Original Article With Video Illustrations

Arthroscopic Suture Anchor Repair Versus Pullout Suture Repair in Posterior Root Tear of the Medial Meniscus: A Prospective Comparison Study

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Purpose: To evaluate functional and radiographic results of arthroscopic suture anchor repair for posterior root tear of the medial meniscus (PRTMM) and compare with pullout suture repair. **Methods:** From December 2006 to August 2008, 51 consecutive patients underwent arthroscopic repair of PRTMM at our hospital. The repair technique was switched over time from pullout suture repair (group 1) to suture anchor repair (group 2). Of the patients, 6 were lost to follow-up, leaving a study population of 45 patients, with 22 menisci (48.9%) in group 1 and 23 (51.1%) menisci in group 2. The mean follow-up duration was 25.9 months (range, 24 to 27 months) in group 1 and 26.8 months (range, 24 to 28 months) in group 2. Compared variables included International Knee Documentation Committee criteria, Kellgren-Lawrence grade, gap distance at PRTMM, structural healing, meniscal extrusion, and cartilage degeneration of the medial femoral condyle. **Results:** At 2 years postoperatively, both groups showed significant improvements in function ($P < .05$) and did not show significant differences in Kellgren-Lawrence grade ($P > .05$) compared with preoperatively. On magnetic resonance imaging, the gap distance at PRTMM was 3.2 ± 1.1 mm in group 1 and 2.9 ± 0.9 mm in group 2 preoperatively ($P > .05$). Complete structural healing was seen in 11 cases in group 1 and 12 cases in group 2 ($P > .05$). Mean meniscal extrusion of 4.3 ± 0.9 mm (group 1) and 4.1 ± 1.0 mm (group 2) preoperatively was significantly decreased to 2.1 ± 1.0 mm (group 1) and 2.2 ± 0.8 mm (group 2) postoperatively ($P < .05$). Regardless of repair technique, incompletely healed cases showed progression of cartilage degeneration (4 cases in group 1 and 2 cases in group 2). **Conclusions:** For PRTMM, our results show significant functional improvement in both the suture anchor repair and pullout suture repair groups. Reduction of meniscal extrusion seems to be appropriate to preserve its protective role against progression of cartilage degeneration after complete healing at PRTMM. **Level of Evidence:** Level III, prospective therapeutic comparative study.

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Tear of the posterior horn of the medial meniscus is not uncommon, especially in eastern countries, where people commonly squat and sit on the floor with their legs in deep flexion. The incidence has been reported to be as high as 27.8% among medial meniscal tears.[1] Meniscal root tears have gained more attention since posterior root tear of the medial meniscus was first reported in 1991 by Pagnani et al.[2,3] This unique lesion causes serious consequences similar to total meniscectomy because of loss of its crucial role of the circumferential fiber bundles of the meniscus transmitting hoop tension through anterior and posterior meniscal root attachments.[4] Therefore repair of a posterior root tear should be considered if possible to restore the anatomy and biomechanical function of the meniscus and to slow or prevent degenerative joint disease.

There are several arthroscopic all-inside techniques, including pullout suture repair and suture anchor repair, that have been introduced in the literature to repair posterior root tear of the medial meniscus.[5-9] Technical difficulties with all-inside repairs involving manipulation of a suture hook and drilling of a tibial tunnel in the narrow medial joint space have been reported, but those difficulties have been significantly addressed by use of a posterior trans-septal portal.[3,10] Previously, we reported an arthroscopic repair technique using a suture anchor and posterior trans-septal portal.[11] By use of a suture anchor, the procedure was simplified, eliminating the need for a tibial tunnel in our repair technique. However, no clinical results have been reported on arthroscopic suture anchor repair of posterior root tear of the medial meniscus in the literature.

The purpose of our study was to evaluate the clinical and radiologic results of arthroscopic suture anchor repair of posterior root tear of the medial meniscus and compare with pullout suture repair. The hypothesis of this study was that arthroscopic suture anchor repair of posterior root tear of the medial meniscus would yield better results than pullout suture repair based on International Knee Documentation Committee (IKDC) scores, reduction of meniscal extrusion, cartilage protection, and structural healing.

