

RATIONALE

The development of an infection after ACLR can have significant complications including loss of articular cartilage, graft failure and loss of knee function [1–3]. Although there is wide agreement that treatment must be initiated as early as possible, several different treatment algorithms have been proposed [4–7]. With regards to the postoperative treatment, there are no studies directly focusing on rehabilitation protocols.

While it is well-established that a graded knee-strengthening program (including quadriceps and hamstrings strengthening) has to be started within the first postoperative days [4,8–11], there is no agreement regarding weightbearing status and range of motion parameters.

Rehabilitative treatment after surgical debridement of an infected ACLR does not differ substantially from primary reconstruction. It should be focused on preventing stiffness and regaining motion through passive and active-assisted range of motion exercises.

There are no studies suggesting an altered rehabilitation protocol in the setting of a postoperative infection. Monaco et al. [10] suggest the use of a brace locked in extension for two weeks, followed by a progressive increase in the range of movement and muscular strength. Alternatively, many authors allow immediate full range of movement under the supervision of a physical therapist [7,11]. Indelli et al. [12] and Wang et al. [3] recommend starting rehabilitation only after complete resolution of symptoms, and suggest only passive motion of the knee and the ankle in the meantime.

There is a lack of consensus on weightbearing status after treatment of an ACL infection. Torres-Claramunt et al. [4,13] suggest starting a strengthening program two weeks after surgery with progressive weightbearing after symptoms decrease. Likewise, weightbearing was gradually increased until resolution of symptoms in the rehabilitation protocol developed by Hantes et al. [14]. However, McAllister et al. [15] and Schub et al. [16], suggest beginning the weightbearing six weeks after surgery.

Overall, there is a lack of evidence to support a standardized approach to rehabilitation after the surgical debridement of an infected ACLR. High-quality controlled trials are needed to provide guidelines for this rare and difficult complication.

REFERENCES

- Matava MJ, Evans TA, Wright RW, Shively RA. Septic arthritis of the knee following anterior cruciate ligament reconstruction: results of a survey of sports medicine fellowship directors. *Arthroscopy*. 1998;14:717–725.
- Judd D, Bottoni C, Kim D, Burke M, Hooker S. Infections following arthroscopic anterior cruciate ligament reconstruction. *Arthroscopy*. 2006;22:375–384. doi:10.1016/j.arthro.2005.12.002.
- Wang C, Ao Y, Wang J, Hu Y, Cui G, Yu J. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction: a retrospective analysis of incidence, presentation, treatment, and cause. *Arthroscopy*. 2009;25:243–249. doi:10.1016/j.arthro.2008.10.002.
- Torres-Claramunt R, Gelber P, Pelfort X, Hinarejos P, Leal-Blanquet J, Pérez-Prieto D, et al. Managing septic arthritis after knee ligament reconstruction. *Int Orthop*. 2016;40:607–614. doi:10.1007/s00264-015-2884-6.
- Abdel-Aziz A, Radwan YA, Rizk A. Multiple arthroscopic debridement and graft retention in septic knee arthritis after ACL reconstruction: a prospective case-control study. *Int Orthop*. 2014;38:73–82. doi:10.1007/s00264-013-2123-y.
- Williams RJ, Laurencin CT, Warren RF, Speciale AC, Brause BD, O'Brien S. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction. Diagnosis and management. *Am J Sports Med*. 1997;25:261–267. doi:10.1177/036354659702500222.
- Schuster P, Schulz M, Immendoerfer M, Mayer P, Schlumberger M, Richter J. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction: evaluation of an arthroscopic graft-retaining treatment protocol. *Am J Sports Med*. 2015;43:3005–3012. doi:10.1177/0363546515603054.
- Gobbi A, Karnatzikos G, Chaurasia S, Abhishek M, Bulgherhoni E, Lane J. Postoperative infection after anterior cruciate ligament reconstruction. *Sports Health*. 2016;8:187–189. doi:10.1177/1941738115618638.
- Kim SJ, Postigo R, Koo S, Kim JH. Infection after arthroscopic anterior cruciate ligament reconstruction. *Orthopedics*. 2014;37:477–484. doi:10.3928/01477447-20140626-06.
- Monaco E, Maestri B, Vadalà A, Iorio R, Ferretti A. Return to sports activity after postoperative septic arthritis in ACL reconstruction. *Phys Sportsmed*. 2010;38:69–76. doi:10.3810/psm.2010.10.1810.
- Cadet ER, Makhni EC, Mehran N, Schulz BM. Management of septic arthritis following anterior cruciate ligament reconstruction: a review of current practices and recommendations. *J Am Acad Orthop Surg*. 2013;21:647–656. doi:10.5435/JAAOS-21-11-647.
- Indelli PF, Dillingham M, Fanton G, Schurman DJ. Septic arthritis in postoperative anterior cruciate ligament reconstruction. *Clin Orthop Relat Res*. 2002;182–188.
- Torres-Claramunt R, Pelfort X, Erquicia J, Gil-González S, Gelber PE, Puig L, et al. Knee joint infection after ACL reconstruction: prevalence, management and functional outcomes. *Knee Surg Sports Traumatol Arthrosc*. 2013;21:2844–2849. doi:10.1007/s00167-012-2264-3.
- Hantes ME, Raoulis VA, Doxariotis N, Drakos A, Karachalios T, Malizos KN. Management of septic arthritis after arthroscopic anterior cruciate ligament reconstruction using a standard surgical protocol. *Knee*. 2017;24:588–593. doi:10.1016/j.knee.2017.02.007.
- McAllister DR, Parker RD, Cooper AE, Recht MP, Abate J. Outcomes of postoperative septic arthritis after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1999;27:562–570. doi:10.1177/03635465990270050301.
- Schub DL, Schmitz LM, Sakamoto FA, Winalski CS, Parker RD. Long-term outcomes of postoperative septic arthritis after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2012;40:2764–2770. doi:10.1177/0363546512461903.

