

BJO



■ KNEE

Outcomes of revision anterior cruciate ligament reconstruction in soccer players

A COHORT STUDY

MARS Group

From Washington University School of Medicine, St. Louis, Missouri, USA

Aims

There is limited information on outcomes of revision ACL reconstruction (rACL) in soccer (association football) athletes, particularly on return to sport and the rate of additional knee surgery. The purpose of this study was to report return to soccer after rACL, and to test the hypothesis that patient sex and graft choice are associated with return to play and the likelihood of future knee surgery in soccer players undergoing rACL.

Methods

Soccer athletes enrolled in a prospective multicentre cohort were contacted to collect ancillary data on their participation in soccer and their return to play following rACL. Information regarding if and when they returned to play and their current playing status was recorded. If they were not currently playing soccer, they were asked the primary reason they stopped playing. Information on any subsequent knee surgery following their index rACL was also collected. Player demographic data and graft choice were collected from their baseline enrolment data at rACL.

Results

Soccer-specific follow-up was collected on 76% (33 male, 39 female) of 95 soccer athletes. Subsequent surgery information was collected on 95% (44 male, 46 female). Overall, 63% of athletes returned to soccer a mean 9.6 months (SD 5.8) after index revision surgery but participation in soccer decreased to 19% at a mean of 6.4 years (SD 1.3) after surgery. There was no significant association of patient sex or graft choice with return to play, time of return to play, or long-term return to play. Females were more likely than males to have subsequent knee surgery following rACL (20% (9/46) vs 5% (2/44); $p = 0.050$). The rate of recurrent graft tear (5.6%; 5/90) was similar between males and females.

Conclusion

Approximately two-thirds of soccer players return to sport after rACL, but the rate of participation drops significantly over time. Neither patient sex nor graft choice at the time of rACL were associated with return to play. Female soccer players face a higher risk for additional knee surgery after rACL than male soccer players.

Cite this article: *Bone Jt Open* 2021;2-12:1043–1048.

Keywords: ACL, ACL revision, ACL Reconstruction, Soccer, Outcomes, Football

Introduction

Anterior cruciate ligament (ACL) tears are a common injury in soccer (association football),¹⁻³ often via a non-contact mechanism.⁴ These injuries are typically treated with ACL reconstruction (ACL), often enabling athletes to return to soccer.⁵ However, studies

have shown there is a high rate of recurrent ACL injury and revision ACL reconstruction (rACL) in soccer athletes.^{5,6}

While rACL has been shown to be associated with worse outcomes than primary ACL in general cohorts,^{7,8} and a number of studies have reported outcomes of ACL

Correspondence should be sent to R. H. Brophy; email: brophyr@wudosis.wustl.edu

doi: 10.1302/2633-1462.212.BJO-2021-0145.R1

Bone Jt Open 2021;2-12:1043–1048.

Table 1. Patient cohort characteristics.

Characteristic	n	Female (n = 46)	Male (n = 44)	Combined (n = 90)	p-value
Age, yrs	90				< 0.001*
Median (IQR)		18 (16 to 21)	26 (21 to 33)	21 (18 to 28)	
Mean (SD)		20 (5.7)	28.1 (9.0)	24.0 (8.5)	
rACLR on dominant leg, % (n)	72				0.81†
No		49 (19/39)	52 (17/33)	50 (36/72)	
Yes		51 (20/39)	48 (16/33)	50 (36/72)	
rACLR graft type, % (n)	90				0.34†
Autograft BTB		52 (24/46)	39 (17/44)	46 (41/90)	
Autograft hamstring		13 (6/46)	23 (10/44)	18 (16/90)	
Allograft		35 (16/46)	39 (17/44)	37 (33/90)	
Returned to play, % (n)	72				0.25†
No		44 (17/39)	30 (10/33)	38 (27/72)	
Yes		56 (22/39)	70 (23/33)	63 (45/72)	
Time to return to play, mths	42				0.42*
Median (IQR)		7.2 (6.0 to 9.8)	9.0 (6.0 to 10.5)	8.5 (6.0 to 10.0)	
Mean (SD)		8.9 (4.7)	10.3 (6.8)	9.6 (5.8)	
Returned at same or higher level, % (n)	72				0.48†
No		56 (22/39)	45 (15/33)	51 (37/72)	
Yes		44 (17/39)	55 (18/33)	49 (35/72)	
Currently playing, % (n)	72				0.73†
No		82 (32/39)	79 (26/33)	81 (58/72)	
Yes		18 (7/39)	21 (7/33)	19 (14/72)	
If didn't return, was knee the primary reason for not returning?, % (n)	58				> 0.999†
No		28 (9/32)	31 (8/26)	29 (17/58)	
Yes		72 (23/32)	69 (18/26)	71 (41/58)	

