

Clinical and Second-Look Arthroscopic Evaluation of Repaired Medial Meniscus in Anterior Cruciate Ligament–Reconstructed Knees

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Background: Tears of the medial meniscus posterior horn (MMPH) are frequently found in knees with deficient anterior cruciate ligaments (ACLs). There are few studies that have evaluated healing of the menisci and the factors associated with healing.

Hypothesis: The repaired menisci would show good healing in the knees with reconstructed ACLs, and the healing capacity of the menisci would differ according to the size, type, and location of the tear as well as the age and gender.

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

Methods: From August 1997 to February 2007, 311 knees underwent MMPH repair using either a modified all-inside or inside-out technique with concomitant ACL reconstruction. Among these patients, a second-look arthroscopy was performed at a mean of 37.7 months postoperatively (range, 12-128 months) in 140 patients. Clinical parameters and outcomes were evaluated. The repaired menisci were divided into complete, incomplete, and failure-to-heal groups. The factors associated with meniscal healing were statistically assessed.

Results: Among 140 patients, 118 (84.3%) showed complete healing, 17 (12.1%) had incomplete healing, and 5 (3.6%) failed to heal. The clinical success rate was 96.4% (135/140) because patients in the incomplete group showed no clinical symptoms associated with meniscal tears. Healing was associated with the tear location ($P < .001$) and type of tear ($P = .0237$) on the univariate analysis and the location ($P = .0401$) only on the multivariate analysis.

Conclusion: Repaired MMPH tears in knees with reconstructed ACLs healed without complications and had satisfactory clinical results. The tear location and type were factors associated with healing on the univariate analysis and location only on the multivariate analysis.

Keywords: knee; anterior cruciate ligament; medial meniscus posterior horn; repair; healing; affecting factor

The incidence of medial meniscal lesions may be as high as 90% to 98% in patients with chronic anterior cruciate ligament (ACL) insufficiency.^{10,18} The interdependence of the ACL and medial meniscus is well documented.^{12,13} The availability of new all-inside repair devices has made meniscal repair techniques easier and more rapid.^{8,11} However, the long-term efficacy of these techniques has not been established, and complications have been reported.^{8,15}

Success rates for meniscal repair have been reported to be between 70% and 90% in the vascular region; however, meniscal repair in the white-white zone is widely believed to have a poor success rate.^{7,9,10,14} Several factors have been documented as influencing the success of repairs.^{14,17} Meniscal repairs performed in conjunction with ACL reconstruction generally have a better healing rate than meniscal repairs in knees with intact ACLs.^{4,17}

The hypotheses of this study were that repaired menisci would show good healing in ACL-reconstructed knees and that the healing capacity of menisci would differ according to the size, type, and location of the tear as well as age and gender. We (1) evaluated the clinical and second-look arthroscopic results of arthroscopic all-inside repair with a suture hook¹ and the modified inside-out repair³ and (2) analyzed the factors associated with meniscal healing.

