

# The American Journal of Sports Medicine

<http://ajs.sagepub.com/>

---

## Success of Meniscal Repair at Anterior Cruciate Ligament Reconstruction

Charles V. Toman, Warren R. Dunn, Kurt P. Spindler, Annunziata Amendola, Jack T. Andrish, John A. Bergfeld, David Flanigan, Morgan H. Jones, Christopher C. Kaeding, Robert G. Marx, Matthew J. Matava, Eric C. McCarty, Richard D. Parker, Michelle Wolcott, Armando Vidal, Brian R. Wolf, Laura J. Huston, Frank E. Harrell, Jr and Rick W. Wright

*Am J Sports Med* 2009 37: 1111  
DOI: 10.1177/0363546509337010

The online version of this article can be found at:  
<http://ajs.sagepub.com/content/37/6/1111>

---

Published by:



<http://www.sagepublications.com>

On behalf of:



[American Orthopaedic Society for Sports Medicine](#)

**Additional services and information for *The American Journal of Sports Medicine* can be found at:**

**Email Alerts:** <http://ajs.sagepub.com/cgi/alerts>

**Subscriptions:** <http://ajs.sagepub.com/subscriptions>

**Reprints:** <http://www.sagepub.com/journalsReprints.nav>

**Permissions:** <http://www.sagepub.com/journalsPermissions.nav>

# Success of Meniscal Repair at Anterior Cruciate Ligament Reconstruction

Charles V. Toman,\* MD, Warren R. Dunn,<sup>†</sup> MD, Kurt P. Spindler,<sup>†</sup> MD, MPH, Annunziata Amendola,<sup>‡</sup> MD, Jack T. Andrish,<sup>§</sup> MD, John A. Bergfeld,<sup>§</sup> MD, David Flanigan,<sup>||</sup> MD, Morgan H. Jones,<sup>§</sup> MD, Christopher C. Kaeding,<sup>||</sup> MD, Robert G. Marx,<sup>#</sup> MD, MS, Matthew J. Matava,\* MD, Eric C. McCarty,<sup>a</sup> MD, Richard D. Parker,<sup>§</sup> MD, Michelle Wolcott,<sup>a</sup> MD, Armando Vidal,<sup>a</sup> MD, Brian R. Wolf,<sup>‡</sup> MD, MS, Laura J. Huston,<sup>†</sup> MS, Frank E. Harrell Jr,<sup>b</sup> PhD, and Rick W. Wright,<sup>\*c</sup> MD

*From the \*Department of Orthopaedic Surgery, Washington University School of Medicine, Barnes-Jewish Hospital, St. Louis, Missouri, the <sup>†</sup>Department of Orthopaedic Surgery and Rehabilitation, Vanderbilt University Medical School, Nashville, Tennessee, <sup>‡</sup>Department of Orthopaedic Surgery, University of Iowa School of Medicine, Iowa City, Iowa, <sup>§</sup>Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, Ohio, <sup>||</sup>Department of Orthopaedic Surgery, The Ohio State University School of Medicine, Columbus, Ohio, <sup>#</sup>Sports Medicine Division, Hospital for Special Surgery, New York, New York, <sup>a</sup>Department of Orthopaedic Surgery, University of Colorado School of Medicine, Denver, Colorado, and <sup>b</sup>Department of Biostatistics, Vanderbilt University Medical School, Nashville, Tennessee*

---

**Background:** Meniscal repair is performed in an attempt to prevent posttraumatic arthritis resulting from meniscal dysfunction after meniscal tears. The socioeconomic implications of premature arthritis are significant in the young patient population. Investigations and techniques focusing on meniscus preservation and healing are now at the forefront of orthopaedic sports medicine.

**Hypothesis:** Concomitant meniscal repair with anterior cruciate ligament reconstruction is a durable and successful procedure at 2-year follow-up.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** All unilateral primary anterior cruciate ligament reconstructions entered in 2002 in a cohort who had meniscal repair at the time of anterior cruciate ligament reconstruction were evaluated. Validated patient-oriented outcome instruments were completed preoperatively and then again at the 2-year postoperative time point. Reoperation after the index procedure was also documented and confirmed by operative reports.