METHODS

From December 2006 to August 2008, 51 consecutive patients (51 meniscal repairs) who underwent arthroscopic repair of posterior root tear of the medial meniscus with suture anchor repair or pullout suture repair at the Center for Joint Disease at our hospital were entered into this study. Patients were included if (1) they were diagnosed with complete posterior root tear of the medial meniscus based on magnetic resonance imaging (MRI) findings as described by Lee et al.[12] (Fig 1), (2) the onset of symptom was less than 6 months previously, (3) the Kellgren-Lawrence grade was less than 4 on preoperative radiographs, (4) they were aged less than 60 years, and (5) they had only a trivial trauma history (squatting and minor slippage). Exclusion criteria were as follows: (1) partial root tear of the medial meniscus with structural continuity (more than one-third of root diameter) on semicoronal and axial views on preoperative MRI; (2) concomitant injuries (fractures, ligament injuries, or other meniscal injuries); (3) posterior root tears of the medial meniscus with deformity; (4) malalignment; and (5) obesity with body mass index greater than 30. Repair technique was switched over time from arthroscopic pullout suture repair to suture anchor repair. Of the patients, 6 were lost to follow-up, leaving a study population of 45 patients, with 22 menisci (48.9%) undergoing suture anchor repair (group 1) and 23 menisci (51.1%) undergoing pullout suture repair (group 2). The mean age was in 53.2 years in group 1 and 52.8 years in group 2. Female patients predominated in both groups, comprising 68.1% of cases (7 of 15) in group 1 and 60.9% of cases (9 of 14) in group 2, with a statistically significant difference ($P < .05$). The mean body mass index was 23.9 (range, 22.7 to 28.2) in group 1 and 24.8 (range, 23.1 to 29.2) in group 2, without a statistically significant difference ($P > .05$). The mean time period from onset of pain to repair was 4.2 months (range, 0.5 to 14 months) in group 1 and 4.8 months (range, 1 to 11 months) in group 2. The mean follow-up duration was 25.9 months (range, 24 to 27 months) in group 1 and 26.8 months (range, 24 to 28 months) in group 2 (Table 1).

Medical records were collected to determine each patient's age, gender, injury mechanism, mean time to repair, and duration of follow-up. Institutional review board approval was obtained before the study (BD2005-072D). Informed consent was obtained from all patients.

Assessment consisted of evaluation using objective and subjective IKDC criteria, Lysholm functional questionnaires, and Hospital for Special Surgery (HSS) scores, as well as joint line tenderness. Subjective evaluation consisted of assessment of effusion, range of motion, evaluation of joint line tenderness, pain on full flexion, locking, and giving way, as well as the McMurray test. Physical examinations were performed and the patients filled out appropriate ques-