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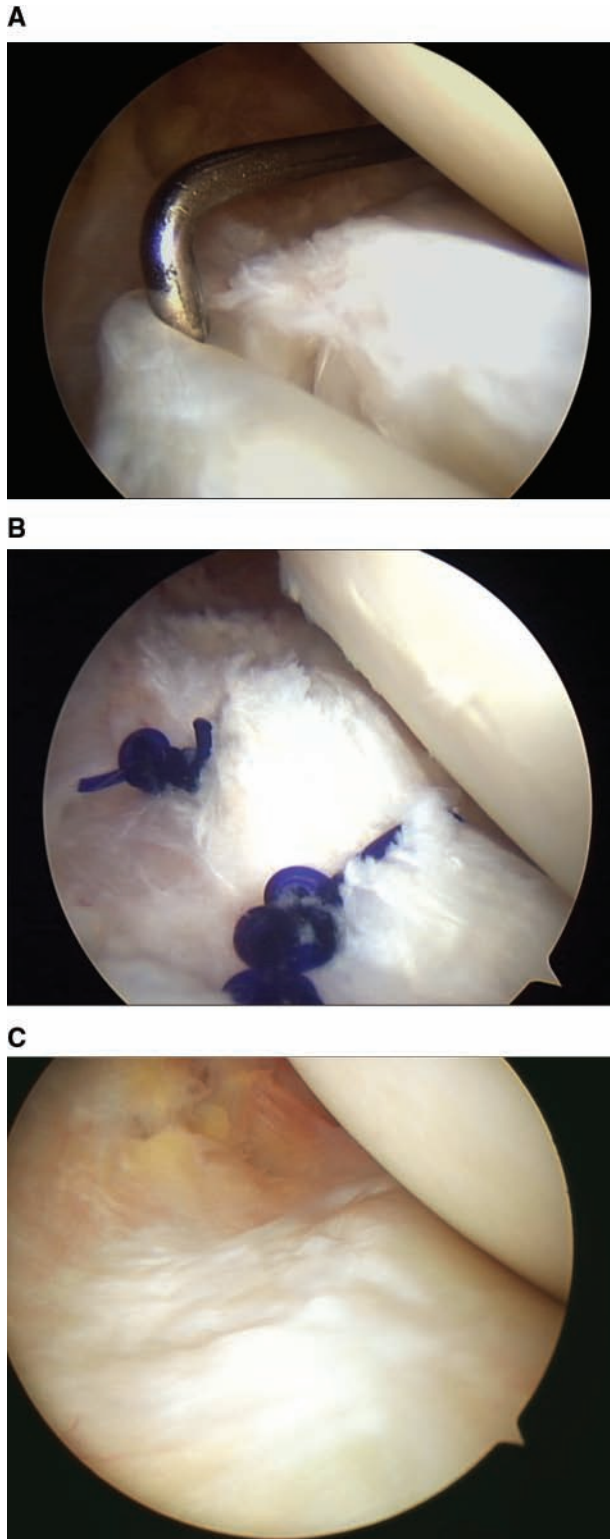


Figure 1. View from the posteromedial portal. A peripheral longitudinal tear was noted, and the posterior meniscocapsular structure moved downward against the remaining meniscus (A). All-inside sutures were performed using a suture hook (B), and complete healing was noted at post-operative 40 months (C).

TABLE 1
Healing Status According to Repair Method^a

Repair Method	Patients, n (%)	Completely Healed, n (%)	Incompletely Healed, n (%)	Failed, n (%)
AI only	88 (63)	78 (89)	9 (10)	1 (1)
AI + IO	52 (37)	40 (77)	8 (15)	4 (8)
Total	140 (100)	118 (84.3)	17 (12.1)	5 (3.6)

^aAI, all-inside; IO, inside-out.

MATERIALS AND METHODS

Demographics

From August 1997 to February 2007, there were 1006 patients who underwent ACL reconstruction. Among these patients, 518 knees had medial meniscal tears; 311 knees underwent medial meniscus posterior horn (MMPH) repair using either a modified all-inside^{1,4} or an inside-out technique³ with concomitant ACL reconstruction. Among these cases, second-look arthroscopy was performed at a mean of 37.7 months postoperatively (range, 12-128 months) in 140 of 311 patients. All of the repairs and second-look arthroscopic surgeries were performed by a single senior surgeon (J.H.A.). We selected patients for second-look arthroscopy who wanted their postie washer and screw hardware removed from the proximal tibia. We explained the purpose of the second-look arthroscopy (the evaluation of ACL and meniscal healing, debridement of frayed tissues) to all patients before surgery and received written consent. This study was approved by the institutional review board of our hospital.

The indications⁴ for meniscal repair included the following: (1) displacement of the torn meniscus with a probe, (2) a longitudinal tear that was 1 cm or longer, (3) a tear within 5 mm of the meniscocapsular junction, and (4) any double longitudinal tears that met all of the above criteria. We used an all-inside technique in 88 patients (63%) where the tear was limited to the posterior horn. We used an inside-out technique in 52 patients (37%) where the tear extended to the midportion of the medial meniscus.