**Results:** A total of 437 unilateral primary anterior cruciate ligament reconstructions were performed with 82 concomitant meniscal repairs (54 medial, 28 lateral) in 80 patients during the study period. Patient follow-up was obtained on 94% (77 of 82) of the meniscal repairs, allowing confirmation of meniscal repair success (defined as no repeat arthroscopic procedure) or failure. The overall success rate for meniscal repairs was 96% (74 of 77 patients) at 2-year follow-up.

**Conclusion:** Meniscal repair is a successful procedure in conjunction with anterior cruciate ligament reconstruction. When confronted with a “repairable” meniscal tear at the time of anterior cruciate ligament reconstruction, orthopaedic surgeons can expect an estimated >90% clinical success rate at 2-year follow-up using a variety of methods as shown in our study.

**Keywords:** meniscal repair; clinical medicine; anterior cruciate ligament (ACL) reconstruction

---

<sup>c</sup>Address correspondence to Rick W. Wright, MD, 1 Barnes-Jewish Hospital, Suite 11300, St. Louis, MO 63110 (e-mail: rwwright1@aol.com).

Presented at the 33<sup>rd</sup> annual meeting of the AOSSM, Calgary, Alberta, Canada, July, 2007.

This project was funded by a grant (R01 AR053684) from the National Institutes of Health.

One or more of the authors has declared a potential conflict of interest: Dr Jones has received research funds from Smith & Nephew; Dr Wright has received unrestricted educational grants from Aircast, Arthrex, and Smith & Nephew; Dr Spindler has received unrestricted educational grants from Aircast, Smith & Nephew, and Vanderbilt Sports Medicine; and Dr Toman has received a grant from NFL Charities.

The incidence of meniscal tears in the acute setting have been documented to be as high as 61 per 100 000, and approximately 850 000 meniscal procedures are performed yearly in the United States.<sup>2</sup> However, many meniscal tears in adolescents and young adults occur concurrently with anterior cruciate ligament (ACL) tears. The goal of meniscal repair is to prevent the sequelae of meniscal dysfunction (ie, posttraumatic osteoarthritis).<sup>6</sup> The socioeconomic implications of posttraumatic arthritis are significant in a 30- to 45-year-old patient population in their prime working years. Thus, investigations and techniques focusing on meniscus preservation and healing are now at the forefront of orthopaedic sports medicine.

To properly assess timeliness and generalizability regarding the outcomes of meniscal repair with ACL reconstruction, a multicenter approach is the preferred study design. For example, a single surgeon in the busiest, most efficient practice would amass 100 to 150 ACL reconstructions yearly and from that number only a small portion (~20%) would undergo meniscal repair. Secondly, a multicenter study can demonstrate the reproducibility of success of repair across sites and among surgeons. Thus, collaboration provides increased sample size and allows for the formation of relevant conclusions before current operative techniques become outdated.

Case series (Level 4 evidence) and comparative outcomes studies (Level 3) of meniscal repair have demonstrated variability in success.<sup>8</sup> At this time, only 5 prospective studies have been published comparing all-inside to inside-out meniscal repairs.<sup>1,3,4,7,9</sup> The most recent systematic review of meniscal repair literature reveals a failure rate of 0% to 43.5%.<sup>8</sup> The primary outcome variable in 80% (26 of 32) of all-inside meniscal repair studies was "clinical failure," defined as reoperation for repair failure. The only conclusion to be drawn from this review was that prospective long-term studies are important to elucidating the failure rates of all-inside meniscal repairs. The aim of the present prospective longitudinal cohort study was to determine the success of primarily all-inside meniscal repairs with ACL reconstruction with reoperation for failure as the primary end point 2 years after meniscal repair and ACL reconstruction.