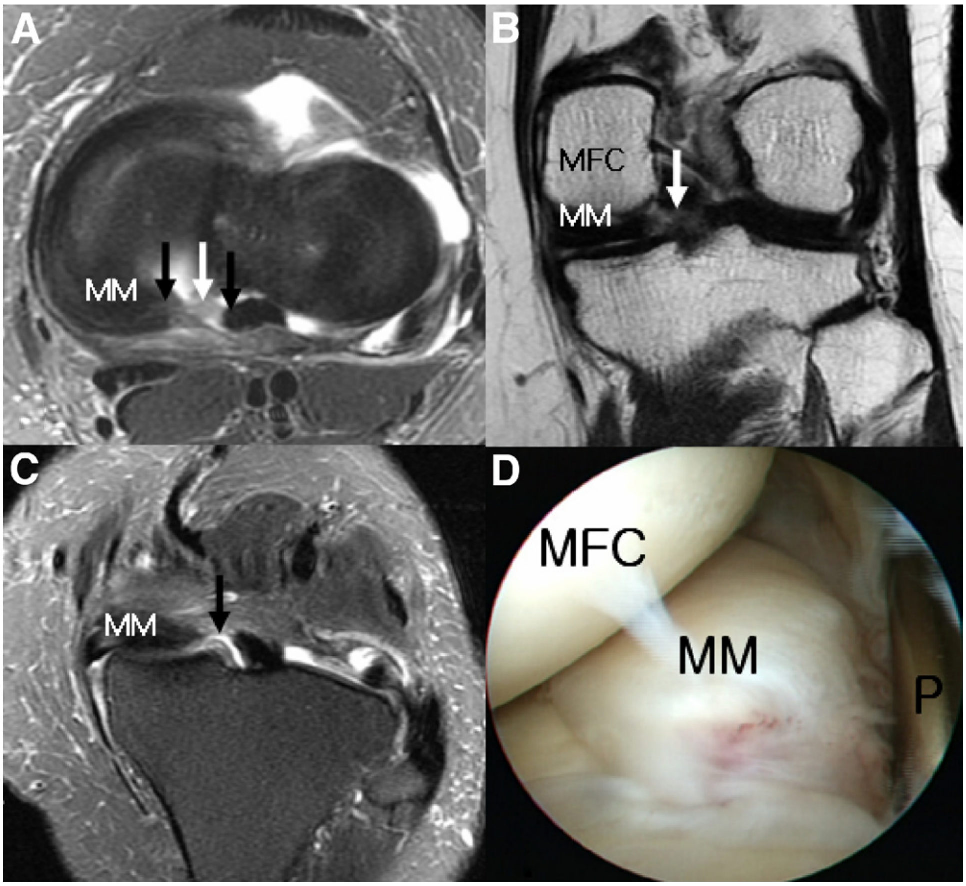

Figure 1. MRI and arthroscopic findings of posterior root tear of medial meniscus (MM). (A) The axial view shows abnormal high-signal change (white arrow) with discontinuity (between 2 black arrows). (B) T1-weighted coronal image shows discontinuity (white arrow) with abrupt truncation of the medial margin of the medial meniscus. (C) On the oblique coronal view, discontinuity with high signal intensity (black arrow) of the posterior horn of the medial meniscus is prominent. (D) The posterior trans-septal portal through the posterolateral portal provides a clear view of the complete radial tear of the medial meniscus. (MFC, medial femoral condyle; P, probe.)

tionnaires preoperatively and postoperatively at 3 months, 6 months, 1 year, and yearly thereafter.

Preoperatively, weight-bearing anteroposterior radiographs, posteroanterior radiographs with 45° of flexion, lateral radiographs, and orthoradiogram (long film, hips to ankles, patella facing forward with both legs loaded equally) were obtained in all cases. The original criteria of Kellgren and Lawrence[13] were used for radiographic comparison: grade 0, no degenerative change; grade 1, questionable osteophytes and no joint space narrowing; grade 2, definitive osteophytes with possible joint space narrowing; grade 3, definitive joint space narrowing with moderate multiple osteophytes and some sclerosis; and grade 4, severe joint space narrowing with cysts, osteophytes, and sclerosis.

Table 1. *Comparison of Groups*

	Group 1 (n = 22)	Group 2 (n = 23)	*P* Value
Age (yr)	53.2 ± 6.1	52.8 ± 5.2	.672
Patients by gender			.71
Men	7 (31.8%)	9 (39.1%)	
Women	15* (68.1%)	14* (60.9%)	
Total	22	23	
BMI	23.9 ± 4.3	24.8 ± 4.4	.61
Mean time from onset of pain to repair (mo)	4.2 ± 1.1	4.8 ± 0.6	.418
Follow-up period (mo)	25.9 ± 4.9	26.8 ± 4.1	.751

NOTE. The values are given as mean and 95% confidence interval.
Abbreviation: BMI, body mass index.
* Statistically significantly higher when compared within group ($P < .05$).