Surgical Procedure and Rehabilitation

We used the all-inside suture technique¹ in approximately two thirds of the meniscal tears where possible (Figure 1). For tears extending to the midportion, we performed the combined inside-out suture technique³ for repair (Table 1) (Figure 2, especially 2D). Central avascular zone tears (mainly radial tears or horizontal tears) were treated with a partial meniscectomy before meniscal repair. The most important point regarding our meniscal repair technique is that we performed vertically oriented suturing using a suture hook in both the all-inside and inside-out techniques; this was because vertically oriented sutures provide excellent tissue coaptation and firm fixation. Further details are listed in our technical note.^{3,4}

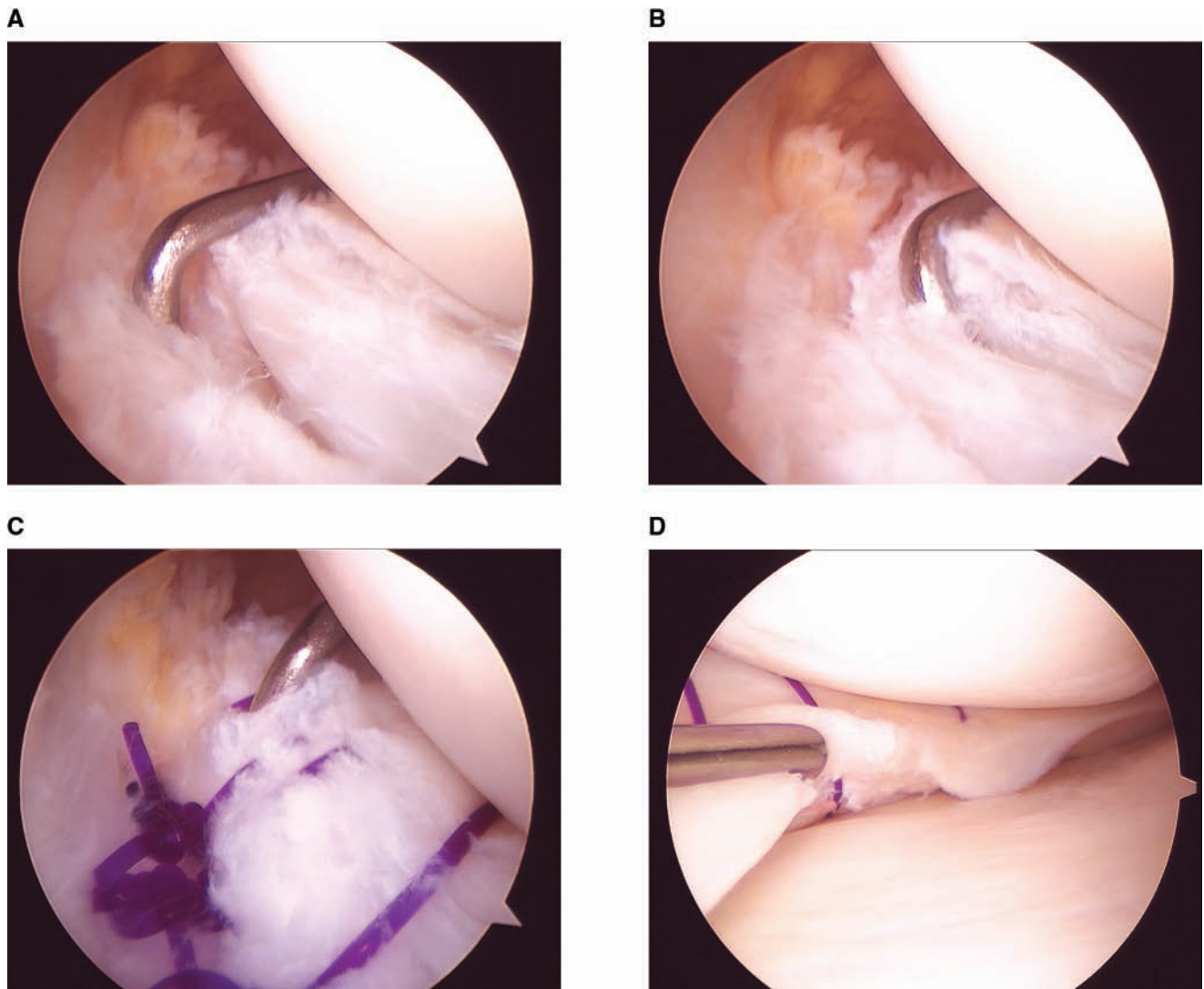


Figure 2. View from the posteromedial portal. An outer longitudinal tear in the red-red zone (A) and an inner longitudinal tear in the red-white zone (B) were noticed. All-inside (C) and inside-out (D) repairs were performed simultaneously.