*Mann-Whitney U test.

†Chi-squared test.

BTB, bone-patellar tendon-bone; IQR, interquartile range; rACLR, revision anterior cruciate ligament reconstruction; SD, standard deviation.

reconstruction in soccer athletes,^{3,5,6,9-13} there are no previous studies reporting outcomes of revision ACLR in soccer athletes. Specifically, the rate of return to play and the risk for future knee surgery following rACLR in soccer athletes is unknown. The purpose of the present study was to assess the rate of return to soccer after rACLR, and to test the hypothesis that patient sex and graft choice are associated with return to play rates and risk for subsequent knee surgery in soccer players who have undergone a rACLR.

Methods

The Multicenter ACL Reconstruction Study (MARS) is an academic and private practice multicentre consortium (83 surgeons over 52 sites) conducting an ongoing prospective cohort study of patients undergoing rACLR.¹⁴ All participating sites obtained local institutional review board (IRB) approval prior to enrolling subjects, and complied with a standardized manual of operations. Patients for this study were identified from current enrollees from this prospective cohort.

Specific to this study, a supplementary IRB approval, requiring additional work on the part of each site, was offered to all sites. When the patients were initially enrolled for their index rACLR, each patient completed

a questionnaire pertaining to their sports participation, level of activity, overall health, and the nature of the injury to their ACL graft. Patients who answered "soccer" in response to either their primary or secondary sport participated in most over the last two years were considered eligible for participation in the current study. A total of 12 sites agreed to participate and obtained IRB approval. The other 40 sites either did not have any soccer players enrolled in their cohort or elected not to complete the additional work necessary to participate. From these 12 sites, 95 eligible soccer players undergoing rACLR were identified. All eligible patients within an IRB-approved site were then contacted and asked a structured series of questions about their participation in soccer at the time of injury and since their injury.

Specific variables extracted from the index enrolment database included age, sex, involved knee (left/right), graft choice at the time of revision surgery (e.g. autograft bone-patellar tendon-bone (BTB), autograft hamstrings, allograft), and incidence and dates of any subsequent surgery (if applicable) following the time of the rACLR. Specific variables collected as part of the soccer questionnaire included the athlete's dominant (kicking) leg (left/right), their pre-injury and postinjury competition level (youth, high school, college, adult recreational,

