
| Moderate virulent infections | 49.80 | 92.20 | 52.16 | 87.14 | 31.15 | 23.40 | 7.6 | 8.40 |
| Severe virulent infections | 51.44 | 93.4 | 54.67 | 91.4 | 41.52 | 31.6 | 12.52 | 9.8 |

The mean CRP and ESR levels in patients with aseptic effusion, moderate and severe virulent infections at day 0, 1 week, and 6 weeks. ESR=Erythrocyte sedimentation rate, CRP=C-reactive protein

**Table 3: Various arthrocentesis parameters of patients with suspicion of infection**

| Arthrocentesis parameters | Aseptic effusion (*n*=9) | Moderate virulence infections (*n*=6) | Severe virulence infections (*n*=11) |
|---|---|---|---|
| Mean WBC/mm$^3$ | 4200 | 71,350 | 78,700 |
| Mean polymorphoneutrophills (%) | 21 | 72.5 | 84 |
| Mean lymphocytes (%) | 77 | 17 | 16 |
| Mean glucose (percentage of blood level) | 79 | 45.6 | 41 |
| Culture | Negative in all | Negative in all | Negative in 5 and positive in 6 |
| Gram stain | | | |
| Positive | Nil | Nil | 5 |
| Negative | Nil | Nil | 1 |
| AFB positive | Nil | Nil | Nil |

WBC=White blood cell, AFB=Acid-fast bacilli

antibiotics. These were labeled as patients with aseptic effusion.

A total of 17 patients did not improve or instead worsened after arthrocentesis and oral antibiotics. These patients were labeled as suffering from infection. These patients were managed with arthroscopic surgical debridement along with injectable antibiotics. One patient required a second surgical debridement because of persistent infection and the ACL graft was also debrided in the second setting. All the infections were intraarticular, with four concomitant deep tibial side wound infections (extraarticular), which were managed with open debridement of the wound. The mean duration of antibiotic treatment was 4.24 weeks (range 2–8 weeks). At a mean followup of 2.8 years (range 1–6.5 years) after the index ACL procedure, there was no recurrence of infection, one patient had nontraumatic ACL insufficiency. The mean VAS improved from 6.2 ± 2.3 at the time of onset of symptoms to 1.18 ± 0.99 at the time of final followup. The mean side-to-side difference using KT-1000 measurement in these cases was 2.29 mm (range 0 mm–4 mm). The mean Lysholm knee score was 79.2 ± 10.52 (range 48–92) at the time of final followup. The mean preinjury and final followup, Tegner's activity level was 6.79 ± 1.6 and 4.8 ± 2.30, respectively.

Nine cases responded to antibiotics and were labeled as aseptic effusion. Their outcome at followup was as follows; at a mean followup of 3 years (range 1–5 years), the mean VAS improved from 4.0 ± 1.1 at the time of onset of symptoms to 0.2 ± 0.4 at the time of final followup. The mean side-to-side difference using KT-1000 measurement in these cases was 2.0 mm (range 0 mm–4 mm) at the time of final followup. The mean Lysholm knee score was 82.1 ± 5.6 (range 72–88) at the time of final followup. The mean preinjury and final followup, Tegner's activity level was 8.0 ± 1.2 and 7.1 ± 1.8, respectively.

## Discussion

Infection after ACL reconstruction is a rare but serious complication. In the present case series, the incidence of infection was 1.2%, which was similar to the other published studies which documented infection rate between 0.1% and 2.4%.[1-5,17] The incidence of infection was higher with STG graft 1.88% (25 out of 1327) as compared to the BPTB graft 0.71% (1 out of 141). These results of the present study are similar to various other studies.[2,4,18] Maletis *et al*. reported higher incidence of infection (0.6%) using STG graft as compared to BPTB graft (0.07%).[19] However, the reason for the same is yet not clear. Several theories have been proposed in literature. Hamstring tendon autografts may take longer to prepare than either BPTB autografts, increasing the time for contamination during graft preparation. Multifilament suture is often used in the preparation of hamstring grafts, which could potentially harbor bacteria. Whether the grafts are contaminated during harvest or while being prepared is also unclear.[19]

We have evaluated various risk factors such as type of graft, gender, obesity, diabetes, smoking, and history of intraarticular steroid injection in our study group. By keeping the other variables constant, we have observed the various risk factors independently. The history of intraarticular steroid injection was a significant risk factor for developing infection after ACLR surgery (OR; 4.2 and $P = 0.001$). Steroids are known to decrease immunity.[20] Moreover, there are reports citing increased postoperative infection rates in cases of total knee arthroplasty who have received intraarticular steroid injections prior to surgery.[21]

Intraarticular steroid injection is generally not included in the mode of treatment of ACL deficient knees. However, in our part of the country, many patients report to quacks initially after suffering an injury, where they are occasionally administered an intraarticular steroid injection. These patients did not suffer from any signs and symptoms of infection after intraarticular injection. Moreover, cell counts that were performed as part of preoperative investigations, were found to be within the normal limits. Hence, asterile injections as the reason for infection, is ruled out.