The protocol for postoperative rehabilitation followed the guidelines for concomitant ACL reconstruction.² The knee was immobilized in a full extension brace for 2 weeks. The ACL brace was worn during joint motion exercises that were conducted at 15° increments per week. Ninety degrees of motion was allowed at 4 weeks after surgery and 135° of motion was allowed at 6 weeks after surgery. Straight line running was allowed at 6 months after surgery, and change-of-direction running was allowed at 9 months after surgery.

Evaluation Methods

During the second-look arthroscopy, repaired menisci were divided into completely healed, incompletely healed, and failure to heal groups according to the criteria reported by Scott et al.¹⁴ We performed subgroup analysis according to the size, type, and location of the tear as well as age and gender. We assessed the repaired meniscus on both the superior

and inferior surface using an anterior portal and a posteromedial portal. A meniscus was considered healed only if healing was present over the length of the tear with a residual cleft at the tear site of less than 10% (less than 1 mm of the inserted probe tip) of the thickness of the meniscus. Incompletely healed menisci were characterized by a residual cleft at the tear site of less than 50% (1-3 mm of the inserted probe tip) full thickness of the meniscus. If the residual cleft was greater than 50% (more than 3 mm of the inserted probe tip) full thickness of the meniscus at any location along the tear site, the repair was considered a failure.^{4,14}

For the subgroup analysis, we recorded the total number of stitches, tear types, and the location of the tear during meniscal repair. The actual tear size was difficult to measure; we therefore recorded the number of stitches needed for the repair and used this as an estimate of the tear size. The stitches were placed at intervals of roughly 4 to 5 mm. Tear types were categorized as simple or complex

TABLE 2
Comparison of Healing Status According to Tear Types

Tear Type	Total, n (%)	Completely		Failed, n (%)
		Healed, n (%)	Incompletely Healed, n (%)	
Simple tear	93 (66)	85 (91)	7 (8)	1 (1)
Single longitudinal tear	72 (77)	66	6	0
Bucket handle tear	21 (23)	19	1	1
Complex tear	47 (34)	33 (70)	10 (21)	4 (9)
Double longitudinal tear	32 (68)	21	8	3
Combined tear	15 (32)	12	2	1

(Table 2). We considered single longitudinal tears and bucket handle tears, without any other combined tears, as simple tears. Double longitudinal tears and combined tears (longitudinal tear combined with avascular zone horizontal or radial tears that required a partial meniscectomy) were considered complex tears. We attempted to repair all tears that were within 5 mm of the peripheral rim. The peripheral red-red zone was defined as the area extending to within 3 mm of the meniscal peripheral rim. The central red-white zone, which has variable vascularity, was defined as the peripheral area between 3 and 5 mm from the meniscocapsular junction. In the case of double longitudinal tears, where both tears could be anywhere between these 2 areas (usually one in the red-red zone and one in the red-white zone), we defined them as coexisting (Table 3).

For the evaluation of the clinical parameters just before second-look arthroscopy, we performed a thorough clinical assessment that included (1) medial joint line pain and tenderness, (2) locking or catching history, (3) recurrent effusion, (4) McMurray test, (5) 2 knee scores (Lysholm knee score and Hospital for Special Surgery [HSS] score), and (6) the International Knee Documentation Committee (IKDC) objective score. A clinically successful meniscal repair was reported if the first 4 clinical parameters were negative.⁴ Second-look arthroscopic evaluation was performed by a senior surgeon, and the clinical evaluation was performed by a sports medicine fellow who was not involved in the second-look operation.

Statistical Methods

A post hoc power analysis was performed retrospectively. If the failure rates of the simple and complex groups were 10% and 40%, more than a 95% detection rate was predicted under α (.05). If failure rates of the red-red zone and red-white zone were 5% and 35%, respectively, more than a 95% detection rate under α (.05) was predicted. However, these limits were chosen arbitrarily.