## MATERIALS AND METHODS

The MOON (Multicenter Orthopaedic Outcomes Network) group is a National Institutes of Health–funded prospective longitudinal cohort of ACL reconstruction. After institutional review board approval from all centers, the group began enrolling all ACL reconstruction patients at 6 sites. A prospective longitudinal cohort design was established to determine the prognosis as well as the predictors of outcomes after ACL reconstruction. The general study design requires that subjects preoperatively complete a 13-page form that includes the mechanism of injury, a series of validated patient-oriented outcome questionnaires (Knee injury and Osteoarthritis Outcome Score, Western Ontario and McMaster Universities Osteoarthritis Index, Marx, Short Form-36, International Knee Documentation

Committee), sports participation history, comorbidities, demographics, prior surgery on either knee, and any current therapies (ie, glucosamine, bracing, nonsteroidal anti-inflammatory drugs). The surgeon completes a detailed operative assessment and treatment of meniscus and articular cartilage injuries. The details of each patient's ACL reconstruction and rehabilitation milestones are recorded. This form has been previously described and interrater agreement previously established with regard to meniscal lesions.<sup>1,3,7,9,10</sup> The postoperative rehabilitation protocol and surgical technique used, including graft selection, surgical approach, and method of graft fixation, was left to the discretion of each surgeon.

Because this present study focused on meniscal repairs at the time of ACL reconstruction, specific-surgeon variable data included left versus right knee (side), medial versus lateral meniscus, length of tear, type of tear, location of tear (anterior versus posterior and peripheral versus middle versus inner one-third), type and number of devices used, surgical approach, and method of meniscal repair.

Our inclusion criteria were all meniscal repairs concurrent with an ACL reconstruction enrolled by a participating site from January 1, 2002 to December 31, 2002. This cohort is a subgroup of the entire ACL reconstruction cohort entered in a large database. Two-year patient follow-up was prospectively obtained with the patient completing the same outcome questionnaire that was originally completed preoperatively. This questionnaire documented any additional surgeries subsequent to the initial ACL reconstruction performed in 2002. Further, all patients were queried by telephone regarding any additional knee surgeries. Operative notes of 2002 ACL reconstructions and follow-up surgeries (if applicable) were obtained to confirm that each patient's meniscal repair had in fact failed. Prior to publication, it was determined that there was incomplete documentation of informed consent on 20 subjects. After conferring with the institutional review board, contact was attempted for these subjects; 16 were re-consented, and the remaining 4 were removed from the final analysis.

Statistical analysis was performed with free open source R statistical software ([www.r-project.org](http://www.r-project.org)).

## RESULTS

From January 1, 2002 to December 31, 2002, 437 unilateral primary ACL reconstructions were performed with 82 concomitant meniscal repairs (54 medial, 28 lateral) in 80 patients. Two patients had simultaneous repairs performed in both the medial and lateral menisci within the same knee. The average age of the entire 2002 ACL reconstruction cohort was 27 years (standard deviation, 11; range, 11-63) with 56% males. The average age for the patients with meniscal repair was 25 years (standard deviation, 25; range, 11-59) with 43 (54%) males. Initial surgeon questionnaires documented that the majority of these meniscal tears were located in the peripheral third of the menisci (81% in the medial meniscus, 43% in the lateral meniscus), in the posterior region (Table 1).

**TABLE 1**  
Repaired Meniscal Tears Stratified by Location

	Medial Meniscus (n = 57)	Lateral Meniscus (n = 29)
Central/Peripheral		
Peripheral 1/3	82.5% (47/57)	48.3% (14/29)
Middle 1/3	5.3% (3/57)	20.7% (6/29)
Middle 1/3 + peripheral 1/3	8.8% (5/57)	20.7% (6/29)
Central 1/3	0.0% (0/57)	3.4% (1/29)
Central 1/3 + middle 1/3	1.7% (1/57)	6.9% (2/29)
Central + middle + peripheral 1/3	1.7% (1/57)	0.0% (0/29)
	Medial Meniscus (n = 57)	Lateral Meniscus (n = 29)
Anterior/Posterior		
Anterior	0.0% (0/57)	3.4% (1/29)
Posterior	78.9% (45/57)	82.8% (24/29)
Anterior + Posterior	21.1% (12/57)	13.8% (4/29)