As far as clinical features are concerned, majority of the patients showed typical signs of infection at the time of presentation such as an increase in pain, swelling, loss of regained knee movements, and fever. Fever was not present in 34.6% (9/26) of the patients with infective arthritis at the time of onset, further establishing the fact that absence of fever does not rule out infection.[4] CRP and ESR were raised or showed an increasing trend in all the patients with infection, which imply that these are the most reliable markers of infections. Thus, CRP and ESR along with clinical features can be the important combination in diagnosing infection.[17,22]

Twenty out of 26 (76.9%) patients developed symptoms after 7 days of index surgery. Therefore, a high index of suspicion should be considered in patients presenting later with aggravation of symptoms.

In the present study, we have managed patients with suspected infection as shown in algorithm Figure 1. In 17 patients, surgical debridement was done. Only in one out of the 17 patients who were treated with surgical intervention, ACL was removed at the time of the second debridement. The meta-analysis by Kuršumović and Charalambous showed 85% graft survival after thorough arthroscopic debridement.[6] Further, we have used oral amoxicillin + clavulanic acid in aseptic effusion while injectable amoxicillin + clavulanic acid and gentamycin in infections with moderate-to-high virulent organisms. Various other studies have reported cephalosporin, gentamycin, ciprofloxacin, clavulanate, and vancomycin as their preferred antibiotics in the management of postoperative infection.[6,7,19] We had preferred oral antibiotics as our first line of treatment as some of the patients were

having aseptic effusion which could be treated effectively with conservative treatment. Furthermore, additional surgery has its own disadvantages which also increase the morbidity to the patient. Therefore, the conservative trial of treatment should be started under strict supervision to avoid over treatment and surgical debridement should only be opted in established infections or patients who fail to respond or worsen despite initial conservative treatment.

In our series, all the patients were treated with same protocol of antibiotics. The rationale behind that was that the most common organism described in literature causing infections post ACL surgery is *Staphylococcus aureus*.[6,7,19] Organisms were isolated from extended cultures in our study in only 6 out of 26 cases (23%) of clinical suspicion of infection and 5 out of 6 cultures showed growth of *staphylococcus aureus*. Hence, a combination of amoxicillin + clavulanic acid was started till culture reports arrived. Gentamycin was added to provide cover for Gram-negative organisms.

The reason for low culture positive infection can either be due to low virulence of organism in some of the patients or empirical treatment with antibiotics by the local physician in some of the cases $n = 2$ before the patient came back to us.

At the final followup, the mean side-to-side difference using KT 1000 arthrometer was 2.29 mm (range 0 mm–4 mm) which was similar to those in our uncomplicated cases 1.9 mm (range 0 mm–5 mm). However, the mean Lysholm score was lower 79.2 ± 10.52 (range 48–92) as compared to our uncomplicated cases 90.96 ± 11.72 (55–100). This finding of our study can be due to damage to cartilage due to infection, which also delays the return to preinjury activity level. However, there can be other reasons as well for the low Lysholm score.[2,6]

In our search pubmed data, there have been very few studies about postoperative infection after ACL reconstruction available from the Asia and Indian subcontinent. In a study by Nag *et al*., 8 patients out of 26 were having the tubercular infection after the ACLRS without any preoperative evidence of tuberculosis.[12] Although in our study too, preoperative patients had similar demographic pattern, but none of our patients were having tuberculosis as the cause of infection after the ACLRS.

## Conclusion

The incidence of infection after the ACLRS is 1.2%. The history of intraarticular steroid injection is an independent risk factor for developing postoperative infection after the ACLRS. The early and aggressive treatment protocol of oral antibiotics in suspected infection, followed by surgical debridement along with injectable antibiotics in confirmed cases of infection or those who are not responding to or deteriorating with antibiotics, yields satisfactory results.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts of interest

There are no conflicts of interest.

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