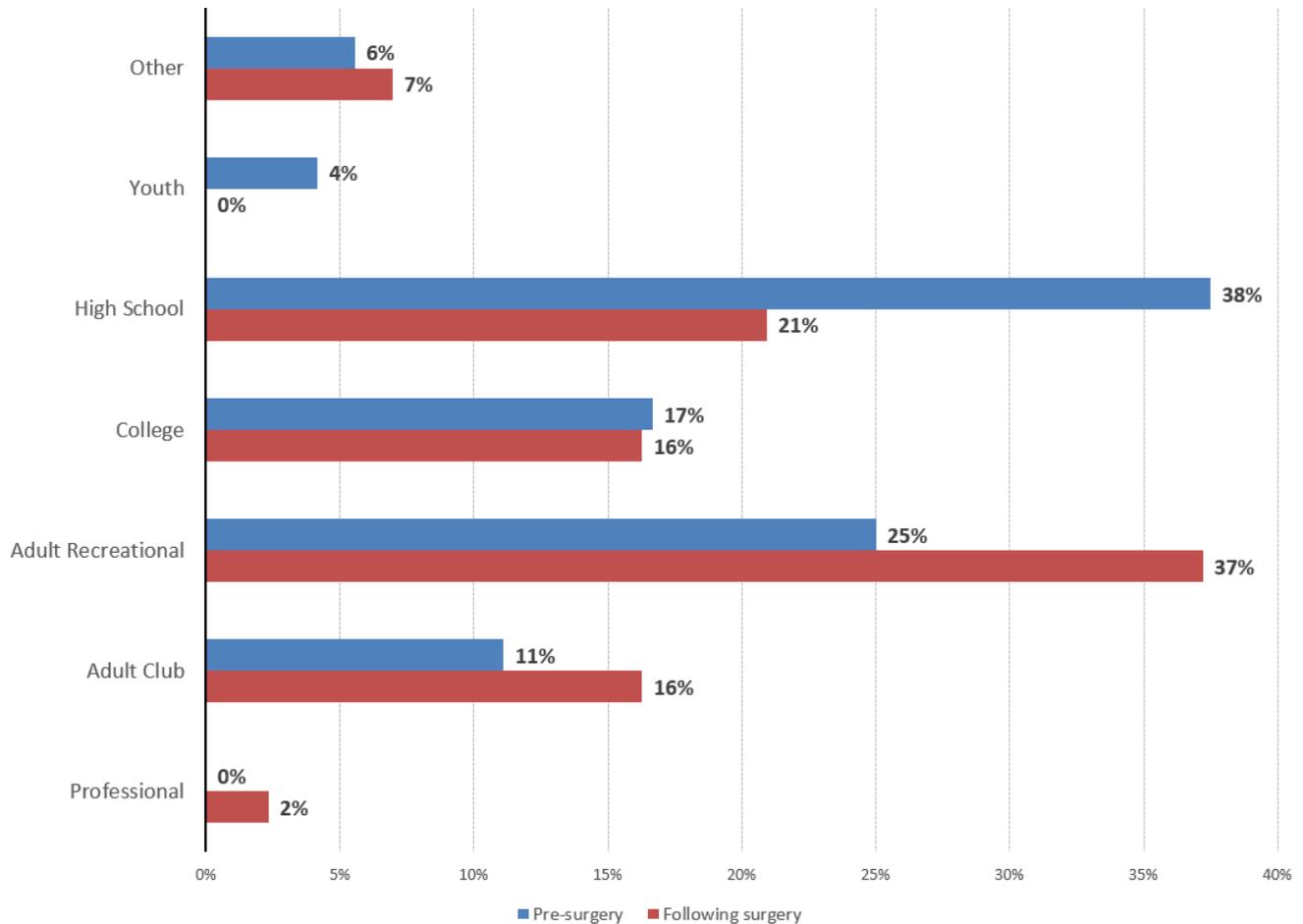


Fig. 1

Level of soccer competition before and after revision anterior cruciate ligament reconstruction.

Table II. Rate of subsequent surgeries, stratified by sex.

Subsequent surgery, % (n)	Female (n = 46)	Male (n = 44)	Combined (n = 90)	p-value*
No	80 (37)	95 (42)	88 (79)	0.050
Yes	20 (9)	5 (2)	12 (11)	

*Fisher's exact test.

adult club, other, professional), if the athlete returned to playing soccer after their rACL (yes/no), time from returning (in months, if applicable), if the athlete was currently playing soccer at the time of the survey (yes/no), and if they weren't playing, was the injury to their knee the primary reason they stopped playing soccer (yes/no).