Authors: Arnaldo Hernandez, Sommer Hammoud, Christopher Hadley

QUESTION 9: When can patients safely undergo revision anterior cruciate ligament reconstruction (ACLR) following treatment for prior infection?

RECOMMENDATION: It is considered safe to perform a revision ACLR following completion of successful treatment for infection and normalization of clinical and laboratory parameters upon resolution of the infection. The literature does not suggest a specific timeframe following resolution of the infection prior to performing revision ACLR.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 92%, Disagree: 0%, Abstain: 8% (Super Majority, Strong Consensus)

RATIONALE

Infection following ACLR is rare, with a reported incidence of 0.14% to 2.25% [1,2]. When infection does occur, there are potentially

significant consequences, particularly regarding patient outcomes [3]. Following allograft ACLR, there is a well-known risk of disease

transmission, although a recent literature review found no difference in infection rates between autograft and allograft ACL reconstructions [4,5].

Graft retention following an infected ACLR is a viable option, as a recent meta-analysis and systematic review reported a success rate of 85% [2]. Matava et al. surveyed 61 orthopaedic surgeons and found that graft removal was not popular as the initial treatment, with only 6% and 33% of respondents removing the autograft and allograft following ACLR infection, respectively. However, in cases of persistent infection, 36% of surgeons removed the graft as part of their treatment regimen [6]. The same survey showed that the most common time frame for revision surgery was a minimum of 6 to 9 months (range, 3 to 15 months) after eradication of the infection [6].

Despite successful outcomes with graft retention, graft removal and revision ACLR remains the preferred method for some surgeons following infection [7]. In a retrospective review, Burks et al. reported on 8 infections out of 1,918 ACL reconstructions. Seven of these were treated with immediate irrigation and debridement with subsequent graft removal and administration of intravenous antibiotics for six weeks. Of those, four successfully underwent revision ACLR at a mean of three weeks (range one to six weeks) after completing antibiotic treatment [7]. In another systematic review and expected value decision analysis of 19 studies, revision ACLR, within 3 to 6 weeks after the infection, was shown to have promising results [8]. Gille et al. prospectively studied 31 patients with ACL infection where the graft was salvaged in 8 patients (26%) and removed in 12 patients (39%). Only two patients underwent revision ACLR at six and eight months post infection [9].

Williams et al. reported on 2,500 ACLRs with 7 infections: the graft was removed in 4 cases. One of these cases underwent successful revision ACLR one year later [10]. In a retrospective review of 3,500 ACL reconstructions, Indelli et al. identified 6 infections treated with arthroscopic debridement of which 2 grafts were removed, culminating in 1 revision ACLR and 1 total knee arthroplasty (TKA) a year later [11]. Furthermore, another study reported one patient treated with initial graft removal and successful revision ACL surgery one year after treatment [12]. Zalavras et al. also described a series of five infected ACL reconstructions treated with radical debridement and graft removal. Two patients had further procedures: 1 revision ACL reconstruction 14 months later and 1 TKA nine months later [13].

