

Incidence of Septic Arthritis After Vancomycin Soaking of the Graft During Arthroscopic Anatomic Anterior Talofibular Ligament and Calcaneofibular Ligament Reconstruction

Grégoire Rougereau,^{*†‡} MD, Sammy Kassab Hassan,^{†‡} MD, Eugénie Valentin,[§] PhD, Sacha Jehan,[†] MD, Thomas Bauer,[†] MD, PhD, Nicolas Baudrier,[†] MD, and Alexandre Hardy,[§] MD

Investigation performed at Clinique du Sport, Paris, France

Background: Vancomycin soaking of the graft during arthroscopic anterior cruciate ligament reconstruction has been shown to be effective in reducing the rate of postoperative infection.

Purpose/Hypothesis: The present study aimed to (1) analyze the effect of vancomycin-soaked grafts during arthroscopic anatomic reconstruction of the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) on the incidence of infection and (2) evaluate the influence of infection on functional outcomes and identify the risk factors of infection. It was hypothesized that vancomycin soaking of the graft would reduce the postoperative infection rate.

Study Design: Cohort study; Level of evidence, 3.

Methods: Consecutive patients at 2 centers who underwent ATFL/CFL reconstruction between December 2011 and July 2022 were included. All patients had undergone anterolateral arthroscopic debridement of the ankle and anatomic ATFL/CFL reconstruction with a gracilis tendon autograft. Vancomycin soaking of the graft was begun in both centers in January 2021. Complications, functional scores, return to sports (RTS) rates, and the level of return were compared between patients with and without vancomycin-soaked grafts and between patients with and without infection.

Results: Overall, 182 patients (48% men; mean age, 34 ± 11.9 years) were included, with a mean follow-up of 23 ± 16.1 months. The rate of postoperative infection was significantly lower in the group with vancomycin soaking versus without (0/92 [0%] vs 8/90 [8.9%]; $P = .001$). At the final follow-up, there were 26 complications (14.3%): 8 infections, 6 recurrent tears, and 12 peripheral neuropathies. The infections developed after a mean of 17 ± 11 days. The functional scores were excellent at the final follow-up (American Orthopaedic Foot and Ankle Society [AOFAS] Ankle-Hindfoot Score, 86.5 ± 18.7 ; Karlsson score, 85 ± 18.3). Patients with infection had significantly decreased AOFAS scores (52.8 ± 27.6 vs 83.3 ± 21.5 ; $P = .003$), Karlsson scores (57 ± 27.7 vs 83.6 ± 20 ; $P = .006$), and RTS rates (25% vs 77%; $P = .005$) versus patients without infection.

Conclusion: Vancomycin-soaked grafts for arthroscopic anatomic ATFL/CFL reconstruction decreased the rate of postoperative infection. Infection led to a deterioration in results. Vancomycin-soaking of the graft did not have a negative effect on functional results.

Keywords: anterior talofibular ligament; lateral ankle instability; ligament reconstruction

Lateral ankle sprains are one of the main causes of ligament injury in athletes.³² The lateral ligaments play a crucial role in the stabilization of the ankle during movements of anterior talar translation and inversion.³ Inappropriate early management or recurrent sprains can result in chronic ankle instability due to lateral ligament complex

failure.^{12,31} Injuries to both the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) represent approximately 20% of the cases of ankle sprain and are also a risk factor for instability.²⁹ After appropriate nonoperative management, ankle stabilization can be obtained with an anatomic surgical reconstruction technique of both bundles of the lateral ligament complex.^{7,15,26} This anatomic reconstruction technique, particularly by mini-invasive arthroscopy, results in good clinical results and a rapid return to sports (RTS).^{8,18-19}

The infection rate in the ligament reconstruction of the ankle could be higher than that of other joints because of the superficial location of this joint and the graft. Nevertheless, data on the incidence of infection after anatomic arthroscopic reconstruction of the lateral ligaments of the ankle are scarce in the literature, and no studies have specifically analyzed whether the presence of infection influences the functional prognosis or RTS after reconstruction.