Patients. A total of 95 patients (of 1,205 enrollees) were identified from the IRB-approved sites as soccer athletes. Soccer-specific follow-up was collected on 76% (72/95; 33 male, 39 female), while subsequent surgery information was collected on 95% (90/95; 44 male, 46 female). Mean age was 24.0 years (standard deviation (SD) 8.5; 14 to 52) (Table I). Male soccer players (mean age 28.1 years (SD 9.0)) were significantly older than the female

soccer players (mean 20.0 years (SD 5.7); $p < 0.001$, Mann-Whitney U test). The dominant leg was injured in one half of the cohort (51% female (20/39), 48% male (16/33)). The most common graft used at the time of the index rACL was BTB autograft, followed by allograft and hamstring autograft, with no significant difference in graft choice between males and females. The largest percentage of athletes were playing high school prior to rACL (38%; 36/95), followed by adult recreational (25%; 24/95) and collegiate (17%; 16/95) (Figure 1).

Statistical analysis. Descriptive statistics were generated for all data. Medians and interquartile ranges (IQRs) as well as means and SDs were given for continuous variables. Frequencies and percentiles were reported for all categorical variables. Return to play (yes/no), both initially and at latest follow-up, and the need for subsequent surgery (if any) were the primary outcome variables analyzed for this cohort. Return to play, both initially and at final follow-up, was analyzed with free open source R statistical software (R Foundation for Statistical Programming, Austria) using a multivariate logistic regression model with return to play as the dependent variable (yes/no),

Table III. Patient characteristics by type of subsequent surgeries.

Characteristic	None (n = 79)	Scope (n = 4)	Revision ACLR (n = 5)	Contralateral ACLR (n = 2)	Combined (n = 90)	p-value
Age, yrs						0.186*
Median (IQR)	21 (18 to 28)	27 (24 to 32)	18 (16 to 19)	18 (17 to 19)	21 (18 to 28)	
Mean (SD)	24.2 (8.6)	28.8 (10.4)	18.0 (2.1)	18.0 (2.8)	24.0 (8.5)	
Sex, % (n)						0.086†
Female	47 (37)	100 (4)	60 (3)	100 (2)	51 (46)	
Male	53 (42)	0 (0)	40 (2)	0 (0)	49 (44)	
Graft type at time of rACLR, % (n)						0.061†
Autograft BTB	48 (38)	25 (1)	0 (0)	100 (2)	46 (41)	
Autograft hamstring	34 (27)	75 (3)	60 (3)	0 (0)	37 (33)	
Allograft	18 (14)	0 (0)	40 (2)	0 (0)	18 (16)	

*Mann-Whitney U test.

†Chi-squared test.

ACLR, anterior cruciate ligament reconstruction; BTB, bone-patellar tendon-bone; IQR, interquartile range; rACLR, revision anterior cruciate ligament reconstruction; SD, standard deviation.

and age, sex, and graft type as the independent variables. Sex-based comparisons were conducted using Fisher's exact tests, Mann-Whitney U tests, or chi-squared tests.

Results

Return to play. Overall, 63% (45/72) returned to soccer after their index rACLR (70% male (23/33), 56% female (22/39)) at a mean 9.6 months (SD 5.8) after surgery (Table I). Of those who returned to play, 78% (35/45) returned to the same or higher level of play. At initial return to play following rACLR (Figure 1), athletes most often competed at the adult recreational level (37%; 36/95), followed by high school (21%; 9/45) and college (16%; 7/45) and adult club (16%; 7/45). At six-year follow-up (mean 6.4 (SD 1.3), participation in soccer fell significantly ($p < 0.001$, chi-squared test) to 19% (14/72) of patients (21% male (7/33), 18% female (7/39)). Among athletes still participating in soccer six years following their rACLR, only 64% (9/14) were playing at the same level, significantly lower than their initial return to play ($p < 0.001$, chi-squared test). Return to play was not associated with age, sex, or graft type. The majority of patients who did not return to play reported that their knee was the primary reason they were no longer playing soccer (41/58, 71%; 17 male, 24 female).