MRI scans were performed with two 1.5-T superconducting magnets (Magnetom Vision and Sonata; Siemens Medical Systems, Erlangen, Germany) using quadrature extremity coils. On the initial MRI studies, diagnosis of posterior root tear of the medial meniscus as well as accompanying cartilage lesion at the medial compartment was evaluated. On the axial image, gap distance at the torn posterior root of the meniscal meniscus was measured (Fig 2). According to Gale et al.,[14] meniscal extrusion was measured as the greatest distance from the most peripheral aspect of the medial meniscus to the border of the tibia excluding osteophytes on the midcoronal image of the medial femoral condyle (Fig 3). On the basis of our study guidelines, all patients in this study were recommended to undergo follow-up MRI to confirm the results of repair regardless of clinical results, and of the patients, 17 (77.3%) in group 1 and 14 (60.9%) in group 2 agreed and underwent follow-up MRI studies at 2 years postoperatively. On the follow-up MRI studies, structural healing at the posterior root tear of the medial meniscus, reduction of meniscal extrusion, and progression of cartilage degeneration of the medial femoral condyle were evaluated. With regard to structural healing, posterior root tear of medial meniscus was considered completely healed if the configuration of the repaired posterior root was normal on T1-weighted images without hyperintense defect on both T2-weighted semicoronal and axial MRI scans. Incomplete structural healing was defined if partial (more than one-third of root diameter) absence of the posterior root of the medial meniscus or high signal intensity replaced the normal dark meniscal sign on semicoronal and axial images.

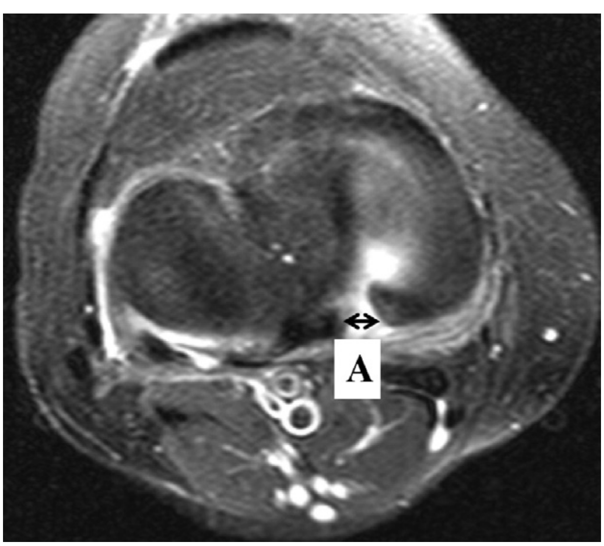

FIGURE 2. The axial view shows measurement of gap distance (arrows), as well as high-signal defect with well-demarcated and rounded shape of torn posterior root of the meniscal meniscus of the knee (A).

FIGURE 3. The measurement of meniscal extrusion was performed by drawing a tangential vertical line at the margin of the medial tibial plateau (solid line) and second vertical line at the outer margin of the medial meniscus parallel to the first line (dashed line). The distance between the 2 vertical lines was defined as the meniscal extrusion width (arrows; A).

Review of all radiographic studies including MRI scans was performed by 2 experienced musculoskeletal radiologists (with 13 years and 7 years of experience, respectively) by consensus in a blinded fashion with regard to arthroscopic results using PACS (picture archiving and communication system) workstations (Marosis; Infinitti, Seoul, Republic of Korea). Articular cartilage of the medial femoral condyle and medial tibial plateau was evaluated by use of dual-echo T2-weighted images in both the sagittal and coronal planes. Cartilage degeneration on the ipsilateral femoral condyle was graded on a categorical scale with a modification of a previous classification system: grade 0, normal cartilage; grade 1, focal blistering and intracartilaginous low–signal intensity area with an intact surface and bottom; grade 2, irregularities on the surface or bottom and loss of thickness of less than 50%; grade 3, deep ulceration with loss of thickness of more than 50%; and grade 4, full-thickness chondral wear with exposure of subchondral bone.

Surgical Procedure

The surgical procedures in all cases were performed by the senior author (J-H.K.).