To reduce the risk of septic arthritis, in addition to preoperative antibiotics, certain knee surgeons recommend soaking the graft in vancomycin during anterior cruciate ligament reconstruction (ACLR).^{2,6} In a recent meta-analysis by Naendrup et al,²⁰ there were no infections in 2976 patients with preoperative vancomycin-soaked grafts compared with infections in 2.1% of patients without vancomycin-soaked grafts. Preventing postoperative infection is essential, especially since infection after ACLR negatively influences the functional outcome.^{17,27} Thus, vancomycin-soaked grafts provide a real clinical benefit in the knee by decreasing the incidence of septic complications and their negative influence on functional outcomes.

The main purpose of this study was to analyze the effect of vancomycin-soaked grafts during arthroscopic anatomic ATFL/CFL reconstruction on the incidence of infection. The secondary purpose was to evaluate the influence of infection on functional outcomes and identify the risk factors of infection. The hypothesis was that vancomycin soaking of the graft would reduce the risk of infection and its impact on clinical outcomes.

METHODS

Study Protocol

The ethics committee approved the study protocol, and all participants were informed of the purpose of the study and provided their consent. Included in the study were consecutive patients who underwent ATFL/CFL reconstruction at 2 separate centers between December 2011 and July 2022. Patients with a follow-up of <6 months were excluded.

The reconstruction technique was the same for all patients—anterolateral arthroscopic ankle debridement and anatomic ATFL/CFL reconstruction with a gracilis tendon autograft.⁷ The indication for an allograft at both centers was a high-level athlete or a history of a hamstring graft for ligament reconstruction in another anatomic site. Postoperative management was the same for all patients—immediate weightbearing with a walking boot for 3 weeks, followed by rehabilitation. Prophylactic antibiotics were the same at both centers: 1.5 g of intravenous cefuroxime 30 minutes before the inflation of the pneumatic tourniquet. In case of allergies, 900 mg of intravenous clindamycin was administered.

Vancomycin soaking of the graft was begun in both centers in January 2021. The vancomycin solution was prepared outside the operating field according to the protocol described by Grayson et al,⁶ in which 1 g of vancomycin was diluted in 100 mL saline solution.² The solution was then poured into a dish placed on the instrument table in the operating field. As soon as the graft was harvested, it was placed in the cup of antibiotic solution and soaked for at least 10 minutes.

Outcome Measures

The following preoperative clinical data were recorded: age at surgery, sex, body mass index, smoking status, Marx score, and Tegner score. At the final follow-up, patients completed the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot and Karlsson scores. The RTS rate, as well as the level of return, was recorded. If infection developed during the follow-up, the responsible pathogens and the treatment modality were recorded until the infection was diagnosed. The treatment of infection was the same for all patients—surgical revision with lavage and arthroscopic synovectomy, then administration of a double empirical broad-spectrum intravenous antibiotics therapy until bacteriological identification, followed by a double oral administration of adapted oral antibiotics therapy for 6 weeks. The absence of recurrent infection was defined as an absence of recurrent infection for 3 months after antibiotics had been discontinued.

Statistical Analysis

The number of participants required for the study was based on an estimated proportion of acute postoperative infection after arthroscopic reconstruction of the lateral ligament complex of the ankle, which was 9% in the group

*Address correspondence to Grégoire Rougereau, MD, Department of Orthopedics and Traumatology, Hospital Ambroise Pare, APHP, Boulogne Billancourt, France (email: greg.rougereau@gmail.com).

[†]Hospital Ambroise Pare, APHP, Boulogne Billancourt, France.

[‡]Hospital Pitie Salpetriere, APHP, Paris, France.

[§]Clinique du Sport, Paris, France.

Final revision submitted July 27, 2023; accepted August 10, 2023.

One or more of the authors has declared the following potential conflict of interest or source of funding: T.B. has received consulting fees from Arthrex. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Ramsay Santé (ref No. IRB00010835).

without vancomycin soaking versus 0% in the group with soaking. With an alpha risk of 5%, a power of 80%, and a bilateral test, a minimum of 85 patients were needed per group for this study.