**TABLE 2**  
Repaired Meniscal Tears Stratified by Type

	Medial Meniscus (n = 57)	Lateral Meniscus (n = 29)
Longitudinal (vertical)	80.7% (46/57)	69.0% (20/29)
Bucket handle	12.3% (7/57)	13.8% (4/29)
Oblique	7.0% (4/57)	13.8% (4/29)
Horizontal	0.0% (0/57)	3.4% (1/29)
Radial	0.0% (0/57)	0.0% (0/29)
Complex	0.0% (0/57)	0.0% (0/29)

Table 2 provides a breakdown of the type of meniscal tears documented in the cohort. Longitudinal tears were the most common type of tear seen for both the medial and lateral menisci (80%, medial meniscus; 69%, lateral meniscus). In the lateral meniscus region, 12% of the tears were bucket-handle types and 15% were oblique tears, while bucket-handle tears occurred more often than oblique tears in the medial meniscus (11% vs 6%, respectively).

In addition to the repairs reported here, 104 patients underwent medial meniscectomy in the ACL reconstruction cohort. Twenty-nine patients had undergone medial meniscectomy at a previous operation before their ACL reconstruction. One hundred thirty-six patients underwent lateral meniscectomy and 17 had undergone lateral meniscectomy before their ACL reconstruction.

The average tear length for medial meniscal tears seen in this cohort was 16.9 mm (standard deviation, 7.9 mm; range, 6-45 mm), while the average tear length for a lateral meniscal tear was 17 mm (standard deviation, 8.7 mm; range, 10-45 mm). In addition, the number of sutures and devices needed to repair these menisci were similar. An average of 3 sutures/devices/implants was needed to repair either side of the meniscus (Table 3).

**TABLE 3**  
Number of Sutures/Devices/Implants

	Medial Meniscus	Lateral Meniscus
Average (standard deviation)	3.0 (1.8)	2.9 (1.9)
Range	(1-10)	(1-9)

Figure 1 outlines the initial, follow-up, and success rates for the medial and lateral meniscal repairs, the surgical approach (all-inside versus inside-out) used, and the types of all-inside meniscal repair devices used (“devices” vs non-absorbable suture). The majority of meniscal repairs were performed using the all-inside technique (80% [65 of 82]). Likewise, the majority of meniscal repairs were medial (66% [54 of 82]). For either meniscus, the group primarily performed all-inside repair. For the medial meniscus, 76% (41 of 54) and for the lateral meniscus 86% (24 of 28) were repaired by all-inside technique. However, the type of all-inside meniscal repair chosen, either “absorbable devices” or nonabsorbable suture devices, differed in the cohort. For the medial meniscus, 73% (30 of 41) of repairs were absorbable devices, whereas in the lateral meniscus only 54% (13 of 24) were absorbable devices.