Subsequent surgery. The rate of subsequent surgery following the index rACLR was 12% (11/90) for the soccer cohort, with a higher rate in females (20%; 9/46) than males (4.5%; 2/44) ($p = 0.050$, Fisher's exact test; Table II). There was a 5.6% (5/90) rate of subsequent ipsilateral ACL reconstruction following rACLR, with no differences between males and females (Table III). There was a trend ($p = 0.061$, chi-squared test) toward lower recurrent ipsilateral ACL graft injury after revision reconstruction with BTB autograft (0%) compared to revision with other graft types (10.2%; 5/49). Two females (4.3%; 2/46) underwent ACLR on the contralateral knee compared to no males.

Discussion

This is the first study to report outcomes after rACLR in soccer athletes. While soccer athletes are able to get back to sport at a reasonable rate after revision ACL reconstruction, soccer participation drops dramatically over time following their revision surgery. Athletes face a significant risk for additional knee surgery, especially females (20%). The rate of revision graft re-tear is about one in 20.

These results are similar to previously published findings in soccer players undergoing primary ACLR by Brophy et al.⁵ Fewer soccer players returned to sport after rACLR compared to primary ACLR (63% vs 72%) but they returned to sports slightly earlier (9.6 months vs 12.2 months). Participation in soccer dropped more quickly after rACLR (19% at 6.4 yrs) than primary ACLR (35% at 7.2 yrs). Patients were more likely to consider their knee as the primary reason they were no longer playing soccer after rACLR (69% in males, 72% in females) compared to primary ACLR (56% in males, 26% in females). Whether this is due to instability, fear of re-injury or the development of degenerative changes in the knee is unknown. Obviously, participation in a sport such as soccer will face natural attrition with age and it is not possible to determine how much this contributes to the decline in participation of this cohort. However, it is notable that the decline in participation is greater in this revision reconstruction cohort than the decline at a similar length follow-up in a primary ACL reconstruction cohort of similar age. There is little reason to expect any difference in the natural attrition between these two groups, suggesting the injury and/or treatment are a likely contributor.

The rate of graft re-tear on the operated knee was higher (5.6%) than the rate of graft re-tear after primary ACLR in soccer players (3%). One of the factors that may contribute to this discrepancy is that more allografts (37%) and fewer BTB autografts (46%) were used for rACLR in soccer players

compared to primary ACLR (allografts 4%, BTB autografts 69%) in soccer players. The most likely reason for this discrepancy is that autograft was used in the primary ACLR and was not available from the ipsilateral knee for rACLR. The rate of contralateral ACLR was lower (2.2%) than after primary ACLR (9%), which may reflect the lower and more rapidly declining participation in soccer, and was higher in females, similar to following primary ACLR.

While many studies have looked at return to sport after ACLR, only a few have reported data on return to sport after rACLR. Shelbourne et al¹⁵ reported that 74% of athletes returned to sport after rACLR but they did not report on long-term participation in sport. Their study included athletes from a variety of sports including soccer, basketball, football, and volleyball. In their study, the rate of graft re-tear after rACLR was 3.5%, slightly lower than in our study (5.6%). Their rate of contralateral ACLR was 1.5%, again lower than our rate of 2.2%. Their overall rate of subsequent surgery was 15%, slightly higher than our rate of 12%. Unfortunately, they did not report the number of men and women in their study, nor did they report sex-specific results. Reinhardt et al¹⁶ reported the results of rACLR in 21 adolescent athletes at two-year follow-up. In this study, there was a 52% rate of return to play at the same level or higher, similar to our rate of 49%. However, there was a 9.5% graft re-tear rate, probably reflecting the younger age and likely higher activity level of this cohort.

The rate of graft re-rupture in our study was higher in soccer players (5.6%) than previously reported for an overall MARS cohort of rACLR patients (3.3%).¹⁷ This previous study also reported a lower re-rupture rate with autografts than allografts for rACLR in all patients. The rate of subsequent surgery for all rACLR patients in the MARS cohort was 13.5%, slightly higher than the rate of 12% in our soccer player cohort.