The study groups consisted of treated patients (ie, with vancomycin-soaked grafts) and nontreated patients (without vancomycin). Further analysis of patients in the nontreated group was conducted according to those who developed postoperative infection. Qualitative variables, described by the number of events and their percentages, were compared using either the Pearson chi-square test or the Fisher exact test, depending on group sizes. Quantitative data were described by means and standard deviations and were compared by the appropriate statistical tests between the Student *t* test and the Mann-Whitney test. Kaplan-Meier curves were performed to evaluate the survival probability of postoperative infection between the 2 study groups and were compared with the log-rank test using time in days as the timescale. Statistical significance was set at $P < .05$. All statistical analyses were performed using the R software Version 4.2 (R Core Team).

RESULTS

A total of 182 patients were included during the study period, with a mean follow-up of 23 ± 16.1 months. There were 92 patients with vancomycin soaking and 90 patients without (Figure 1). The study population included 48% men, with a mean overall age at surgery of 34 ± 11.9 years. The cause of the initial injury was work-related in 30 cases (16.5%). Patient characteristics according to the study group are presented in Table 1. There was a high proportion of nonsmokers in the nontreated group, as well as a longer follow-up. The rate of postoperative infection between the groups with and without vancomycin was significantly different (0/92 [0%] vs 8/90 [8.8%], respectively; $P = .001$).

At the final follow-up, there were 26 complications (14.3%): 8 infections, 6 graft tears, and 12 peripheral neuropathies. Infection developed after a mean of 17 ± 11 days. No infections occurred after the first postoperative month; thus, the survival curves were only evaluated for the first 60 days after surgery (Figure 2). The survival curves were significantly different between the 2 groups ($P = .004$), with a higher incidence of infection in the group without vancomycin soaking. The following bacteria were identified: methicillin-sensitive *Staphylococcus aureus* in 4 cases, *Staphylococcus epidermidis* in 1 case, *Streptococcus agalactiae* in 1 case, and *Pseudomonas aeruginosa* and *Escherichia coli* (both of which are nonsensitive to vancomycin) in 1 case each. There were no recurrent infections after treatment with lavage synovectomy and appropriate antibiotics.

The functional scores for all patients were excellent at the final follow-up, with mean AOFAS and Karlsson scores of 86.5 ± 18.7 and 85 ± 18.3 , respectively. Vancomycin soaking of the graft did not affect functional results compared with the nontreated, noninfected graft (Table 2).

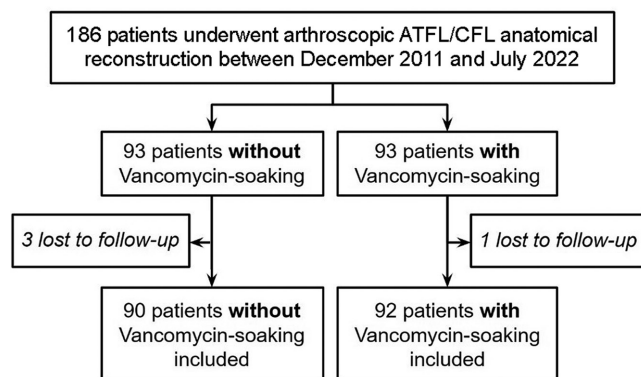


Figure 1. Flowchart of patient inclusion in the study. ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.

The functional scores and RTS rates were then compared between the nontreated patients without infection versus those with infection (Table 3). Infection significantly decreased the AOFAS score ($P = .003$) and the Karlsson score ($P = .006$). Moreover, the development of infection significantly reduced the RTS rate at the final follow-up (77% vs 25%; $P = .005$). A comparison of patient and surgical characteristics between the nontreated patients with versus without infection indicated no potential risk factors for developing postoperative infection (Table 4).

DISCUSSION

The main finding of this study was that perioperative vancomycin soaking of the graft during arthroscopic anatomic reconstruction of the external ligament complex of the ankle significantly reduced the rate of postoperative infection.