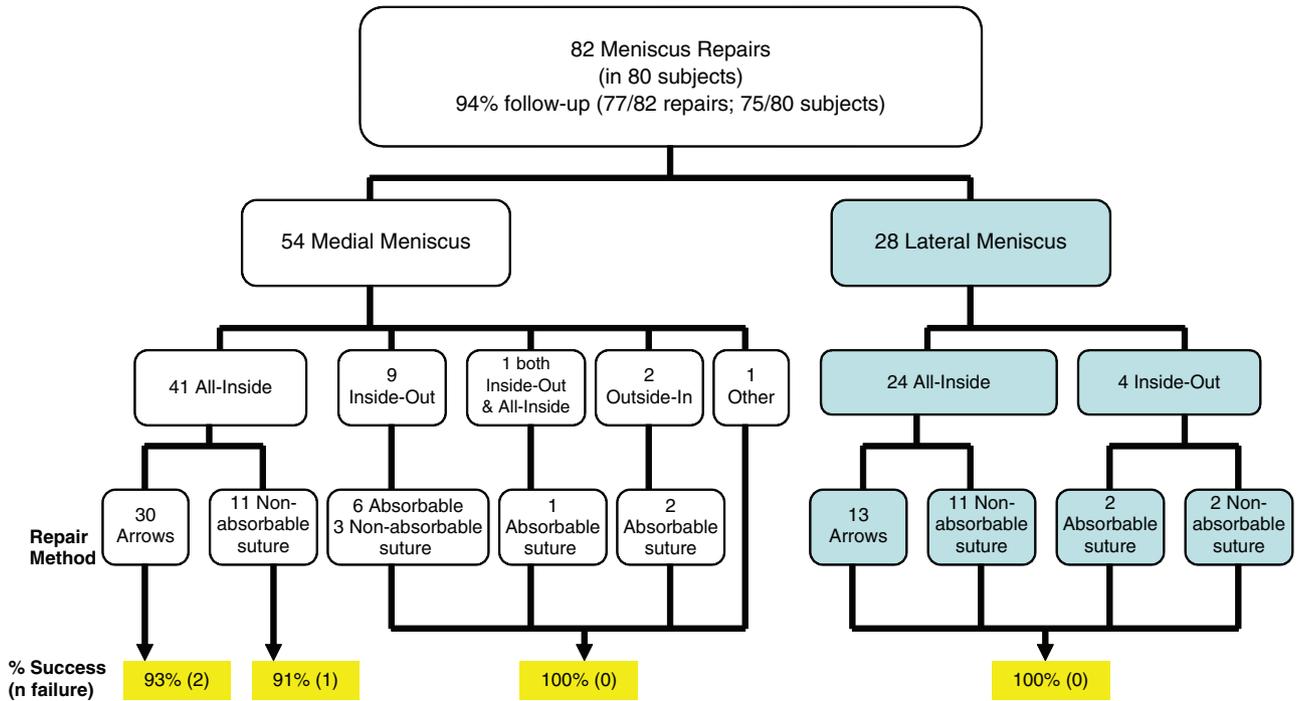
Figure 2 outlines patient follow-up and additional surgical procedures captured within the meniscal repair cohort. Patient follow-up was obtained on 94% (77 of 82) of the meniscal repairs, allowing confirmation of meniscus success (defined as no repeat arthroscopic procedure) or repair failure. The 5 patients lost to follow-up included 4 all-inside repairs (3 for medial meniscus and 1 for lateral meniscus) and 1 inside-out medial meniscal repair.

Nine percent (7 of 77) of patients required additional arthroscopic procedures. These include 3 patients (4%) who required arthroscopic removal for failed meniscal repair, 1 for scar debridement, and 3 patients (4%) with either an ACL graft failure (n = 1) or contralateral ACL reconstruction (n = 2). The meniscus was noted to be healed at the time of repeat surgery in the 3 cases of ACL graft failure or scar debridement.

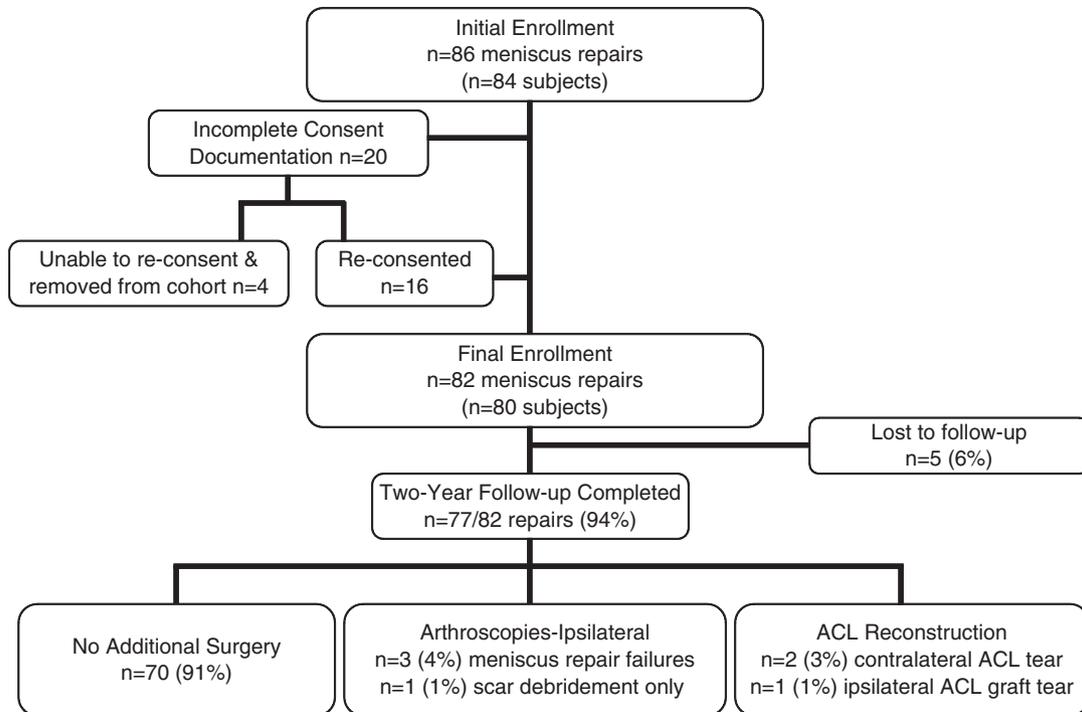
The overall success rate for meniscal repairs was 96% (74 of 77 patients). The 3 repair failures were identified at 2-year follow-up. Upon identification, both the initial meniscal repair and follow-up records were obtained to confirm that each patient’s meniscal repair had in fact failed.

