Klein et al. suggested a stage-oriented therapy for the treatment of bacterial joint infections in 1989, based on three stages of infection, which largely coincided with the stages I to III according to Gaechter [3].

An extensive irrigation of the joint and removal of all hematoma, fibrin deposits and partial synovectomy should be performed when synovitis is present [4,5]. In the presence of cartilage erosions in the joint or additional septa, a subtotal synovectomy is recommended [3]. Other studies advocate for a synovectomy during the first irrigation and debridement procedure, with fair results [6,7]. Zalavras et al. reported a successful outcome following a complete synovectomy [8]. More recent papers again recommend a synovectomy only in stages III and IV [9].

Prompt recognition of an infection and intervention with irrigation and debridement alone can prevent the need to remove ligament grafts and hardware. Therefore, a synovectomy should not be routinely performed during arthroscopic treatment of an acute infection following ACLR. However, this issue has not been well studied, and further studies are needed to address the influence of synovectomy in the management of infected ACLR.

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QUESTION 4: Should the graft and all hardware be removed in the treatment of patients with an acute infection following anterior cruciate ligament reconstruction (ACLR)?

RECOMMENDATION: The initial approach to an acute infection following ACLR should be arthroscopic irrigation and debridement, retention of a stable graft and hardware and intravenous antibiotic therapy.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

The incidence of septic arthritis after anterior cruciate ligament (ACL) surgery is low (0.14 to 2.25%) [1]. In acute postoperative infections, graft and hardware removal versus retention remains controversial with the goal being to eradicate the infection, preserve the articular cartilage and retain a functioning graft.

A prospective study by Abdel-Aziz et al. analyzed 2,560 ACL procedures with 24 cases of septic arthritis, with a mean follow-up of five years. In all patients, arthroscopic surgical debridement was performed (average three procedures), followed by intravenous antibiotic treatment. In all 24 cases, infection was eradicated with this protocol. No functional differences were found compared to control group according to Lysholm, International Knee Documentation Committee (IKDC) and Knee Injury and Osteoarthritis Outcome Score (KOOS) ratings [2]. Likewise, Schuster et al. reviewed more than 7,000 ACLRs, identifying a total of 36 cases of acute postoperative infections. The graft was retained in all but one case (97.2%) with a mean of 2.25 (+/-1.22 SD) procedures required to treat the infection [3].

In a meta-analysis, Kuršumović et al. reported a success rate of 85% for graft retention and infection eradication [4]. They analyzed 16 studies with a total of 147 knee infections after ACLR. Increased rates of failure were seen in cases with persistent infection requiring subsequent procedures, from 4.4% with one arthroscopic debridement, to 11.4% with two procedures, or 25% with more than three surgeries [4]. In a similar systematic review, Makhni et al. analyzed 19 studies with a total of 203 cases of septic arthritis following ACLR and reported a success rate with graft retention of 78% [5].

Wang et al. also demonstrated success after serial irrigation and debridement and intravenous antibiotics. In addition, they demonstrated a greater graft retention rate when infection was diagnosed and treated immediately (< 7 days) suggesting a crucial time constraint to treatment [1].

Therefore, the data suggests that the initial approach to acute postoperative infection after ACLR should be to attempt to retain the graft and hardware. However, there are cases in which removal should be considered, which may include presence of gross purulence, when infection is resistant to multiple irrigations and debridement, possible bony involvement of the tibia or femur and/or a non-functional graft [6,7].

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QUESTION 5: How many arthroscopic procedures are reasonable for the management of an infected anterior cruciate ligament reconstruction (ACLR) prior to considering graft and hardware removal?

RECOMMENDATION: Prior to considering stable graft and hardware removal, at least two arthroscopic procedures are reasonable for the management of an infected ACLR. There is evidence for successful treatment and graft retention with further arthroscopic procedures.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Septic arthritis after arthroscopic ACLR is rare with an overall frequency to be around 1% [1–4]. However, when it does occur, it is a potentially serious event with possible sequelae of osteomyelitis, arthrofibrosis and damage to the articular cartilage leading to osteoarthritis [5–7]. Although a rare occurrence, surgeons who routinely perform this procedure are likely to encounter this complication during their career [8].

Repeated arthroscopic lavage is part of the algorithm to treat infection after ACLR [4]. The number of arthroscopic procedures necessary is guided by clinical and laboratory progression as well as organism virulence and patient-related factors such as age and pre-existent comorbidities [3,9]. In a study by Bostrom Windhamre et al., patients suffering from septic arthritis after ACLR underwent a mean of 3.7 interventions (range 1 to 11) [10]. Arthroscopic lavage was repeated if the patient had persistent fever, swelling and a C-reactive protein level greater than 50 mg/L. In a study of 90 cases of septic arthritis after ACLR conducted by Saper et al., arthroscopic irrigation and debridement was performed in 95.5% (86/90) of cases with an average of 1.51 procedures [2].

According to Abdel-Aziz et al., a median of three (range 1 to 6) repeated arthroscopic debridement and synovectomy procedures were required to eradicate infection [3]. In another study by Schulz et al., irrigation and debridement successfully treated the infection with a mean of 2.2 procedures with no recurrences of septic arthritis or bone infection [11]. Kim et al. presented 146 patients producing 111 (78.1%) positive intraoperative cultures. *Staphylococcus epidermidis* was identified in 46 knees (41.4%) with *Staphylococcus aureus* found as the second most common organism and presented in 38 knees (34.2%) with infection after ACLR [12]. This report differs from the previous general consensus that *Staphylococcus aureus* was the most commonly reported organism in ACLR infection [9].

In their study of 147 patients with infections of the knee, Wang et al. noted that coagulase-negative *Staphylococcus* (CNS) was the most common pathogen and represented 45.6% of the infections. *Staphylococcus aureus* was second most common and was reported to cause 23.8% of the infections [7]. The virulence of the infective organisms can affect the course of treatment, but the age of the patient appears to have some bearing on the outcome and the number of arthroscopic procedures required to control the infection. Mouzopoulos et al. reported that patients over the age of 25 years required, on average, 1.12 more procedures to control infection compared to patients under the age of 25 [9].

Immediate arthroscopic lavage and debridement should be followed by six to eight weeks of intravenous antibiotic therapy, and then two to four weeks of oral antibiotics. In cases of persistent infection, repeat arthroscopy is recommended, but serious consideration for graft removal should be considered [9]. In patients with a retained graft, McAllister et al. reported that an average of 2.75 procedures were needed to sterilize the knee joint [5]. Graft retention is important, as 30% of patients with the graft retained following surgery experienced knee instability compared to 65% of patients who had their graft removed [11,13]. Early diagnosis of infection is critical, as the literature has reported that infection diagnosed within seven days post-ACL reconstruction has a higher rate of graft salvage than those infections diagnosed beyond seven days post-op [7]. Furthermore, graft retention following infection after ACLR is a viable procedure with a reported overall success rate of 85% [14].

Upon reviewing the literature, it was found that at least two arthroscopic treatments are needed to control infection after ACLR and prior to graft and hardware removal. Despite the lack of randomized clinical trials, several retrospective studies have reported that arthroscopic lavage and debridement for infection following ACLR is an effective therapeutic intervention to minimize the severity of sequelae, including osteoarthritis, osteomyelitis and arthrofibrosis [5].

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