

Prospective Comparison of Arthroscopic Medial Meniscal Repair Technique

Inside-Out Suture Versus Entirely Arthroscopic Arrows

Kurt P. Spindler,*† MD, Eric C. McCarty,* MD, Todd A. Warren,* NP, ATC, Clinton Devin,* MD, and Jason T. Connor,‡ MS

*From the *Vanderbilt Sports Medicine Center, Department of Orthopaedics and Rehabilitation, Nashville, Tennessee, and ‡Department of Biostatistics & Epidemiology, The Cleveland Clinic Foundation, Cleveland, Ohio*

Background: Medial meniscal repairs are commonly performed with inside-out sutures and entirely arthroscopic with arrows, but few comparative evaluations on failures have been performed.

Hypothesis: No differences in failure rates exist between medial meniscal repairs performed with inside-out suture or entirely arthroscopic at the time of anterior cruciate ligament reconstruction.

Study Design: Prospective cohort study.

Materials: A single surgeon performed 47 consecutive inside-out suture repairs from August 1991 to June 1996 and 98 consecutive entirely arthroscopic repairs with arrows from June 1996 to December 1999. All data were derived from a prospective database and rehabilitation was held constant (nonweightbearing 5 weeks). Clinical success was defined as no reoperation for failed medial meniscal repair. Statistical evaluation was by Kaplan-Meier curves and Cox proportional hazards model.

Results: The inside-out suture group had 85% follow-up (40 of 47) with a median 68 months and the entirely arthroscopic group had 87% follow-up (85 of 98) with a median 27 months. There were seven failures in each group. Both Kaplan-Meier curves and the Cox proportional hazards model showed no difference in time to reoperation between techniques ($P = 0.85$). Three-year success rates (proportions with no reoperations) were 88% for sutures versus 89% for arrows.

Conclusions: Repairs of the longitudinal posterior horn of the medial meniscus during an anterior cruciate ligament reconstruction with nonweightbearing for 5 weeks can be performed with an equivalent high degree of clinical success for both repair techniques.

© 2003 American Orthopaedic Society for Sports Medicine

Meniscal repair is preferable to partial meniscectomy based on documented healing of tears by second-look arthroscopy^{1, 2, 11, 12, 15, 20, 21, 27-29, 34} and prevention of radiographic changes of early osteoarthritis in long-term studies.^{6, 24} Presently, evaluation of "healing" of meniscal repairs is by indirect evaluation or clinical success^{3, 5, 9, 13, 17, 21, 23, 25, 33} because second-look arthroscopy is rarely possible and MRI has been shown to be unreliable.²² Despite the consensus opinion that repair is preferable, there are few prospective comparative or random-

ized trials on meniscal repair techniques. Broadly defined, there are four basic surgical approaches: open, inside-out sutures, outside-in sutures, and entirely arthroscopic with implantable devices.

Entirely arthroscopic techniques are probably the most common because they avoid postoperative morbidity of incisions and some are technically easier and faster than outside-in with sutures.¹ Because posterior horn tears of both the medial and lateral meniscus are common with ACL tears,³¹ but difficult to repair by outside-in technique,^{21, 25} the surgeon's major decision involving meniscal repair is which technique to use—inside-out with sutures or entirely arthroscopic.¹⁸ The only published study comparing these two techniques was by Albrecht-Olsen et al.¹ Their prospective randomized evaluation included second-look arthroscopy at 3 to 4 months postoperatively

† Address correspondence and reprint requests to Kurt P. Spindler, MD, Vanderbilt Sports Medicine Center, 2601 Jess Neely Drive, Nashville, TN 37212.