The incidence of infection reported in the literature for all lateral ankle ligament reconstruction techniques combined is between 4.2% and 8.7%.^{4,14,16,28} The specific rate of postoperative infection after arthroscopic anatomic reconstruction of the lateral ligament complex is not well known. The only study evaluating the development of infection after this type of surgery was published by Lopes et al,¹⁵ who found an infection rate of 4.2% in a series of 171 reconstructions. However, theirs was a multicenter study with different follow-up procedures and protocols to ours, which could explain the difference in findings. Indeed, in our study at 2 centers, the overall rate of infection was 4.4% (8/182), with an infection rate of 8.9% (8/90) in the group without vancomycin soaking and 0% (0/92) in the group with soaking. This infection rate is higher than that in ACLR, estimated at 2.1%.²⁰ This difference could be due to the superficial position of the tibiotalar joint and the contact between the graft and the arthroscopic portals, especially in the case of hematomas, which are reported complications in 3% of this type of surgery.⁸ Among other complications, the overall rate of postoperative neurological pain was 6.7% (6/90) in the

TABLE 1
Characteristics and Rates of Infection of the Study Population^a

Characteristic	With Vancomycin (n = 92)	Without Vancomycin (n = 90)	P
Age at surgery, y	33.5 ± 12.8	35.7 ± 11.3	.19
Sex			.90
Female	49 (53)	46 (51)	
Male	43 (47)	44 (49)	
BMI, kg/m ²	25 ± 5.4	25.4 ± 4.7	.63
Follow-up, mo	10.5 ± 5.5	36.2 ± 21.9	<. .0001
Smoking status			.02
Nonsmoker	67 (73)	76 (89)	
Former smoker	10 (11)	4 (5)	
Current smoker	15 (16)	5 (6)	
Inability to work	13 (14)	17 (18)	.56
High blood pressure history	3 (3)	0 (0)	.25
Cardiac disease history	3 (3)	0 (0)	.25
Diabetes	2 (2)	2 (2)	>.99
Immunosuppressive therapy	0 (0)	1 (1)	.50
Peripheral neuropathies	6 (6.5)	6 (6.6)	>.99
Surgical characteristics			
Allograft	0 (0)	3 (3.3)	.12
Calcaneal osteotomy	3 (3)	3 (3)	>.99
Osteochondral lesion of the talar dome	11 (12)	7 (8)	.46
Anterior ankle impingement	12 (13)	8 (9)	.48
Posterior ankle impingement	0 (0)	6 (7)	.01
Medial collateral ligament repair	0 (0)	2 (2)	.24
Syndesmosis	0 (0)	1 (1)	.50
Graft tear	1 (1)	5 (6)	.11
Returned to sport	73 (79)	65 (72)	.31
Type of sport			.68
Pivotal sport	32 (35)	32 (36)	
Contact pivotal sport	19 (21)	16 (18)	
Returned to sport at preinjury level	54 (59)	54 (60)	.88
Infection after surgery			.001
No	92 (100)	82 (91)	
Yes	0 (0)	8 (9)	

^aData are reported as mean ± SD or n (%). Bold P values indicate statistically significant differences between groups ($P < .05$). BMI, body mass index.

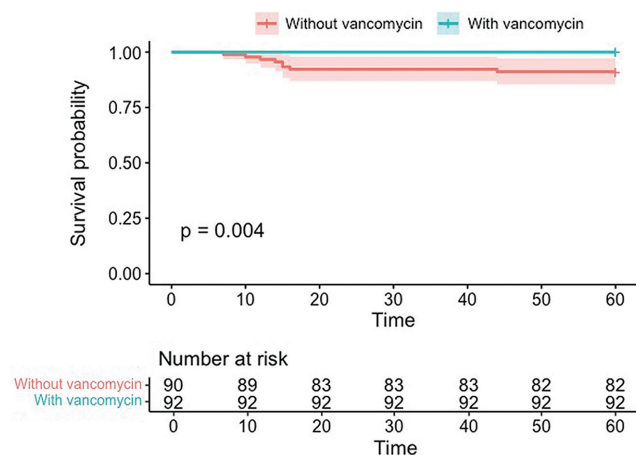


Figure 2. Kaplan-Meier curves of infection incidence according to the study group. Time is measured in days.

group without vancomycin. This rate is similar to that found in the literature.^{1,34}

Vancomycin soaking has been used in ACLR for nearly a decade.^{2,24,30} The recent meta-analysis by Naendrup et al²⁰ confirmed the efficacy of this technique in the management of septic complications, with no infections found in the 2976 cases in the literature. In the study by Kursumovic and Charalambous,¹¹ the risk of infection could be decreased 10-fold. Most infections are caused by skin flora bacteria—mainly *Staphylococcus aureus* and *Propionibacterium acnes*.⁵ Kanj et al¹⁰ have shown that while vancomycin soaking reduces inflammatory proteins, such as interleukin-6, it does not change the molecular structure or the structure of the hamstring tendons.