The limitations of this study include the relatively small cohort size, which may be underpowered for some of the questions we asked. Recall bias may affect the accuracy of return to play (and level of play upon return) although this approach has been used previously.⁵ The study was underpowered to include other potentially important variables such as the status of meniscal and articular cartilage. No follow-up physical examination or KT-1000 data¹⁸ is available to assess for persistent or recurrent instability which could affect return to play. The results reflect selection bias of the surgeons and patients involved and may not be generalizable to other geographical and practice locations. Finally, follow-up did not include imaging studies to assess for degenerative changes which could contribute to the decrease in soccer participation over time.

Despite these limitations, this is the first study to report return to play and risk for future injury and surgery following rACLR in soccer players. These athletes should be advised that while the majority of patients get back

to soccer, participation drops off significantly over time, with the knee being the primary reason why most athletes stop playing soccer. There is an increased risk of subsequent knee surgery in these patients, especially female athletes. The rate of recurrent ipsilateral ACL graft tear is higher than after primary ACLR in these athletes and BTB autograft may be the preferable graft choice, when available, for rACLR in soccer players. More research is needed to more accurately assess the role of graft choice, as well as other variables such as meniscal and articular cartilage injury, in return to play, and risk for future surgery following rACLR in these athletes.



Take home message

- About two-thirds of soccer players return to their sport after revision anterior cruciate ligament (ACL) reconstruction, but this drops off quickly over time.

- Male and female soccer players have similar rates of return to sport and rates of ACL graft re-tear, but females are four times more likely than males to undergo additional knee surgery after revision ACL reconstruction.

References

1. Agel J, Evans TA, Dick R, Putukian M, Marshall SW. Descriptive epidemiology of collegiate men's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. *J Athl Train*. 2007;42(2):270-277.
2. Dick R, Putukian M, Agel J, Evans TA, Marshall SW. Descriptive epidemiology of collegiate women's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. *J Athl Train*. 2007;42(2):278-285.
3. Waldén M, Hägglund M, Magnusson H, Ekstrand J. Anterior cruciate ligament injury in elite football: A prospective three-cohort study. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(1):11-19.
4. Brophy RH, Stepan JG, Silvers HJ, Mandelbaum BR. Defending puts the anterior cruciate ligament at risk during soccer: a gender-based analysis. *Sports Health*. 2015;7(3):244-249.
5. Brophy RH, Schmitz L, Wright RW, et al. Return to play and future ACL injury risk after ACL reconstruction in soccer athletes from the Multicenter Orthopaedic Outcomes Network (MOON) group. *Am J Sports Med*. 2012;40(11):2517-2522.
6. Erickson BJ, Harris JD, Cvetanovich GL, et al. Performance and return to sport after anterior cruciate ligament reconstruction in male Major League Soccer players. *Orthop J Sports Med*. 2013;1(2).
7. Battaglia MJ 2nd, Cordasco FA, Hannafin JA, et al. Results of revision anterior cruciate ligament surgery. *Am J Sports Med*. 2007;35(12):2057-2066.
8. Wright RW, Dunn WR, Amendola A, et al. Anterior cruciate ligament revision reconstruction: Two-year results from the MOON cohort. *J Knee Surg*. 2007;20(4):308-311.
9. Bak K, Jørgensen U, Ekstrand J, Scavenius M. Reconstruction of anterior cruciate ligament deficient knees in soccer players with an iliotibial band autograft. A prospective study of 132 reconstructed knees followed for 4 (2-7) years. *Scand J Med Sci Sports*. 2001;11(1):16-22.
10. Howard JS, Lembach ML, Metzler AV, Johnson DL. Rates and determinants of return to play after anterior cruciate ligament reconstruction in National Collegiate Athletic Association Division I soccer athletes: a study of the Southeastern Conference. *Am J Sports Med*. 2016;44(2):433-439.
11. Roi GS, Nanni G, Tencone F. Time to return to professional soccer matches after ACL reconstruction. *Sport Sci Health*. 2006;1(4):142-145.
12. Roos H, Ornell M, Gärdsell P, Lohmander LS, Lindstrand A. Soccer after anterior cruciate ligament injury—an incompatible combination? A national survey of incidence and risk factors and a 7-year follow-up of 310 players. *Acta Orthop Scand*. 1995;66(2):107-112.
13. Zaffagnini S, Grassi A, Marcheggiani Muccioli GM, et al. Return to sport after anterior cruciate ligament reconstruction in professional soccer players. *Knee*. 2014;21(3):731-735.