No author or related institution has received any financial benefit from research in this study. See "Acknowledgments" for funding information.

and showed equal healing. However, neither this study nor any others have a minimum 2-year clinical follow-up. Therefore, we performed this prospective comparative evaluation of clinical success. A single surgeon's consecutive medial meniscal repair technique during ACL reconstruction was switched from inside-out (polydioxanone [PDS] suture) to entirely arthroscopic (with bioabsorbable arrows); rehabilitation and weightbearing status was kept constant. Our hypothesis was there would be no difference in survival rate of medial meniscal repairs performed during ACL reconstruction for sutures versus arrows as determined by repeat surgery for failure.

MATERIALS AND METHODS

All meniscal repairs were performed during ACL reconstructions in patients who were entered into a prospective ACL reconstruction database initiated in 1991 between Vanderbilt Sports Medicine Center and the Cleveland Clinic. This database is the backbone of the Multicenter Orthopaedic Outcomes Network (MOON) founded in 2001. The location of the tear (peripheral versus central and medial versus lateral meniscus)^{25,33} and ACL status^{5,7,29,36} are significant variables in meniscal repair healing. As shown in Table 1, these variables were approximately equally distributed between treatment groups. The rehabilitation was kept constant throughout the study period since, although not documented in the literature, rehabilitation (range of motion and weightbearing) is thought to influence meniscal healing rates.

Inclusion criteria for this study were medial meniscal repairs of the peripheral third or junction of the peripheral third with the middle third performed by the senior surgeon (KPS) with patellar tendon ACL reconstruction between August 1991 and December 1999. Forty-seven consecutive patients (August 1991 to June 1996) had arthroscopically assisted inside-out repair using 2–0 PDS sutures (Ethicon, Summit, New Jersey), and 98 consecutive patients (June 1996 to December 1999) had entirely arthroscopic technique with bioabsorbable arrows (Bionix, Blue Bell, Pennsylvania).

For the inside-out technique with absorbable 2–0 PDS, the suture was arthroscopically inserted in a predominantly horizontal fashion through a dual-barrel guide (Acuflex, Mansfield, Massachusetts) and tied over the posteromedial capsule through a posteromedial incision. The posteromedial incision was extended to the capsule, a curved retractor was placed, and the needles were guided out of the incision. For the entirely arthroscopic technique with first-generation absorbable Bionix arrows, the arrows were inserted with the standard instrumentation provided. Care was taken to make sure the arrowhead was buried, and no sharp trocar as guiding hole was used.

Initial postoperative care consisted of femoral nerve block,⁸ use of a cryotherapy device and knee immobilizer (for the 1st week), and keeping the patient nonweight-bearing. Rehabilitation was begun on the 1st postoperative day and consisted of progressive range of motion exercises as tolerated by patients and strict nonweight-bearing for the first 5 weeks, with gradual return to full

TABLE 1
Comparison of Two Groups of Patients with Medial Meniscal Repair during ACL Reconstruction by Two Techniques (Inside-out Suture and All Arthroscopic Arrows)

Variable	Inside-out				Arthroscopic			
	Total		Follow-up		Total		Follow-up	
	Preop	Follow-up	Success	Fail	Preop	Follow-up	Success	Fail
Number of patients	47	40 (85%)	33	7	98	85 (87%)	78	7
Average age	24.4 ± 8.1	24.8 ± 8.3	24.8 ± 8.2	24.8 ± 9.5	23.4 ± 9.4	23.4 ± 9.7	23.8 ± 9.9	18.3 ± 2.9
% Male	57.4	52.5	54.5	42.9	52.0	51.8	53.8	28.6
% Primary ACL	95.7	95.0	93.9	100	94.8	96.4	96.1	100
% Lateral meniscal tear	78.8	80.0	78.8	85.7	59.2	57.6	59.0	42.9
% Lateral meniscal repair	0.0	0.0	0.0	0.0	9.2	8.2	9.0	0.0
% Posterior horn only	89.4	87.5	84.8	100	93.8	92.9	92.2	100
Medial meniscal tears								
Average tear length (mm)	15.8 ± 4.3	16.0 ± 4.7	15.7 ± 4.3	17.1 ± 6.4	15.6 ± 3.3	15.7 ± 3.5	15.8 ± 3.6	15.4 ± 1.1
% Complete tears	97.9	97.5	97.0	100	99.0	98.8	98.7	100
% Peripheral third	100	100	100	100	95.88	95.24	94.81	100
% Type								
Longitudinal	91.5	90.0	87.9	100	83.5	82.1	81.8	85.7
Bucket-handle	8.5	10.0	12.1	0	15.5	16.7	16.9	14.3
Degenerative	10.6	12.5	15.2	0	22.7	23.8	24.7	14.3
Average no. sutures or arrows	4.3 ± 1.7	4.2 ± 1.7	4.1 ± 1.7	4.7 ± 1.7	2.5 ± 1.0	2.6 ± 1.1	2.5 ± 1.1	3.0 ± 1.3
Median no. sutures or arrows	4 (3–5)	4 (3–5)	4 (3–4)	5 (3–6)	2 (2–3)	2 (2–3)	2 (2–3)	2.5 (2–4)