Pullout Suture Repair: Pullout suture repair was performed using techniques described by Ahn et al.[3]

After a routine arthroscopic examination of the knee joint, posteromedial and posterolateral portals were made through a transillumination technique. Viewing through the posteromedial portal, the surgeon established the trans-septal portal as described in Ahn and Ha[10] (Video 1, available at www.arthroscopyjournal.org). Through the posteromedial portal, the tip of the anterior cruciate ligament (ACL) tibial drilling guide (Linvatec, Largo, FL) was placed at the decorticated insertion site of the posterior horn of the meniscus and drilled from the anteromedial cortex of the proximal tibia to the insertion site of the posterior horn of the medial meniscus. A tibial tunnel was made with a 2.9-mm cannulated drill bit for the 4.0-mm cannulated screw (Fig 4A). By use of a crescent-shaped suture hook (Linvatec), vertical mattress suture was placed on the detached portion of the medial meniscus posterior horn with No. 1 nylon suture material. Then, both ends of the strands of the nylon were replaced into No. 2 Ethibond were retrieved (Ethicon, Somerville, NJ) by the shuttle relay technique. With wire loop, the ends of the Ethibond were retrieved to the outside of the tibial tunnel. After adequate reduction and tension control, the Ethibond suture materials were post-tied to and fixed with a 3.5-mm cortical screw with a washer on the anterior cortex of the tibia (Fig 4B).

Suture Anchor Repair: Suture anchor repair was performed by the technique that we reported previously (Video 2, available at www.arthroscopyjournal.org).[11] The standard anterolateral and anteromedial portals were made immediately adjacent to the lateral and medial border of the patellar tendon and 1 cm above the joint line to allow an easy passage through the intercondylar notch into the posterior compartment of the knee joint. The posterior trans-septal portal was

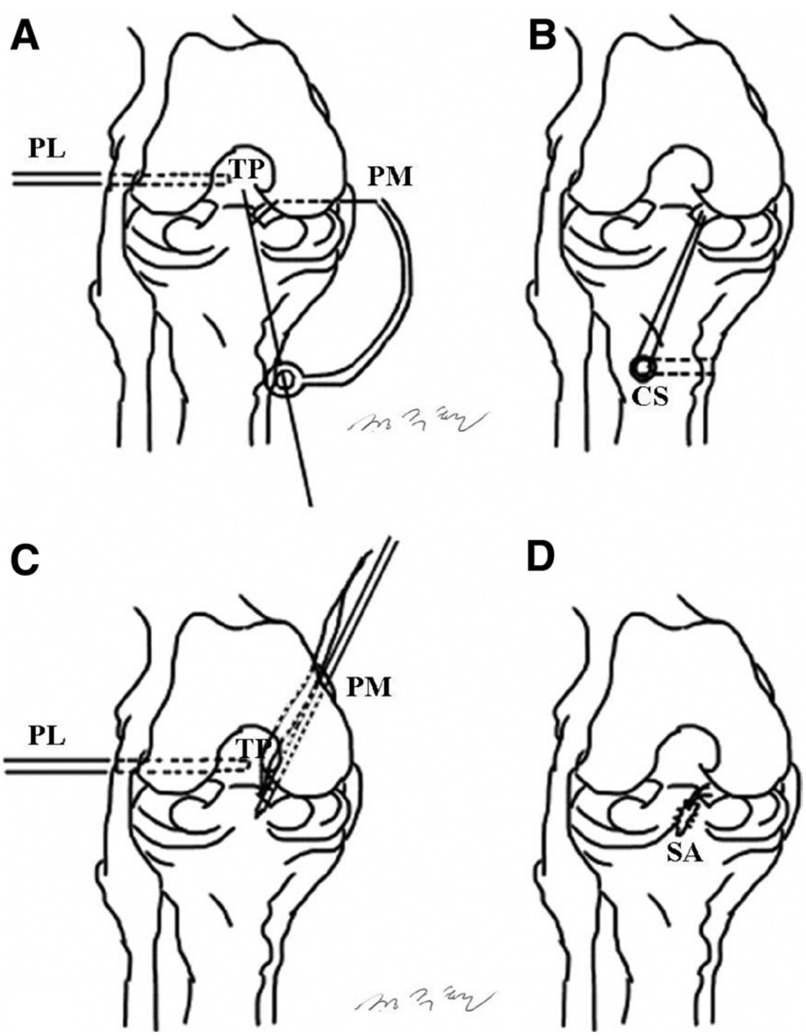

FIGURE 4. Two different repair techniques for posterior root tear of medial meniscus: (A, B) pullout suture repair and (C, D) suture anchor (SA) repair. (A) The tip of the ACL tibial drilling guide was placed at the decorticated insertion site of the posterior horn of the meniscus and drilled from the anteromedial cortex of the proximal tibia to the insertion site of the posterior horn of the medial meniscus. (B) After adequate reduction and tension control, the Ethibond suture materials were post-tied to and fixed with a 3.5-mm cortical screw (CS) with a washer on the anterior cortex of the tibia. (C) Under visualization through the posterior trans-septal portal (TP) through the posterolateral portal (PL), a suture anchor was located through the posteromedial portal (PM). (D) Knots were pushed down with a knot pusher under adequate reduction and tension.