Hantes et al. reported 7 infected cases in a series of 1,242 ACL reconstructions. One patient did well with irrigation and debridement and six had a recurrence of infection, requiring subsequent graft and hardware removal. These patients were offered subsequent revision ACLR and graft reimplantation three months after the last operation. Four of the six patients underwent revision with ipsilateral bone patellar tendon bone autograft at an average of five months (range four to nine) post eradication of infection. The authors recommend revision ACLR after eradication of the infection

for at least three months, with normal knee motion, no knee effusion and normal laboratory values [14].

Despite the lack of randomized clinical trials, there are several retrospective studies with low numbers of revision ACLR following treatment for prior infection. There is no consensus on the appropriate timing of revision reconstruction, with a reported range of three weeks to over a year. In general, it seems appropriate to delay surgery for a minimum of six weeks, but waiting three to six months post-eradication of infection may be optimal. Importantly, criteria such as normal knee motion, lack of knee effusion and normal laboratory markers must be considered before proceeding.

REFERENCES

- [1] Wang C, Lee YHD, Siebold R. Recommendations for the management of septic arthritis after ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2014;22:2136–2144. doi:10.1007/s00167-013-2648-z.
- [2] Kuršumović K, Charalambous CP. Graft salvage following infected anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Bone Joint J.* 2016;98-B:608–615. doi:10.1302/0301-620X.98B5:35990.
- [3] Schuster P, Schulz M, Immendoerfer M, Mayer P, Schlumberger M, Richter J. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction: evaluation of an arthroscopic graft-retaining treatment protocol. *Am J Sports Med.* 2015;43:3005–3012. doi:10.1177/0363546515603054.
- [4] Makhni EC, Steinhaus ME, Mehran N, Schulz BS, Ahmad CS. Functional outcome and graft retention in patients with septic arthritis after anterior cruciate ligament reconstruction: a systematic review. *Arthroscopy.* 2015;31:1392–1401. doi:10.1016/j.arthro.2014.12.026.
- [5] Greenberg DD, Robertson M, Vallurupalli S, White RA, Allen WC. Allograft compared with autograft infection rates in primary anterior cruciate ligament reconstruction. *J Bone Joint Surg Am.* 2010;92:2402–2408. doi:10.2106/JBJS.L.00456.
- [6] Matava MJ, Evans TA, Wright RW, Shively RA. Septic arthritis of the knee following anterior cruciate ligament reconstruction: results of a survey of sports medicine fellowship directors. *Arthroscopy.* 1998;14:717–725.
- [7] Burks RT, Friederichs MG, Fink B, Luker MG, West HS, Greis PE. Treatment of postoperative anterior cruciate ligament infections with graft removal and early reimplantation. *Am J Sports Med.* 2003;31:414–418. doi:10.1177/03635465030310031501.
- [8] Kusnezov N, Eisenstein ED, Dunn JC, Wey AJ, Peterson DR, Waterman BR. Anterior cruciate ligament graft removal versus retention in the setting of septic arthritis after reconstruction: a systematic review and expected value decision analysis. *Arthroscopy.* 2018;34:967–975. doi:10.1016/j.arthro.2017.08.246.
- [9] Gille J, Gerlach U, Oheim R, Hintze T, Himpe B, Schultz A-P. Functional outcome of septic arthritis after anterior cruciate ligament surgery. *Int Orthop.* 2015;39:1195–1201. doi:10.1007/s00264-014-2600-y.
- [10] Williams RJ, Laurencin CT, Warren RF, Speciale AC, Brause BD, O'Brien S. Septic arthritis after arthroscopic anterior cruciate ligament reconstruction. Diagnosis and management. *Am J Sports Med.* 1997;25:261–267. doi:10.1177/036354659702500222.
- [11] Indelli PF, Dillingham M, Fanton G, Schurman DJ. Septic arthritis in post-operative anterior cruciate ligament reconstruction. *Clin Orthop Relat Res.* 2002;182:188.
- [12] Kurokouchi K, Takahashi S, Yamada T, Yamamoto H. Methicillin-resistant *Staphylococcus aureus*-induced septic arthritis after anterior cruciate ligament reconstruction. *Arthroscopy.* 2008;24:615–617. doi:10.1016/j.arthro.2008.01.012.
- [13] Zalavras CG, Patzakis MJ, Tibone J, Weisman N, Holtom P. Treatment of persistent infection after anterior cruciate ligament surgery. *Clin Orthop Relat Res.* 2005;439:52–55.
- [14] Hantes ME, Raoulis VA, Doxariotis N, Drakos A, Karachalios T, Malizos KN. Management of septic arthritis after arthroscopic anterior cruciate ligament reconstruction using a standard surgical protocol. *Knee.* 2017;24:588–593. doi:10.1016/j.knee.2017.02.007.