**DISCUSSION**

The clinical success of overall meniscal repair as well as each specific method for either meniscus was >91%. The 3 failures were distributed with 1 each in the medial meniscus device, medial meniscus inside-out, and lateral meniscus device. However, to determine if 2 methods are significantly different by 5% to 10%, one would require a total sample size of 500 to 1000 patients, respectively. The extremely low event rate for failure (n = 3) precludes



**Figure 1.** Multicenter Orthopaedic Outcomes Network (MOON) meniscal repair cohort with anterior cruciate ligament (ACL) reconstruction.



**Figure 2.** Patient follow-up and additional surgical procedures. ACL, anterior cruciate ligament.

evaluation of predictors. Each potential predictor requires, in general, 10 events. Thus, for the clinician choosing between these methods versus another method with 100% success, one would not be able to scientifically distinguish

an observed <9% difference (100%–91%) using clinical success as the primary outcome.

Five prospective studies (3 randomized controlled trials [Level 1] and 2 cohorts [Level 2]) have compared all-inside

techniques with inside-out meniscal repair.<sup>1,3,4,7,9</sup> In the study by Albrecht-Olsen et al,<sup>1</sup> the success rate for all-inside stints was 91% versus a 75% success rate with the inside-out suture technique. Spindler et al,<sup>9</sup> in an ACL reconstruction population with medial meniscal repair, showed a near equal rate of success with all-inside absorbable devices and inside-out suture techniques at 89% and 88%, respectively. Bryant et al<sup>4</sup> noted equal success with all-inside and inside and out techniques at 78%. Similar results were shown by Barber et al,<sup>3</sup> with all-inside stints yielding a 91% success rate and inside-out sutures a 100% success rate. Finally, Hantes et al<sup>7</sup> showed all-inside repair to be successful in 65% of cases and the inside-out technique successful in 95%. Three studies, those of Albrecht-Olsen et al, Hantes et al, and Bryant et al, evaluated operative time between all-inside and inside-out meniscal repair. The all-inside technique was faster in all studies, yielding an average repair time of 14 minutes for all-inside and 18 minutes for inside-out repairs in the Hantes et al<sup>7</sup> study and 30 versus 60 minutes in the Albrecht-Olsen<sup>1</sup> group and 24.8 minutes versus 41.9 minutes in the Bryant et al group.<sup>4</sup> Analogous to these prospective comparative studies, our clinical success between all-inside versus inside-out was within 10%, with the lowest success being 91%.

The strengths of this current study are the prospective study design, documented interrater agreement of surgeons for meniscal tears and treatment,<sup>5</sup> generalizability among sites and surgeons, and 94% follow-up. The techniques used represent the most common forms of repair currently in clinical use.

The weaknesses of this study include short-term follow-up of 2 years, relatively low sample size within each individual repair method, and the low failure rate, which precludes analysis for predictors of outcome. These weaknesses will be addressed as the cohort matures both in length of follow-up and in number of patients enrolled. Re-evaluation of the cohort is planned at 6 years, and additional enrollment is ongoing. Accumulating more patients will increase the sample size within each specific repair method, allowing for multivariable analysis of factors contributing to success and failure. An additional weakness of this study is the lack of standardization of the postoperative rehabilitation protocol. In subsequent years of the cohort, the rehabilitation protocol has been standardized to minimize variability.