Although vancomycin could be toxic to adjacent tissue, the dilution ratio decreases rapidly within 1 hour after placement. Thus, there should be no risk to osteoclasts or chondrocytes from local accumulation of this drug.⁶ There are no studies showing that toxicity from this drug

TABLE 2
Comparison of Postoperative Functional Scores and RTS
Between Treated Patients and Nontreated and Noninfected Patients^a

Variable	With Vancomycin (n = 92)	Without Vancomycin or Infection (n = 82)	P
Marx score	8.6 ± 5.5	7.1 ± 5.6	.10
Tegner score	5.2 ± 1.9	5 ± 2	.61
AOFAS score	92.4 ± 9.2	83.3 ± 21.5	.02
Karlsson score	88.8 ± 12.9	83.6 ± 20	.35
Returned to sport	73 (79.3)	63 (76.8)	.72
Returned to sport at preinjury level	54 (58.7)	52 (63.4)	.54

^aData are reported as mean ± SD or n (%). The bold P value indicates a statistically significant difference between groups (P < .05). AOFAS, American Orthopaedic Foot and Ankle Society; RTS, return to sports.

TABLE 3
Comparison of Postoperative Functional Scores and RTS Between Nontreated Patients With Versus Without Infection^a

Variable	Without Vancomycin		P
	Without Infection (n = 82)	With Infection (n = 8)	
Marx score	7.1 ± 5.6	4.3 ± 6.5	.14
Tegner score	5 ± 2	3.9 ± 2.4	.15
AOFAS score	83.3 ± 21.5	52.8 ± 27.6	.003
Karlsson score	83.6 ± 20	57 ± 27.7	.006
Returned to sport	63 (77)	2 (25)	.005
Type of sport			.57
Pivotal sport	31 (49)	1 (50)	
Contact pivotal sport	16 (25)	0 (0)	
Returned to sport at preinjury level	52 (63)	2 (25)	.06

^aData are reported as mean ± SD or n (%). Bold P values indicate statistically significant differences between groups (P < .05). AOFAS, American Orthopaedic Foot and Ankle Society; RTS, return to sports.

TABLE 4
Comparison of Characteristics in Nontreated Patients With Versus Without Infection^a

Characteristic	Without Vancomycin		P
	Without Infection (n = 82)	With Infection (n = 8)	
Age at surgery, y	35.9 ± 11.3	34.2 ± 12.1	.70
Sex			.32
Female	41 (50)	5 (63)	
Male	41 (50)	3 (38)	
BMI, kg/m ²	25.5 ± 4.7	23.8 ± 4.9	.20
Follow-up, mo	36.5 ± 21.6	32.5 ± 24.5	.64
Smoking status			.55
Nonsmoker	70 (90)	6 (75)	
Former smoker	4 (5)	1 (13)	
Current smoker	4 (5)	1 (13)	
Inability to work	14 (16)	1 (8)	.88
High blood pressure history	0 (0)	0 (0)	—
Cardiac disease history	0 (0)	0 (0)	—
Diabetes	1 (1)	1 (12)	.20
Immunosuppressive therapy	1 (1)	0 (0)	>.99
Peripheral neuropathies	5 (6)	0 (0)	.94
Surgical characteristics			
Calcaneal osteotomy	3 (4)	0 (0)	.98
Osteochondral lesion of the talar dome	6 (7)	1 (13)	.49
Anterior ankle impingement	8 (10)	0 (0)	.78
Posterior ankle impingement	6 (7)	0 (0)	.96
Medial collateral ligament repair	2 (2)	0 (0)	>.99
Syndesmosis	1 (1)	0 (0)	>.99

^aData are reported as mean ± SD or n (%). Dashes indicate areas not applicable. BMI, body mass index.

influences the tear rate, the graft, or the functional outcome.^{2,9,13,21-23} Finally, the use of this vancomycin-soaking protocol is also supported by its excellent cost-effective ratio.²⁵ Despite these benefits, only an estimated 37.9% of surgeons use this protocol type.³³

This is the first study to evaluate this vancomycin-soaking protocol in the anatomic reconstruction of the lateral ligament complex of the ankle. The results of this series suggest that the same benefit of a decreased frequency of postoperative infection can be found in the ankle as in other joints. Moreover, this study shows that infectious complications influence functional outcomes as well as the rate and level of RTS in patients. While vancomycin soaking did not affect the functional outcomes, the presence of an infection decreased the rate of RTS at the final follow-up by >50%. Thus, like ACLR, vancomycin soaking in ATFL/CFL reconstruction seems to result in an important clinical improvement by reducing the risk of infection and the associated poorer functional outcome.