weightbearing without support by the 6th postoperative week. This protocol was constant in both groups. However, initially (early 1990s) all patients undergoing ACL reconstruction were inpatients, this later changed to 23-hour stays, and currently all ACL reconstructions are performed as outpatient procedures.

The initial prospective database was initiated by the senior author to prospectively document demographic information, mechanism of injury, initial outcomes assessment, and intraoperative information on meniscal, articular cartilage, and ligament injuries and treatments in addition to specifics of ACL reconstruction. Variables recorded for meniscal tear/repair were location (medial versus lateral, anterior versus posterior horn, peripheral third versus middle third versus central third), length in millimeters, type of tear (longitudinal, radial, bucket-handle), presence of degeneration, number of sutures or arrows used in repair, and repair technique. These variables were recorded on a scale diagram and then entered numerically in the database. The database is housed in the Department of Biostatistics at The Cleveland Clinic Foundation.

Follow-up of these two groups was by lower extremity multidimensional health assessment questionnaire and, in a limited basis, a phone interview. The lower extremity multidimensional health assessment questionnaire is an 11-page document containing the entire Knee Injury and Osteoarthritis Outcome Score (KOOS),²⁶ Western Ontario McMaster Osteoarthritis Index (WOMAC),⁴ Short-form (SF-36),^{30,35} Lysholm,^{10,16} and International Knee Documentation Committee-99 (IKDC)¹⁴ questionnaires, and follow-up on key demographic information. Furthermore, it specifically asks if the patient has had any additional surgery on either knee. The primary outcome variable for clinical success of meniscal repair was no reoperation for failure of healing of the meniscal repair. If reoperation occurred, the operative note was reviewed to verify that operation was for failure of the meniscus to heal and not for treatment of a cyclops lesion. In the rare occurrence when no operative dictation was available (2 of 14), we assumed failure of the meniscal repair.

Kaplan-Meier curves were used to visually illustrate differences in time to reoperation between groups. Cox proportional hazards models were used to statistically compare efficacy of treatment techniques. For this simple two-group design, this reduces to a standard log-rank test. All statistical tests were performed at the $\alpha = 0.05$ significance level.

Finally, a Cox proportional hazards model was fit adjusted for propensity score. Propensity scores were calculated by using the patients' sex, age, and characteristics of their injury, including primary ACL involvement, simultaneous lateral tear, posterior horn tear, middle one-third tear, longitudinal tear, degenerative component, and number of sutures. Although date of surgery completely determined which procedure was performed, by using these patient and injury characteristics to calculate a propensity score we improved the analysis. Because treatment was not randomized, adjusting for propensity scores helped adjust for any changes in the patient population

from the early-to-mid 1990s (when the inside-out technique was used) to the late 1990s (when the entirely arthroscopic technique with arrows was used), which may have confounded the results.