Other weaknesses include difficulty in defining the age of the meniscal tears, acute versus chronic. Evaluation of this point was precluded by the patients' inability to characterize the timing of injury. An additional weakness is the definition of repair failure as reoperation. Unfortunately, currently it is very difficult to obtain repeat arthroscopy or MRI scans secondary to cost in a cohort of this size. We acknowledge that some of these seeming clinical successes could be anatomic failures. A systematic review of all-inside

meniscal repair was recently published that helps to define outcome following meniscal repair. Lozano et al<sup>8</sup> found that the standard measure of outcome in meniscal repair was a need for reoperation in 26 of 32 studies evaluating all-inside repair. Finally, our conclusions apply only to meniscal repairs at the time of ACL reconstruction, which fit the location, size, and configuration of these tears, and the results cannot be extended to isolated meniscal repairs not done in conjunction with ACL reconstruction.

In summary, when confronted with a "repairable" meniscal tear at the time of an ACL reconstruction, orthopaedic surgeons can choose between several all-inside methods or inside-out repairs with an estimated >90% randomized clinical success rate at 2-year follow-up. With the observed success rate, powering a clinical trial to significantly improve efficacy in this population is not practical based on sample size requirements. As the MOON database prospectively accumulates patients, conclusions regarding the best modality of meniscal repair may be able to be made. In the interim, prospective longitudinal studies are needed focusing on clinical success of meniscal repair in the absence of ACL reconstruction or with the ACL intact. We believe this information is beneficial for the surgeon counseling patients and their families regarding expected outcomes, benefits, and risks of meniscal repair at the time of ACL reconstruction.

## REFERENCES

1. Albrecht-Olsen P, Kristensen G, Burggaard P, Joergensen U, Toerholm C. The arrow versus horizontal suture in arthroscopic meniscus repair: a prospective randomized study with arthroscopic evaluation. *Knee Surg Sports Traumatol Arthrosc.* 1999;7(5):268-273.
2. Baker BE, Peckham AC, Puppato F, Sanborn JC. Review of meniscal injury and associated sports. *Am J Sports Med.* 1985;13(1):1-4.
3. Barber FA, Johnson DH, Halbrecht JL. Arthroscopic meniscal repair using the BioStinger. *Arthroscopy.* 2005;21(6):744-750.
4. Bryant D, Dill J, Litchfield R, Amendola A, Giffin R, Fowler P, Kirkley A. Effectiveness of bioabsorbable arrows compared with inside-out suturing for vertical, reparable meniscal lesions: a randomized clinical trial. *Am J Sports Med.* 2007;35(6):889-896.
5. Dunn WR, Wolf BR, Amendola A, et al. Multirater agreement of arthroscopic meniscal lesions. *Am J Sports Med.* 2004;32(8):1937-1940.
6. Fairbank T. Knee joint changes after meniscectomy. *J Bone Joint Surg Br.* 1948;4:664-670.
7. Hantes ME, Zachos VC, Varitimidis SE, Dailiana ZH, Karachalios T, Malizos KN. Arthroscopic meniscal repair: a comparative study between three different surgical techniques. *Knee Surg Sports Traumatol Arthrosc.* 2006;14(12):1232-1237.
8. Lozano J, Ma CB, Cannon WD. All-inside meniscus repair: a review of clinical studies. *Clin Orthop Relat Res.* 2007;455:134-141.
9. Spindler KP, McCarty EC, Warren TA, Devin C, Connor JT. Prospective comparison of arthroscopic medial meniscal repair technique: inside-out suture versus entirely arthroscopic arrows. *Am J Sports Med.* 2003;31(6):929-934.
10. Spindler KP, Warren TA, Callison JC Jr, Secic M, Fleisch SB, Wright RW. Clinical outcome at a minimum of five years after reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Am.* 2005;87(8):1673-1679.