Limitations

This study has several limitations. It was a retrospective study, and the vancomycin protocol was established during the follow-up; thus, the follow-up in those patients was shorter than that in the nontreated controls. In addition, the minimum follow-up was just 6 months. Nevertheless, all of the infections developed within the first month after surgery, which makes it possible to exclude a bias from infections that could develop later on. No infection risk factor was defined in the subgroup of patients without vancomycin-soaked grafts. This was probably because of a lack of power, and further studies should be conducted to look for possible risk factors.

CONCLUSION

Vancomycin-soaked grafts for arthroscopic anatomic ATFL/CFL reconstruction reduced the risk of postoperative infection. Infection after ATFL/CFL reconstruction led to a deterioration in results. Vancomycin soaking of the graft did not have a negative effect on functional results.

REFERENCES

- Arshad Z, Aslam A, Al Shdefat S, Khan R, Jamil O, Bhatia M. Complications following ankle arthroscopy. *Bone Joint J.* 2023;105-B(3):239-246.
- Bohu Y, Klouche S, Sezer HB, et al. Vancomycin-soaked autografts during ACL reconstruction reduce the risk of post-operative infection without affecting return to sport or knee function. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(8):2578-2585.
- Burks RT, Morgan J. Anatomy of the lateral ankle ligaments. *Am J Sports Med.* 1994;22(1):72-77.
- Coughlin MJ, Schenck RC, Grebing BR, Treme G. Comprehensive reconstruction of the lateral ankle for chronic instability using a free gracilis graft. *Foot Ankle Int.* 2004;25:231-241.
- Eriksson K, Karlsson J. Local vancomycin in ACL reconstruction: a modern rationale for morbidity prevention and patient safety. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(9):2721-2723.
- Grayson JE, Grant GD, Dukie S, Vertullo CJ. The in vitro elution characteristics of vancomycin from tendons. *Clin Orthop Relat Res.* 2011;469(10):2948-2952.
- Guillo S, Cordier G, Sonnerly-Cottet B, Bauer T. Anatomical reconstruction of the anterior talofibular and calcaneofibular ligaments with an all-arthroscopic surgical technique. *Orthop Traumatol Surg Res.* 2014;100(suppl 8):S413-S417.
- Guillo S, Odagiri H, van Rooij F, Bauer T, Hardy A. All-inside endoscopic anatomic reconstruction leads to satisfactory functional outcomes in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc.* 2021;29(4):1318-1324.
- Jacquet C, Jaubert M, Pioger C, et al. Presoaking of semitendinosus graft with vancomycin does not alter its biomechanical properties: a biomechanical in vitro-controlled study using graft from living donors. *Arthroscopy.* 2020;36(8):2231-2236.
- Kanj WW, Flynn JM, Spiegel DA, Dormans JP, Baldwin KD. Vancomycin prophylaxis of surgical site infection in clean orthopedic surgery. *Orthopedics.* 2013;36(2):138-146.
- Kursumovic K, Charalambous CP. Relationship of graft type and vancomycin presoaking to rate of infection in anterior cruciate ligament reconstruction: a meta-analysis of 198 studies with 68,453 grafts. *JBJS Rev.* 2020;8(7):e1900156.
- Lam KC, Snyder Valier AR, Valovich McLeod TC. Injury and treatment characteristics of sport-specific injuries sustained in interscholastic athletics: a report from the athletic training practice-based research network. *Sports Health.* 2015;7:67-74.
- Lansdown DA, Riff AJ, Meadows M, Yanke AB, Bach Jr BR. What factors influence the biomechanical properties of allograft tissue for ACL reconstruction? A systematic review. *Clin Orthop Relat Res.* 2017;475(10):2412-2426.
- Li Q, Ma K, Tao H, et al. Clinical and magnetic resonance imaging assessment of anatomical lateral ankle ligament reconstruction: comparison of tendon allograft and autograft. *Int Orthop.* 2018;42:551-557.