established as described earlier. A transillumination technique was used to establish the posteromedial and posterolateral portals. A high posteromedial portal is established more than 2 cm proximal from the joint line, which is about at the upper margin of the transilluminated area. An anchor can be placed more vertically, thus being more securely fixed on the tibia, through a high posteromedial working portal. The creation of the posterior trans-septal portal and decortication on the insertion site of the posterior horn of the medial meniscus proceeded in the same manner as described earlier. We used Duet suture anchor (Linvatec) to repair the meniscal root tear. Under visualization through the posterior trans-septal portal through the posterolateral portal, a suture anchor was located (Fig 4C). Then, a 5.5-mm cannula (Linvatec) was inserted between the medial femoral condyle and cruciate ligaments through an anterolateral portal. Two strands of the suture from the same side of the anchor were retrieved through the cannula. Under visualization from the same portal, with a straight-neck suture hook (Linvatec), one-third of the peripheral portion of the torn meniscus was hooked from the femoral side to the tibial side in a vertical direction. Then, No. 0 polydioxanone (PDS) suture material (Ethicon), which was already loaded into the suture hook, was advanced. One limb of the PDS suture from the tibial side was retrieved with a suture retriever through the 8-mm cannula that was inserted from the anterolateral portal. The strand of the PDS was twisted to make a shuttle relay, and the strand of the anchor suture was hooked to the shuttle relay. The limb of the suture that had been retrieved through the anterolateral portal could come out through the posteromedial portal, passing the substance of the medial meniscus. A knot was pushed down with a knot pusher under adequate reduction and tension, and additional securing half-stitch sutures were placed. Because Duet suture anchor is preloaded with 2 sutures, another knot can be made during the same process (Fig 4D).

Postoperative Protocol

The same postoperative protocol was used in both groups. A long cylinder leg cast was applied in the fully extended position for 2 weeks. At 2 weeks postoperatively, patients were non–weight bearing and a hinged postoperative brace was applied, and flexion of the knee was allowed to 30° for the next 2 weeks. Thereafter patients increased flexion of the knee by 15° per week until the sixth week to allow range of motion of 90°. This protocol prohibited deep flexion until week 8 postoperatively, because extreme flexion was considered to cause incomplete healing or retear after repair. Partial weight bearing was allowed at 6 weeks postoperatively, followed by full weight bearing at 8 weeks. Further flexion, squatting, and return to sports were allowed after 6 months.

Statistical Analysis

Before the study, a power analysis was performed based on functional score. A standardized difference of 0.8 point in functional score of the repaired knee estimated a sample size of 22 patients in each group with 80% power when α was .05. The Student *t* test was used when we compared both groups, with significance at $P < .05$. Compared variables included effusion, range of motion, pain on full flexion, evaluation of joint line tenderness, locking, giving way, McMurray test, objective and subjective IKDC criteria, Lysholm functional questionnaire, and HSS score. For radiographic comparison, the Kellgren-Lawrence grade, structural healing at the posterior root tear of the medial meniscus, meniscal extrusion, and progression of cartilage degeneration of the medial femoral condyle were evaluated.

RESULTS

On subjective evaluation including effusion, range of motion, joint line tenderness, pain on full flexion, locking, giving way, and McMurray test, both groups showed significant improvements at the last follow-up compared with preoperatively ($P < .05$) (Table 2). Between groups, no statistically significant difference was observed ($P > .05$). The range of motion was 9.7° more in group 2 at the last follow-up, but it did not show a statistically significant difference ($P > .05$).