14. **MARS Group, Wright RW, Huston LJ, et al.** Descriptive epidemiology of the multicenter ACL revision study (MARS) cohort. *Am J Sports Med.* 2010;38(10):1979–1986.
15. **Shelbourne KD, Benner RW, Gray T.** Return to sports and subsequent injury rates after revision anterior cruciate ligament reconstruction with patellar tendon autograft. *Am J Sports Med.* 2014;42(6):1395–1400.
16. **Reinhardt KR, Hammoud S, Bowers AL, Umunna BP, Cordasco FA.** Revision ACL reconstruction in skeletally mature athletes younger than 18 years. *Clin Orthop Relat Res.* 2012;470(3):835–842.
17. **MARS Group.** Effect of graft choice on the outcome of revision anterior cruciate ligament reconstruction in the Multicenter ACL Revision Study (MARS) cohort. *Am J Sports Med.* 2014;42(10):2301–2310.
18. **Branch TP, Mayr HO, Browne JE, Campbell JC, Stoehr A, Jacobs CA.** Instrumented examination of anterior cruciate ligament injuries: minimizing flaws of the manual clinical examination. *Arthroscopy.* 2010;26(7):997–1004.

Author contributions:

- R. H. Brophy: Conceptualization, Project administration, Data curation, Writing – original draft, Writing – review & editing.

Funding statement:

- This study received funding from the AOSSM, Smith & Nephew, National Football League Charities, and Musculoskeletal Transplant Foundation. This project was funded by grant No. 5R01-AR060846 from the National Institutes of Health/National Institute of Arthritis and Musculoskeletal and Skin Diseases.

ICMJE COI statement:

- R. Brophy declares educational support to their institution from Smith & Nephew, unrelated to this article. B. A. Levy declares payment from Smith & Nephew for

consultancy, unrelated to this article. K. P. Spindler declares payments from Smith & Nephew Endoscopy for research funding, unrelated to this article.

MARS Group:

- Robert H Brophy, MD; Laura J Huston; Amanda Haas; John P Albright, MD; Christina R Allen, MD; Annunziato Amendola, MD; Champ L Baker, III, MD; James L Carey, MD, MPH; Charles L Cox, MD; R Alexander Creighton, MD; Warren R Dunn, MD, MPH; Amanda K Haas, MA; Jo A Hannafin, MD, PhD; Elliott B Hershman, MD; Rudolf G Hoellrich, MD; Ganesh V Kamath, MD; Brett A Lantz, MD; Bruce A Levy, MD; C Benjamin Ma, MD; Robert G Marx, MD; Matthew J Matava, MD; Robert G McCormack, MD; James R Slauterbeck, MD; Matthew V Smith, MD; Jeffrey T Spang, MD; Kurt P Spindler, MD; Michael J Stuart, MD; Timothy N Taft, MD; Darius G Viskontas, MD; Brian R Wolf, MD; Rick W Wright, MD.

Acknowledgements:

- We would also like to thank Diane L. Dahm, MD (Mayo Clinic, Rochester, Minnesota, USA) and Elizabeth Garofoli (Washington University School of Medicine, St. Louis, Missouri, USA) for their effort and leadership on this project.

Ethical review statement:

- This study was approved by the Washington University School of Medicine Institutional Review Board ID #: 201502076

Open access funding:

- The authors confirm that open access funding was provided by the USA Department of Health and Human Services; National Institutes of Health; National Institute of Arthritis and Musculoskeletal and Skin Diseases; NCT00625885.

© 2021 Author(s) et al. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (CC BY-NC-ND 4.0) licence, which permits the copying and redistribution of the work only, and provided the original author and source are credited. See <https://creativecommons.org/licenses/by-nc-nd/4.0/>