- Lopes R, Andrieu M, Cordier G, et al. Arthroscopic treatment of chronic ankle instability: prospective study of outcomes in 286 patients. *Orthop Traumatol Surg Res.* 2018;104(suppl 8):S199-S205.
- Mabit C, Tourné Y, Besse JL, et al. Chronic lateral ankle instability surgical repairs: the long term prospective. *Orthop Traumatol Surg Res.* 2010;96(4):417-423.
- 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(7):1392-1401.
- Michels F, Cordier G, Burssens A, Vereecke E, Guillo S. Endoscopic reconstruction of CFL and the ATFL with a gracilis graft: a cadaveric study. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(4):1007-1014.
- Michels F, Guillo S, Vanrietvelde F, et al. How to drill the talar tunnel in ATFL reconstruction? *Knee Surg Sports Traumatol Arthrosc.* 2016;24(4):991-997.
- Naendrup JH, Marche B, de Sa D, et al. Vancomycin-soaking of the graft reduces the incidence of septic arthritis following ACL reconstruction: results of a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(4):1005-1013.
- Offerhaus C, Balke M, Hente J, Gehling M, Blendl S, Hoher J. Vancomycin pre-soaking of the graft reduces postoperative infection rate without increasing risk of graft failure and arthrofibrosis in ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(9):3014-3021.
- Palmer JE, Russell JP, Grieshaber J, et al. A biomechanical comparison of allograft tendons for ligament reconstruction. *Am J Sports Med.* 2017;45(3):701-707.
- Perez-Prieto D, Perelli S, Corcoll F, Rojas G, Montiel V, Monllau JC. The vancomycin soaking technique: no differences in autograft re-uptake rate. A comparative study. *Int Orthop.* 2021;45(6):1407-1411.
- 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.
25. Ruelos VCB, Puzitiello RN, Menendez ME, et al. Vancomycin pre-soaking of anterior cruciate ligament tendon grafts is highly cost-effective for preventing infection. *Arthroscopy.* 2021;37(10):3152-3156.
 26. Spennacchio P, Seil R, Mouton C, Scheidt S, Cucchi D. Anatomic reconstruction of lateral ankle ligaments: is there an optimal graft option? *Knee Surg Sports Traumatol Arthrosc.* 2022;30(12):4214-4224.
 27. Torres-Claramunt R, Pelfort X, Erquicia J, et al. Knee joint infection after ACL reconstruction: prevalence, management and functional outcomes. *Knee Surg Sports Traumatol Arthrosc.* 2013;21(12):2844-2849.
 28. Usuelli FG, Indino C, Di Silvestri CA, Manzi L, Mafulli N. Clinical outcomes and return to sport after minimally invasive reconstruction of the lateral ligament complex with semitendinosus tendon autograft in chronic lateral ankle instability. *J Am Podiatr Med Assoc.* 2021;11:111.
 29. Vega J, Malagelada F, Dalmau-Pastor M. Arthroscopic all-inside ATFL and CFL repair is feasible and provides excellent results in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(1):116-123.
 30. 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.
 31. Vuurberg G, Pereira H, Blankevoort L, van Dijk CN. Anatomic stabilization techniques provide superior results in terms of functional outcome in patients suffering from chronic ankle instability compared to non-anatomic techniques. *Knee Surg Sports Traumatol Arthrosc.* 2018;26:2183-2195.
 32. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ. The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am.* 2010;92(13):2279-2284.
 33. Xiao M, Sherman SL, Safran MR, Abrams GD. Surgeon practice patterns for pre-soaking ACL tendon grafts in vancomycin: a survey of the ACL study group. *Knee Surg Sports Traumatol Arthrosc.* 2021;29(6):1920-1926.
 34. Zekry M, Shahban SA, El Gamal T, Platt S. A literature review of the complications following anterior and posterior ankle arthroscopy. *Foot Ankle Surg.* 2019;25(5):553-558.