Univariate analysis was performed with the χ^2 test or the Fisher exact test for categorical variables and with the Wilcoxon 2-sample test for continuous variables. Multivariate analysis was performed with the use of logistic regression analysis. The outcome analyzed as a dependent variable was the healing status of the repaired meniscus

TABLE 3
Comparison of Healing Status According to Location of Tear

Location of Tear	Total, n (%)	Completely		Failed, n (%)
		Healed, n (%)	Incompletely Healed, n (%)	
Total number	140 (100)	118 (84.3)	17 (12.1)	5 (3.6)
Red-red	82 (59)	77 (94)	5 (6)	0 (0)
Red-white	34 (24)	27 (79)	5 (15)	2 (6)
Coexistence (red-red & red-white)	24 (17)	14 (58)	7 (29)	3 (13)

(complete or not), which was regressed against a variety of independent variables including age, gender, type (simple and complex), size, and location (red-red, red-white, coexistence) of the tear. SPSS 12.0 (SPSS, Chicago, Illinois) was used for the statistical analysis. A *P* value of <.05 was considered to be statistically significant.

RESULTS

There were 126 men and 14 women included in this study. The average patient age at the time of the second-look arthroscopy was 30 years (range, 15-54 years). The mean time from ACL reconstruction and meniscal repair to second-look arthroscopy and clinical evaluation was 37.7 months (range, 12-128 months).

Among 140 patients, 118 (84.3%) patients showed complete healing (Figure 1), 17 (12.1%) showed incomplete healing, and 5 (3.6%) failed to heal (Figure 3). The clinical success rate was 96.4% (135 of 140). The size of the tear, age, and gender were factors not associated with healing (*P* = .7822, .124, and .214, respectively). Healing was associated with the type of tear (*P* = .0237) and location (*P* < .001) (Tables 2 and 3). When these factors were subjected to multiple logistic regression analysis, location (*P* = .0401) (red-red, red-white, or coexistence) was the only factor associated with complete healing of the meniscus.

Patients with incompletely healed tears and tears that failed to heal had complex tears or tears involving the red-white zone. Seventeen patients (12.1%) had incomplete healing at second-look arthroscopy, but none of the patients in this group showed any clinical sign of a meniscal tear. Therefore, we counted these patients as successful cases when determining the clinical success rate.

The mean Lysholm score was 70.9 ± 9.36 (range, 30-95) before surgery, and it improved to 93.3 ± 3.8 (range, 68-99) after surgery. The mean HSS score was 76.7 ± 8.5 (range, 28-95) before surgery, and it improved to 95.9 ± 4.7 (range, 75-100) after surgery. Regarding the IKDC objective score, 134 (95.7 %) patients had a normal (104 patients, 74.3%) or nearly normal (30 patients, 21.4%) level.

DISCUSSION

The principle finding of this study was a clinical success rate of 96.4% (135 of 140) for meniscal repairs with