RESULTS

From September 1991 to June 1996, 260 ACL reconstructions were performed and 47 were concomitant with a medial meniscal repair (18% for the inside-out group). From June 1996 to December 1999, 391 ACL reconstructions were performed, with 98 concomitant medial meniscal repairs (25% for the arthroscopic group). In the inside-out suture group, 85% follow-up (40 of 47) was achieved, with a median follow-up of 68 months (Table 1). For the arthroscopic arrow group, 87% follow-up (85 of 98) was obtained, with a median follow-up of 27 months. Seven failures were observed in the inside-out group and seven in the arthroscopic group. Follow-up was by the lower extremity multidimensional health assessment questionnaire in all but three patients in the inside-out group and all but six patients in the arthroscopic group. Therefore, less than 10% of our follow-up was by phone interview only. In Table 1, we compare the major variables anticipated in success or failure of meniscal repair by surgical technique. The only notable difference between patients undergoing the inside-out and arthroscopic procedures was that fewer patients in the arthroscopic group had lateral tears (59.2% versus 78.7%, $P = 0.02$), although more of these lateral tears were repaired in arthroscopic group patients (9.0% versus 0%, $P = 0.01$). All other factors shown in Table 1 were similar between the two groups.

The primary outcome in this study was time to reoperation on the meniscus. The Kaplan-Meier plot compares the time to reoperation after meniscal repair between the inside-out and arthroscopic groups (Fig. 1). The survival curves for the two groups were extremely similar—crossing seven times within 3 years of operation.

The Cox proportional hazard model was used to formally test for differences in time to reoperation. The Cox model indicated no difference in time to reoperation between surgical techniques ($P = 0.85$). The risk of reoperation was 1.12 times (95% confidence interval [CI], 0.35 to 3.61) as high in the inside-out group as in the arthroscopic group at any point in time after meniscal repair. The 36-month success rates (proportions with no reoperation) were 87.5% (95% CI, 77.8 to 98.4) for the inside-out group versus 89% (95% CI, 80.9 to 99.7) for the arthroscopic group. If this small difference were the true difference, an incredibly large number of patients would be required to verify this difference was in fact true. Although the observed difference was just 1% at 3 years, the current sample size offers 80% power to detect a statistically significant difference of 28% at 3 years.

The Cox proportional hazards model was also fit while adjusting for individual patients' propensity scores. Again there was no evident difference between surgical techniques ($P = 0.77$). The model indicated the hazard of reoperation was 1.26 times (95% CI, 0.37 to 4.24) as

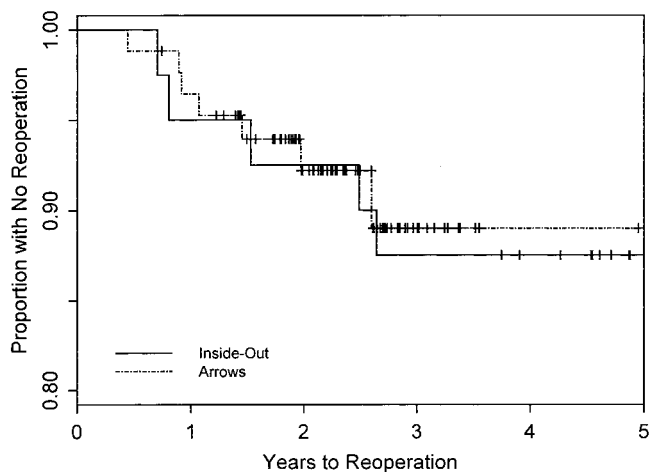


Figure 1. Kaplan-Meier plot of medial meniscal repair survival between inside-out with sutures versus entirely arthroscopic with arrows. Plot close-up view emphasizes any differences that might exist between techniques. Note clinical success at 3 years was approximately 90% in both groups. Vertical ticks indicate lengths of follow-up in patients not requiring reoperation.

