[4] Smith TO, Hing CB. A meta-analysis of tourniquet assisted arthroscopic knee surgery. Knee. 2009;16:317–321. doi:10.1016/j.knee.2009.01.004.
[5] Budny J, Fox J, Rauh M, Fineberg M. Emerging trends in anterior cruciate ligament reconstruction. J Knee Surg. 2017;30:63–69. doi:10.1055/s-0036-1579788.
[6] Tomita M, Motokawa S. Effects of air tourniquet on the antibiotics concentration, in bone marrow, injected just before the start of operation. Mod Rheumatol. 2007;17:409–412. doi:10.3109/s10165-007-0609-4.
[7] Sherman OH, Fox JM, Snyder SJ, Del Pizzo W, Friedman MJ, Ferkel RD, et al. Arthroscopy--"no-problem surgery." An analysis of complications in two thousand six hundred and forty cases. J Bone Joint Surg Am. 1986;68:256–265.
[8] Reigstad O, Grimsgaard C. Complications in knee arthroscopy. Knee Surg Sports Traumatol Arthrosc. 2006;14:473–477. doi:10.1007/s00167-005-0694-x.
[9] Váchal J, Kríz J, Jehlicka D, Novák P. [Infectious complications after arthroscopic replacement of the cruciate ligaments]. Acta Chir Orthop Traumatol Cech. 2005;72:28–31.
[10] Brophy RH, Wright RW, Huston LJ, Nwosu SK, Spindler KP, Kaeding CC, et al. Factors associated with infection following anterior cruciate ligament reconstruction. J Bone Joint Surg. 2015;97:450–454. doi:10.2106/JBJS.N.00694.
[11] Maletis GB, Inacio MCS, Reynolds S, Desmond JL, Maletis MM, Funahashi TT. Incidence of postoperative anterior cruciate ligament reconstruction infections: graft choice makes a difference. Am J Sports Med. 2013;41:1780–1785. doi:10.1177/0363546513490665.
[12] Cancienne JM, Mahon HS, Dempsey IJ, Miller MD, Werner BC. Patient-related risk factors for infection following knee arthroscopy: an analysis of over 700,000 patients from two large databases. Knee. 2017;24:594–600. doi:10.1016/j.knee.2017.02.002.
[13] Clement RC, Haddix KP, Creighton RA, Spang JT, Tennant JN, Kamath GV. Risk Factors for infection after knee arthroscopy: analysis of 595,083 cases from 3 United States databases. Arthroscopy. 2016;32:2556–2561. doi:10.1016/j.arthro.2016.04.026.
[14] Dimnjaković D, Hrabač P, Bojanić I. Value of tourniquet use in anterior ankle arthroscopy: a randomized controlled trial. Foot Ankle Int. 2017;38:716–722. doi:10.1177/1071100717702461.
[15] Koo SJJ, Ho P. Wrist arthroscopy under portal site local anesthesia without tourniquet and sedation. Hand Clinics. 2017;33:585–591. doi:10.1016/j.hcl.2017.06.001.
[16] Ong MTY, Ho PC, Wong CWY, Cheng SHS, Tse WL. Wrist arthroscopy under portal site local anesthesia (PSLA) without tourniquet. J Wrist Surg. 2012;1:149–152. doi:10.1055/s-0032-1326726.
[17] Zaidi R, Hasan K, Sharma A, Cullen N, Singh D, Goldberg A. Ankle arthroscopy: a study of tourniquet versus no tourniquet. Foot Ankle Int. 2014;35:478–482. doi:10.1177/1071100713518504.

Authors: Ramón Barredo, Roberto Rossi, Nirav K. Patel

QUESTION 8: What strategies should be employed to minimize recurrent infection of a previously infected joint during subsequent joint reconstructive (non-arthroplasty) procedures?

RECOMMENDATION: We recommend that joints with remote or recent history of infection be aspirated and the synovial fluid analyzed for the presence of infection. The affected joint should not exhibit any clinical signs of infection such as erythema, swelling, warmth and others at the time of planned reconstruction.

LEVEL OF EVIDENCE: Limited

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

RATIONALE

Our extensive literature search did not reveal any studies specifically focusing on the prevention of recurrent infection in previously infected joints during reconstructive (non-arthroplasty) procedures. It is, however, well-established that previous septic arthritis is a risk factor for subsequent surgical site infection (SSI) and periprosthetic joint infection (PJI) [1–4]. Furthermore, different studies described the risk factors for developing septic arthritis, such as morbid obesity, tobacco use, inflammatory arthritis, chronic kidney disease, diabetes and hemodialysis [5–7]. Cancienne et al. reported in their case-control study of over 530,000 shoulder arthroscopies that prior steroid injection, revision surgery and malnutrition were independent risk factors for infection [8].