Regarding functional scores, both groups showed significant improvement compared with preoperatively ($P < .05$). Between groups, no statistically significant difference was observed ($P > .05$) (Table 3).

On radiographic evaluation, there were no statistically significant changes compared with preoperatively in both groups ($P > .05$) (Table 4). On MRI, the preoperative gap distance at the torn root of the medial meniscus was 3.2 ± 1.1 mm in group 1 and 2.9 ± 0.9 mm in group 2, without a statistically significant difference between groups ($P > .05$). Postoperatively, both groups showed a significantly decreased gap distance at the torn root of the medial meniscus compared with preoperatively ($P < .05$). On follow-up MRI at 2 years postoperatively, complete structural healing was seen in 11 cases in group 1 and 12 cases

TABLE 2. *Subjective Evaluation*

	Group 1 (n = 22)			Group 2 (n = 23)		
	Preoperative	Last Follow-up	*P* Value	Preoperative	Last Follow-up	*P* Value
Effusion	19	1	.002*	17	1	.035*
Range of motion (°)	81.7 ± 4.9	119.1 ± 5.1	.024*	75.8 ± 5.9	128.8 ± 7.1	.044*
Joint line tenderness	22	2	.01*	23	3	.025*
Pain on full flexion (°)	20	2	.02*	21	1	.023*
Locking	14	0	.0098*	11	0	.01*
Giving way	4	1	.03*	5	0	.03*
McMurray test	18	1	.01*	17	1	.02*

NOTE. No statistically significant differences ($P < .05$) were found between groups.
* Statistically significantly higher compared with preoperatively ($P < .05$).

in group 2 without statistical significance ($P > .05$). However, incomplete structural healing was seen in 6 cases in group 1 and 2 cases in group 2 with statistical significance ($P < .05$) (Table 5). Mean preoperative meniscal extrusion, 4.3 ± 0.9 mm in group 1 and 4.1 ± 1.0 mm in group 2, was significantly decreased postoperatively in both groups (to 2.1 ± 1.0 mm in group 1, and 2.2 ± 0.8 mm in group 2) ($P < .05$). In patients with incomplete structural healing, postoperative meniscal extrusion, 3.8 ± 1.0 mm in group 1 and 3.9 ± 1.4 mm in group 2, was significantly greater than that in patients with complete structural healing, 1.8 ± 0.8 in group 1 and 1.9 ± 0.4 in group 2 ($P <$ .05). With regard to progression of cartilage degeneration of the medial femoral condyle of the knee, 6 cases (27%) in group 1 and 5 cases (21%) in group 2 showed cartilage degeneration preoperatively, whereas 9 cases (40.9%) in group 1 and 8 cases (34.7%) in group 2 showed cartilage degeneration postoperatively on follow-up MRI. There was no statistically significant difference in both groups. The number of cases with grade 3 cartilage degeneration increased, from 3 to 7 in group 1 and from 3 to 4 in group 2, with a statistically significant difference between groups ($P < .05$) (Table 5). Regardless of repair technique, progression of cartilage degeneration was seen with incomplete healing (4 cases in group 1 and 2 cases in group 2) (Table 6).

DISCUSSIONS

Recently, posterior root tear of the medial meniscus has become increasingly recognized, but relatively few reports have described the results of repair of this unique pattern of meniscal tear. This is a prospective comparative study on both functional and structural results of 2 different all-inside arthroscopic repair techniques for posterior root tear of the medial meniscus.

For diagnosis of posterior root tear of the medial meniscus, clinical suspicion based on the patient's history, physical examination, and careful evaluation of MRI studies is important. In our study the incidence of tear of the posterior root of the medial meniscus was 11.6% among medial meniscal tears, and female patients predominated in both groups. It is conceivable that some housework still requires frequent squatting in our country and that affected the prevalence of posterior horn tears of the medical meniscus.