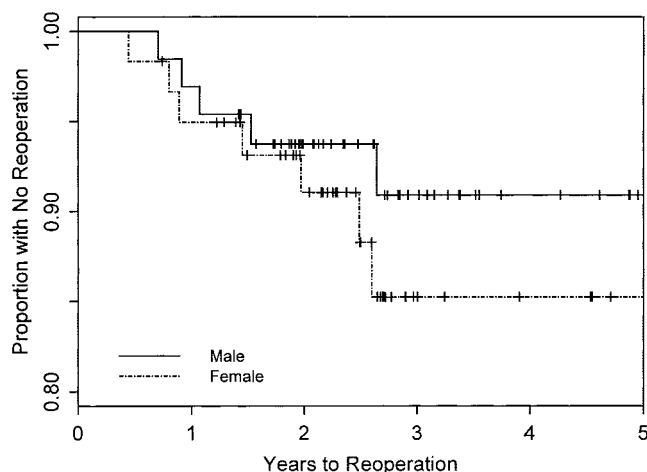


Figure 2. Kaplan-Meier plot of medial meniscal repair survival between male and female patients. Plot close-up view emphasizes any differences that might exist between techniques. Note that the clinical success at 3 years is 94% for male patients and 87% for female patients. Vertical ticks indicate lengths of follow-up in patients not requiring reoperation.

high in the inside-out group as in the arthroscopic group. This is approximately the same hazard ratio as seen when not adjusting for propensity scores. The similar hazard ratios indicate that, while patients were not randomized to treatment groups, there was no evidence the results were confounded by a change in population over time.

Having found no difference in surgical outcome between medial meniscal repair techniques, we investigated other factors such as sex, injury location, and severity of original injury for their effect on time to reoperation. No other factors were statistically significant. Although not a statistically significant result, a Cox model of time to reoperation versus sex showed that the hazard ratio for female patients was nearly 2 times that of male patients: 1.98 (95% CI, 0.66 to 5.9). Figure 2 shows the Kaplan-Meier plots for time to reoperation by sex.

Clinical function was assessed by several validated outcomes questionnaires and compared between the inside-out and arthroscopic groups (Table 2). All outcomes instruments demonstrated no significant differences

between success and failure within techniques, and scores were good to excellent for all groups. However, all scores were higher in the successful patients than in the failure (reoperation) patients. The SF-36 physical and mental component scores were within normal for population (50 ± 10). As expected, the KOOS quality of life and sports and recreation subdomain scores were lower than the WOMAC and overall KOOS scores. However, because of the multiple potential confounding variables, especially the longer follow-up period in the inside-out group, a direct comparison between the inside-out and arthroscopic groups was not valid but provides a general overview of subject clinical function.

Complications were reviewed from clinical notes, and any occurrences of infection, neurapraxia, wound healing problems, painful arrow tips, and abnormal intraarticular findings at repeat arthroscopy were recorded. Transient neurapraxia was observed in 13% of patients (6 of 47) in the inside-out group. Both wound healing problems (4%, or 2 of 47 patients in the inside-out group) and painful arrow tips (1%, or 1 of 98 in the arthroscopic group) re-

TABLE 2
Comparison of Outcome Scores on Questionnaires (Mean \pm SD)

Score	Inside-Out		Arthroscopic	
	Success	Fail	Success	Fail
IKDC 99	82 \pm 11	65 \pm 23	80 \pm 14	73 \pm 18
Lysholm	85 \pm 14	80 \pm 11	87 \pm 11	79 \pm 10
SF-36 Physical function scale	53 \pm 7	51 \pm 12	52 \pm 7	51 \pm 4
SF-36 Mental component scale	55 \pm 6	47 \pm 9	53 \pm 7	54 \pm 4
WOMAC	94 \pm 9	89 \pm 17	93 \pm 8	88 \pm 11
KOOS Total	90 \pm 10	84 \pm 19	88 \pm 10	81 \pm 16
KOOS Quality of life subdomain	76 \pm 17	69 \pm 26	74 \pm 19	65 \pm 17
KOOS Sports and recreation subdomain	81 \pm 18	71 \pm 35	82 \pm 17	72 \pm 29

solved without complication. There were no cases of wound healing problems or neurapraxia in the arthroscopic group. Review of failures in both groups showed no consistent pattern. No grooving of the medial femoral condyles was observed, and two patients in the arthroscopic group had new grade II chondromalacia lesions of the medial femoral condyle. Two patients in the arthroscopic group had arthroscopic debridement of a cyclops lesion at approximately 3 months, at which time the meniscal repair appeared healed, but both patients had subsequent failure of repair within a couple years.