Multiple PJI and SSI risk mitigation strategies may be considered in a patient with remote or recent history of joint infection undergoing a reconstructive non-arthroplasty procedure [1–3,9,10]. These are discussed in further detail below.

- Medical optimization: Consider optimization of modifiable risk factors such as treatment of any systemic or local infection, correction of malnutrition, weight reduction in patients with morbid obesity (> 40 kg/m^2), treatment of vascular insufficiency, smoking cessation, correction of hyperglycemia and preoperative cessation of immune-modifying medications [10].
- Antibiotics: Administer prophylactic antibiotics to reduce the risk of recurrent infection. In patients with previous methicillin-resistant *Staphylococcus aureus* (MRSA) infection, the addition of vancomycin or teicoplanin as perioperative antibiotic prophylaxis should be considered [10,11].
- Skin preparation: Preoperative surgical site preparation using soap (antimicrobial or non- antimicrobial) or an antiseptic agent on the night before the operative day should be considered [2,10].
- Particle-free operating environment: While there is no definitive evidence for the efficacy of laminar air flow in non-arthroplasty surgery, the number of theatre personnel and operating room traffic should be minimized to reduce the risk of recurrent infection [10].
- Respect the soft tissue: Meticulous surgical technique, proper wound closure and an effort to reduce the surgical time may help minimize the risk of recurrent infection [10,12].
- Intraoperative wound irrigation: Copious intraoperative irrigation is considered an effective strategy to reduce the number of pathogens in the surgical wound [10].
- Wound management: Antimicrobial dressings may reduce the risk of SSI [10,13].

More recently, pre-soaking of hamstring tendon autograft in a vancomycin solution has been shown to reduce septic arthritis following ACL reconstruction. As such, we recommend soaking the autograft (and possibly allograft) in an antibiotic solution such as vancomycin when used in previously infected knees [14–17].

In the absence of specific literature related to the above question, we recommend that all measures are taken to ensure that infection in the affected joint is resolved, which includes absence of erythema, swelling and so on. In addition, the affected joint should be aspirated and the synovial fluid analyzed for signs of infection.

During the reconstruction of the previously infected joint, all available strategies for prevention of infection should be implemented.

REFERENCES

[1] Solomkin JS, Mazuski J, Blanchard JC, Itani KMF, Ricks P, Dellinger EP, et al. Introduction to the Centers for Disease Control and Prevention and the Healthcare Infection Control Practices Advisory Committee guideline for the prevention of surgical site infections. Surgical Infections. 2017;18:385–393. doi:10.1089/sur.2017.075.

[2] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg. 2017;152:784–791. doi:10.1001/jamasurg.2017.0904.

[3] Leaper DJ, Edmiston CE. World Health Organization: global guidelines for the prevention of surgical site infection. J Hosp Infect. 2017;95:135–136. doi:10.1016/j.jhin.2016.12.016.

[4] Parvizi J, Gehrke T, Chen AF. Proceedings of the International Consensus on Periprosthetic Joint Infection. Bone Joint J. 2013;95-B:1450–1452. doi:10.1302/0301-620X.95B11.33135.

[5] Cancienne JM, Mahon HS, Dempsey IJ, Miller MD, Werner BC. Patient-related risk factors for infection following knee arthroscopy: an analysis of over 700,000 patients from two large databases. Knee. 2017;24:594–600. doi:10.1016/j.knee.2017.02.002.

[6] Xu C, Peng H, Li R, Chai W, Li X, Fu J, et al. Risk factors and clinical characteristics of deep knee infection in patients with intra-articular injections: a matched retrospective cohort analysis. Semin Arthritis Rheum. 2018;47(6):911–916. doi:10.1016/j.semarthrit.2017.10.013.

[7] Cancienne JM, Gwathmey FW, Miller MD, Werner BC. Tobacco use is associated with increased complications after anterior cruciate ligament reconstruction. Am J Sports Med. 2016;44:99–104. doi:10.1177/0363546515610505.

[8] Cancienne JM, Brockmeier SF, Carson EW, Werner BC. Risk factors for infection after shoulder arthroscopy in a large Medicare population. Am J Sports Med. 2018:3635465517749212. doi:10.1177/0363546517749212.

[9] Parvizi J, Gehrke T. International Consensus Group on Periprosthetic Joint Infection. Definition of periprosthetic joint infection. J Arthroplasty. 2014;29:1331. doi:10.1016/j.arth.2014.03.009.

[10] Heller S, Rezapoor M, Parvizi J. Minimising the risk of infection: a peri-operative checklist. Bone Joint J. 2016;98-B:18–22. doi:10.1302/0301-620X.98B1.36365.