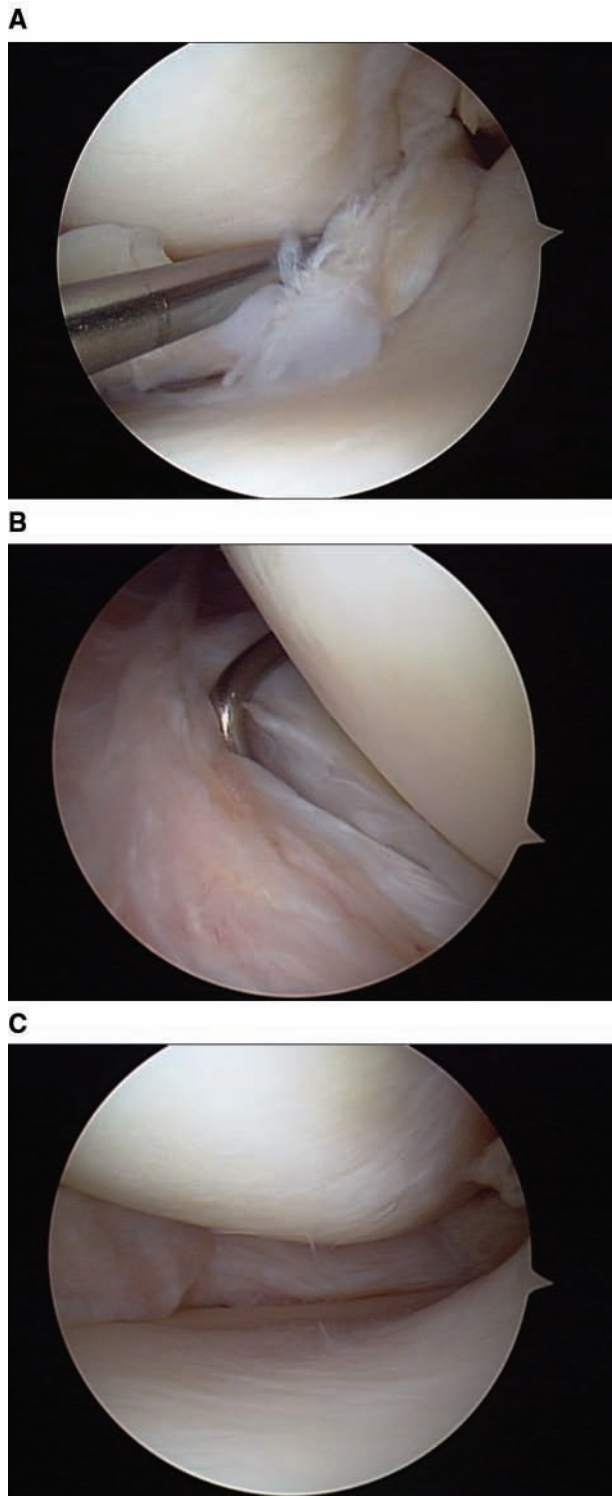


Figure 3. A, Fourteen months after surgery, the meniscus failed to heal and was displaced anteriorly. B, Viewing from the posteromedial portal, the original tear site remained unhealed. C, A meniscectomy was performed.

concomitant ACL reconstruction. The success of the procedure was confirmed by second-look arthroscopy. The tear

location and tear type were factors associated with healing on the univariate analysis and the location only on the multivariate analysis.

The success rates for meniscal repairs have been reported to be from 70% to 90% in vascular regions.^{7,9,10,14} Feng et al⁹ reported an 89.6% healing rate for the repair of bucket-handle tears, most with concurrent ACL reconstruction, which were also confirmed by second-look arthroscopy. Tenuta and Arciero¹⁷ also evaluated meniscal healing using second-look arthroscopy. The healing rate of meniscal repairs in conjunction with ACL reconstruction was higher than for isolated repairs (90% vs 57%). Based on their results, the ideal patient profile for meniscal repair is a patient less than 30 years of age with a tear within 3 mm of the meniscosynovial junction with the repair done in conjunction with an ACL reconstruction.

The interdependence of the ACL and medial meniscus has been well studied.¹² Allen et al⁵ reported that the resultant forces on the medial meniscus increased by as much as 200% in response to anterior tibial loads after ACL tears. In addition, the in situ forces in a reconstructed ACL graft increased between 33% and 50% after medial meniscectomy.¹³ Deficiency of the medial meniscus has been proposed as a secondary cause of ACL failure and has been identified as a significant precursor to osteoarthritis and general debilitation of the knee.^{6,16} However, Shelbourne and Rask¹⁵ reported that repaired unstable peripheral vertical medial meniscal tears had a failure rate of 13.6%, with most retears occurring more than 2 years after the initial repair. They also reported that most (94%) stable medial meniscal tears treated with abrasion and trephination remained asymptomatic without stabilization. Our experience is consistent with others in that concurrent ACL reconstruction appears to enhance meniscal healing. However, a significantly displaced meniscus, such as a displaced bucket-handle tear or an MMPH tear with vertical step off, must be repaired because healing is expected when contact is obtained with the torn end.⁴ Because of poor visualization of the posterior meniscocapsular junction of the medial meniscus, when using a standard portal, an additional posteromedial portal is essential for precise evaluation of the tear configuration. In a previous report, we showed that a torn posterior meniscocapsular structure moved inferiorly against the remaining meniscus, displacing the tear during knee flexion. This motion of the torn medial meniscus can partially explain the slow healing observed in MMPH peripheral rim tears, despite a rich vascular supply to the red-red zone.⁴

The limitations of this study include the following: (1) This study includes potential bias because of the nonrandom nature of patient selection. However, there were no differences in the demographic data between patients with second-look arthroscopy and patients without second-look arthroscopy (Table 4). (2) There is a possibility of incomplete healing within the interstitial portion of the meniscus because we probed the meniscus with direct surface observation. (3) This method of repair is difficult to perform and requires extensive time and effort. (4) The number of patients was relatively small for the subgroup analysis of the incompletely healed and failure to

TABLE 4
Demographics of All Medial Meniscus Posterior
Horn-Repaired Patients^a

	Patients With Second Look	Patients Without Second Look
No. of patients	140	171
Age (SD; range), y	30.3 (9.73; 15-54)	29.4 (8.52; 14-62)
Sex (male:female)	127:14	100:71
AI only/AI + IO	88/52	118/63

^aSD, standard deviation; AI, all-inside; IO, inside-out.

heal groups versus the total number of evaluated patients. (5) The number of sutures is a relatively weak proxy for actual measurement of the tear length. However, it is hard to measure the entire length of a tear all at once because the tear configurations are usually curved around a posterior and posteromedial corner.