Our research indicated that medial meniscal repair with both techniques (in patients undergoing ACL reconstruction and kept nonweightbearing for 5 to 6 weeks postoperatively) had a clinical success of 88% at 3 years. Furthermore, we are 95% confident that the 3-year success rate is at least as high as 77% when using either surgical technique. We observed no statistically significant or clinically relevant differences between the two medial meniscal repair techniques, inside-out with sutures and entirely arthroscopic with arrows.

DISCUSSION

In this prospective comparative evaluation of two medial meniscal repair techniques, no observed difference in clinical success rates was observed. All proven parameters influencing repair of the medial meniscus,²⁵ ACL reconstruction,^{5, 7, 29, 32, 36} peripheral complete tear,³³ and several other parameters thought to be important (postoperative weightbearing status, range of motion, size or length of tear, and type of tear), were equivalent between groups. However, clinical success, as defined by our investigation, does not directly equate with healing. Several studies have found on second-look arthroscopy that the menisci can be partially healed without clinical symptoms.^{25, 34} Specifically, Albrecht-Olsen et al.,¹ in a prospective randomized study of inside-out meniscal repair with sutures versus arthroscopic repair with arrows, evaluated meniscal healing by second-look arthroscopy at 3 to 4 months. In that study, patients were kept nonweightbearing for 5 weeks. At the follow-up arthroscopic evaluation, 91% of the arthroscopic group and 75% of the inside-out group had completely or partially healed menisci ($P = 0.11$). No further follow-up was reported.

Clearly, the goal of meniscal repair is not just "healing" but also the absence of clinical symptoms requiring later meniscal removal. Although the exact percentage of "clinically silent" meniscal tears is unknown, in this young active population we hypothesize they either have to modify their activity to reduce symptoms or undergo repeat arthroscopic treatment. Cases in which the repaired meniscus does not heal but is asymptomatic may result in a higher risk of degenerative changes over the years compared with cases in which actual meniscal healing occurs. Therefore, evaluation by meniscal repair survival (Kaplan-Meier plots/Cox proportional hazards modeling) is a practical way to report success as well as evaluate comparisons of techniques.

In the current health care setting, the ability to perform second-look arthroscopic procedures is nearly impossible because of cost and ethical considerations. Even with arthroscopic inspection, how we define partial versus complete healing and stability of repair is relatively subjective. Muellner et al.²² showed that MRI cannot differentiate between healed meniscus and not healed meniscus. Perhaps newer techniques to visualize repaired meniscus by MRI will provide us with an accurate and reliable noninvasive alternative to operative inspection.

Several authors have defined the absence of clinical symptoms as clinical success.^{3, 5, 9, 13, 17, 21, 25, 33} However, clinical symptoms after ACL reconstruction can be a result of cyclops lesion or scar tissue, instability of ACL grafts, patellofemoral pain, or degenerative changes in the medial compartment and are not restricted to failed meniscal repair. Therefore, we decided the most objective criterion to plot success versus failure was reoperation for failed meniscal repair verified by operative dictation and prospective knee diagrams of pathologic lesions found at arthroscopic surgery. Although we probably overestimated the 5- and 10-year "success rates," at 3 years postoperatively in this extremely active population 88% survival is encouraging. Ten-year follow-up is ongoing.