[11] AlBuhairan B, Hind D, Hutchinson A. Antibiotic prophylaxis for wound infections in total joint arthroplasty: a systematic review. J Bone Joint Surg Br. 2008;90:915–919. doi:10.1302/0301-620X.90B7.20498.

[12] Namba RS, Inacio MCS, Paxton EW. Risk factors associated with deep surgical site infections after primary total knee arthroplasty: an analysis of 56,216 knees. J Bone Joint Surg. Am 2013;95:775–782. doi:10.2106/JBJS.L.00211.

[13] Kuo FC, Chen B, Lee MS, Yen SH, Wang JW. AQUACEL® Ag surgical dressing reduces surgical site infection and improves patient satisfaction in minimally invasive total knee arthroplasty: a prospective, randomized, controlled study. Biomed Res Int. 2017;2017:1262108. doi:10.1155/2017/1262108.

[14] Eriksson K, Karlsson J. Local vancomycin in ACL reconstruction: a modern rationale (2016) for morbidity prevention and patient safety. Knee Surg Sports Traumatol Arthrosc. 2016;24:2721–2723. doi:10.1007/s00167-016-4283-y.

[15] Phegan M, Grayson JE, Vertullo CJ. No infections in 1300 anterior cruciate ligament reconstructions with vancomycin pre-soaking of hamstring grafts. Knee Surg Sports Traumatol Arthrosc. 2016;24:2729–2735. doi:10.1007/s00167-015-3558-z.

[16] Pérez-Prieto D, Torres-Claramunt R, Gelber PE, Shehata TMA, Pelfort X, Monllau JC. Autograft soaking in vancomycin reduces the risk of infection after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2016;24:2724–2728. doi:10.1007/s00167-014-3438-y.

[17] Vertullo CJ, Quick M, Jones A, Grayson JE. A surgical technique using presoaked vancomycin hamstring grafts to decrease the risk of infection after anterior cruciate ligament reconstruction. Arthroscopy. 2012;28:337–342. doi:10.1016/j.arthro.2011.08.301.

Authors: Dragan Radoičić, Ramón Barredo, Eric Wicks

QUESTION 9: Is the surgical management of a patient with infection following anterior cruciate ligament reconstruction (ACLR) an emergency, or can the patient be optimized prior to surgical intervention? If so, what needs to be optimized?

RECOMMENDATION: Infection following ACLR is not a surgical emergency in most cases. Sepsis associated with infected anterior cruciate ligament (ACL) requires an emergency treatment. Most surgeons agree that surgical intervention should take place without delay, on a prompt basis, preferably on the same day as the clinical presentation of an ACLR infection. The patient's condition needs to be optimized prior to surgery.

LEVEL OF EVIDENCE: Moderate

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

RATIONALE

Infection following ACLR is a rare event affecting up to 2.25% of patients, but it is a serious complication [1–15]. Surgical management of ACLR infections is frequently discussed in the literature, but the timing of surgical intervention is not clearly stated in the majority of these publications [3,4,6,10–12,16–18].

A few studies have addressed the issue of timing of surgery. A study by Schuster et al. stated that the surgery should be performed on the day of admission [19]. Another study by Mouzopoulos et al. also declared that the infection should be treated without delay [20]. In a review article, Wang et al. reported a summary of various studies by stating a recommendation for immediate operative treatment [21]. Torres-Claramunt et al. also reported that the generally-accepted treatment is "arthroscopic lavage, performed as soon as possible" [22]. It is known that articular cartilage degrades rapidly and loses nearly half of its glycosaminoglycan and collagen composition in the first week of a joint infection [23,24]. Therefore, a significant delay should not be experienced in the initiation of surgical treatment in patients presenting with an infection of ACL reconstruction.

The major drawback in the literature is that almost all of the studies published on infection following ACLR have been retrospective reviews. It is well-established in these studies that infection following ACLR can rarely be a life-threatening emergency. A timely and well-planned course of action based on clinical and laboratory data and microbiological findings is recommended. Graft retention has been shown as a goal along with articular cartilage protection, so lengthy delays should be avoided [1,3,6,11,13,17,18,25,26].

A protocol for patient optimization prior to surgery has not been clearly established. Clinical examination and aspiration of the knee joint is recognized as the first step in diagnosis at initial patient presentation with a suspected postoperative ACLR infection. It is also generally reported that broad-spectrum antibiotics, preferably cephalosporins, should be started as soon as possible after joint aspiration is performed [10,12,15,16,19,20,22,27]. The antibiotics should target coagulase-negative *Staphylococcus* (CNS) and *Staphylococcus aureus*, as these are the most common infecting organisms. Antibiotic therapy should be modified as soon as culture results identify the specific pathogen and the susceptibility.

Blood tests for infectious and inflammatory markers, such as white blood cell count, erythrocyte sedimentation rate and C-reactive protein, should also be conducted on the day of presentation.