Repaired medial menisci in ACL-reconstructed knees showed good healing that was confirmed by second-look arthroscopy. The clinical success rate was 96.4% (135/140). Tear location and tear type were factors associated with healing on the univariate analysis and location only on the multivariate analysis.

REFERENCES

- Ahn JH, Kim SH, Yoo JC, Wang JH. All-inside suture technique using two posteromedial portals in a medial meniscus posterior horn tear. *Arthroscopy*. 2004;20:101-108.
- Ahn JH, Park JS, Lee YS, Cho YJ. Femoral bioabsorbable cross-pin fixation in anterior cruciate ligament reconstruction. *Arthroscopy*. 2007;23:1093-1099.
- Ahn JH, Wang JH, Oh I. Modified inside-out technique for meniscal repair. *Arthroscopy*. 2004;20 Suppl 2:178-182.
- Ahn JH, Wang JH, Yoo JC. Arthroscopic all-inside suture repair of medial meniscus lesion in anterior cruciate ligament-deficient knees: results of second-look arthroscopies in 39 cases. *Arthroscopy*. 2004;20:936-945.
- Allen CR, Wong EK, Livesay GA, Sakane M, Fu FH, Woo SL. Importance of the medial meniscus in the anterior cruciate ligament-deficient knee. *J Orthop Res*. 2000;18:109-115.
- Baratz ME, Fu FH, Mengato R. Meniscal tears: the effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. *Am J Sports Med*. 1986;14:270-275.
- DeHaven KE. Meniscus repair. *Am J Sports Med*. 1999;27:242-250.
- Fargn E, Sherman O. Meniscal repair devices: a clinical and biomechanical literature review. *Arthroscopy*. 2004;20:273-286.
- Feng H, Hong L, Geng XS, Zhang H, Wang XS, Jiang XY. Second-look arthroscopic evaluation of bucket-handle meniscus tear repairs with anterior cruciate ligament reconstruction: 67 consecutive cases. *Arthroscopy*. 2008;24:1358-1366.
- Henning CE. Current status of meniscus salvage. *Clin Sports Med*. 1990;9:567-576.
- Kalliakmanis A, Zourtos S, Bousgas D, Nikolaou P. Comparison of arthroscopic meniscal repair results using 3 different meniscal repair devices in anterior cruciate ligament reconstruction patients. *Arthroscopy*. 2008;24:810-816.
- Mesiba M, Zurakowski D, Soriano J, Nielson JH, Zarins B, Murray MM. Pathologic characteristics of the torn human meniscus. *Am J Sports Med*. 2007;35:103-112.
- Papageorgiou CD, Gil JE, Kanamori A, Fenwick JA, Woo SL, Fu FH. The biomechanical interdependence between the anterior cruciate ligament replacement graft and the medial meniscus. *Am J Sports Med*. 2001;29:226-231.
- 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 Am*. 1986;68:847-861.
- Shelbourne KD, Rask BP. The sequelae of salvaged nondegenerative peripheral vertical medial meniscus tears with anterior cruciate ligament reconstruction. *Arthroscopy*. 2001;17:270-274.
- Sherman MF, Warren RF, Marshall JL, Savatsky GJ. A clinical and radiographical analysis of 127 anterior cruciate insufficient knees. *Clin Orthop Relat Res*. 1988;227:229-237.
- Tenuta JJ, Arciero RA. Arthroscopic evaluation of meniscal repairs: factors that effect healing. *Am J Sports Med*. 1994;22:797-802.
- Warren RF, Marshall JL. Injuries of the anterior cruciate and medial collateral ligaments of the knee. A long-term follow-up of 86 cases: part II. *Clin Orthop Relat Res*. 1978;136:198-211.