This study did not demonstrate that the two techniques are equivalent for lateral meniscal tears, tears in an ACL-intact knee in either meniscus, or if an accelerated rehabilitation program is allowed with early weightbearing. However, with an ACL reconstruction, given the observed equivalence of healing (partial and complete) by second-look arthroscopy^{1, 2, 11, 12, 15, 19, 27-29, 34} and identical clinical success at 3 years (after 5 weeks of nonweightbearing), these two techniques should yield equal success for medial meniscal tears. The surgeon can choose either technique to satisfactorily achieve medial meniscal repair. In our experience there is more postoperative pain early in the rehabilitation process from the posteromedial incision of the inside-out technique, and obtaining full extension is more difficult. In conclusion, within the specific parameters shown (involvement of the peripheral third posterior horn of the medial meniscus, ACL reconstruction, and nonweightbearing for 5 weeks) either technique will yield excellent clinical success at 3 years.

ACKNOWLEDGMENTS

The authors thank Lynn S. Cain for editorial assistance and Heather Stanfield for technical assistance. Funding for this study was provided by Vanderbilt Sports Medicine Center.

REFERENCES

1. Albrecht-Olsen P, Kristensen G, Burggaard P, et al: The arrow versus horizontal suture in arthroscopic meniscus repair: A prospective randomized study with arthroscopic evaluation. *Knee Surg Sports Traumatol Arthrosc* 7: 268-273, 1999

2. Alpar E, Bilsel N: Meniscus repair. *Arch Orthop Trauma Surg* 110: 112–113, 1991
3. Barrett GR, Treacy SH, Ruff CG: Preliminary results of the T-fix endoscopic meniscus repair technique in an anterior cruciate ligament reconstruction population. *Arthroscopy* 13: 218–223, 1997
4. Bellamy N, Buchanan W, Goldsmith C: Validation study of WOMAC: A health status instrument for measuring clinically important patient-relevant outcomes following total hip or knee arthroplasty in osteoarthritis. *Orthop Rheumatol* 1: 95–108, 1988
5. Cannon WD Jr, Vittori JM: The incidence of healing in arthroscopic meniscal repairs in anterior cruciate ligament-reconstructed knees versus stable knees. *Am J Sports Med* 20: 176–181, 1992
6. DeHaven KE: Decision-making factors in the treatment of meniscus lesions. *Clin Orthop* 252: 49–54, 1990
7. DeHaven KE, Lohrer WA, Lovelock JE: Long-term results of open meniscal repair. *Am J Sports Med* 23: 524–530, 1995
8. Edkin BS, McCarty EC, Spindler KP, et al: Analgesia with femoral nerve block for anterior cruciate ligament reconstruction. *Clin Orthop* 369: 289–295, 1999
9. Egli S, Wegmuller H, Kosina J, et al: Long-term results of arthroscopic meniscal repair. An analysis of isolated tears. *Am J Sports Med* 23: 715–720, 1995
10. Höher J, Munster A, Klein J, et al: Validation and application of a subjective knee questionnaire. *Knee Surg Sports Traumatol Arthrosc* 3: 26–33, 1995
11. Horibe S, Shino K, Maeda A, et al: Results of isolated meniscal repair evaluated by second-look arthroscopy. *Arthroscopy* 12: 150–155, 1996
12. Horibe S, Shino K, Nakata K, et al: Second-look arthroscopy after meniscal repair. Review of 132 menisci repaired by an arthroscopic inside-out technique. *J Bone Joint Surg* 77B: 245–249, 1995
13. Hurel C, Mertens F, Verdonk R: Biofix resorbable meniscus arrow for meniscal ruptures: Results of a 1-year follow-up. *Knee Surg Sports Traumatol Arthrosc* 8: 46–52, 2000
14. Irrgang JJ, Anderson AF, Boland AL, et al: Development and validation of the International Knee Documentation Committee subjective knee form. *Am J Sports Med* 29: 600–613, 2001
15. Kimura M, Shirakura K, Hasegawa A, et al: Second look arthroscopy after meniscal repair. Factors affecting the healing rate. *Clin Orthop* 314: 185–191, 1995
16. Lysholm J, Gillquist J: Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *Am J Sports Med* 10: 150–154, 1982
17. Mariani PP, Santori N, Adriani E, et al: Accelerated rehabilitation after arthroscopic meniscal repair: A clinical and magnetic resonance imaging evaluation. *Arthroscopy* 12: 680–686, 1996
18. McCarty EC, Marx RG, DeHaven KE: Meniscus repair: Considerations in treatment and update of clinical results. *Clin Orthop* 402: 122–134, 2002
19. Miller DB Jr: Arthroscopic meniscus repair. *Am J Sports Med* 16: 315–320, 1988
20. Morgan CD, Casscells SW: Arthroscopic meniscus repair: A safe approach to the posterior horns. *Arthroscopy* 2: 3–12, 1986
21. Morgan CD, Wojtys EM, Casscells CD, et al: Arthroscopic meniscal repair evaluated by second-look arthroscopy. *Am J Sports Med* 19: 632–638, 1991
22. Muellner T, Egkher A, Nikolic A, et al: Open meniscal repair: Clinical and magnetic resonance imaging findings after twelve years. *Am J Sports Med* 27: 16–20, 1999
23. Plasschaert F, Vandekerckhove B, Verdonk R: A known technique for meniscal repair in common practice. *Arthroscopy* 14: 863–868, 1998
24. Rockborn P, Gillquist J: Results of open meniscus repair. Long-term follow-up study with a matched uninjured control group. *J Bone Joint Surg* 82B: 494–498, 2000
25. Rodeo SA, Seneviratne AM: Outside-in arthroscopic meniscal repair. *Sports Med Arthrosc Rev* 7: 20–27, 1999
26. Roos H, Laurén M, Adalberth T, et al: Knee osteoarthritis after meniscectomy: Prevalence of radiographic changes after twenty-one years, compared with matched controls. *Arthritis Rheum* 41: 687–693, 1998
27. Rosenberg TD, Scott SM, Coward DB, et al: Arthroscopic meniscal repair evaluated with repeat arthroscopy. *Arthroscopy* 2: 14–20, 1986
28. Rubman MH, Noyes FR, Barber-Westin SD: Arthroscopic repair of meniscal tears that extend into the avascular zone. A review of 198 single and complex tears. *Am J Sports Med* 26: 87–95, 1998
29. Scott GA, Jolly BL, Henning CE: Combined posterior incision and arthroscopic intra-articular repair of the meniscus. An examination of factors affecting healing. *J Bone Joint Surg* 68A: 847–861, 1986
30. Shapiro ET, Richmond JC, Rockett SE, et al: The use of a generic, patient-based health assessment (SF-36) for evaluation of patients with anterior cruciate ligament injuries. *Am J Sports Med* 24: 196–200, 1996
31. Spindler KP, Schils JP, Bergfeld JA, et al: Prospective study of osseous, articular, and meniscal lesions in recent anterior cruciate ligament tears by magnetic resonance imaging and arthroscopy. *Am J Sports Med* 21: 551–557, 1993
32. Tenuta JJ, Arciero RA: Arthroscopic evaluation of meniscal repairs. Factors that effect healing. *Am J Sports Med* 22: 797–802, 1994
33. Valen B, Molster A: Meniscal lesions treated with suture. A follow-up study using survival analysis. *Arthroscopy* 10: 654–658, 1994
34. Van der Reis W, Cannon WD Jr: Arthroscopic meniscal repair using the inside-out technique. *Sports Med Arthrosc Rev* 7(1): 8–19, 1999
35. Ware JE Jr, Sherbourne CD: The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 30: 473–483, 1992
36. Warren RF: Meniscectomy and repair in the anterior cruciate ligament-deficient patient. *Clin Orthop* 252: 55–63, 1990