TABLE 3. *Functional Score Comparison*

	Group 1 (n = 22)			Group 2 (n = 23)		
	Preoperative	Last Follow-up	*P* Value	Preoperative	Last Follow-up	*P* Value
Subjective IKDC score	57.3 ± 4.1	91.8 ± 4.6	.0061*	58.5 ± 2.1	93.4 ± 3.2	.04*
Objective IKDC score						
Abnormal	22	0	.0027*	23	0	.0004*
Normal or nearly normal	0	17	.0005*	0	19	.0005*
Lysholm score	54.3 ± 4.1	92.5 ± 5.5	.0035	55.4 ± 4.1	93.2 ± 1.2	.0012
HSS score	55.3 ± 5.1	91.7 ± 3.4	.0051	54.7 ± 5.1	93.8 ± 2.2	.0014

* Statistically significantly higher compared with preoperatively ($P < .05$).

TABLE 4. *Radiographic Comparison*

	Group 1 (n = 22)			Group 2 (n = 23)		
Kellgren-Lawrence	Preoperative	Last Follow-up	*P* Value	Preoperative	Last Follow-up	*P* Value
Grade 1	7	4	.31	7	5	.34
Grade 2	15	15	.50	16	18	.23
Grade 3	0	3*	.04†	0	0	.51
Grade 4	0	0		0	0	
Total	22	22		23	23	

* Statistically significantly higher when compared between groups ($P < .05$).
† Statistically significantly higher compared with preoperatively ($P < .05$).

Regarding clinical features of posterior horn tears, one of the notable characteristic findings compared with other meniscal tears is abrupt onset with more severe pain, and they are usually associated with only minor trauma. Our cases were consistent with those findings. Of our cases, 31 (68.9%) were caused by minor trauma such as squatting, and the other patients did not remember any specific trauma history. The mean time period from onset of pain to repair was 4.2 months (range, 0.5 to 14 months) in group 1 and 4.8 months (range, 1 to 11 months) in group 2 in our study. Most of the patients showed specific clinical appearance of posterior root tear of the medial meniscus, and we only included acute repairable complete tears. This might have affected the results of our repairs positively.

Regarding functional scores and radiographic findings, there were significant improvements in both groups compared with preoperatively ($P < .05$). The range of motion was better in group 2 (128.8°) postoperatively than in group 1 (119.1°), but there was no statistically significant difference. Subjective and objective IKDC scores, Lysholm scores, and HSS scores were significantly improved in both groups compared with preoperatively. All functional scores showed no statistically significant difference between groups ($P > .05$). In group 2 placement of the ACL guide, tibial tunneling, and screw fixation for post-tie were not necessary. By eliminating these unnecessary procedures, greater decreases in postoperative discomfort were expected.

The posterior horn of the meniscus is essential for maintaining normal circumferential hoop tension and preventing meniscal extrusion.[7,15] Loss of hoop tension due to a tear of the posterior horn of the medial meniscus causes progression of osteoarthritis similar to total meniscectomy.[4,16] On radiographic evaluation in our study, postoperative progression of the Kellgren-

TABLE 5. *Evaluation on MRI*

	Group 1 (17/22)*			Group 2 (14/23)*		
	Preoperative	Last Follow-up	*P* Value	Preoperative	Last Follow-up	*P* Value
Gap distance at the root (mm)	3.2 ± 1.1	0.5 ± 0.2	.031	2.9 ± 0.9	0.6 ± 0.2	.041
Complete structural healing		11/17			12/14	.45
Incomplete healing		6/17			2/14	.0004†
Total		17/17			14/14	
Meniscal extrusion (mm)	4.3 ± 0.9	2.1 ± 1.0	.42	4.1 ± 1.0	2.2 ± 0.8	.027‡
Complete healing group	3.9 ± 0.9	1.8 ± 0.8	.026‡	4.1 ± 0.8	1.9 ± 0.4	.021‡
Incomplete healing group	4.3 ± 0.9	3.8 ± 1.0	.72	4.4 ± 1.6	3.9 ± 1.4	.68
Cartilage degeneration						
Grade 1	1	0		0	0	.61
Grade 2	3	2		2	2	.68
Grade 3	3	7		3	4	.021†
Grade 4	0	0		0	1	.56
Total	6	9		5	8	.82
Microfracture		3			3	

* Number of patients who underwent follow-up MRI/total number of patients in each group.
† Statistically significantly higher when compared between groups ($P < .05$).
‡ Statistically significantly higher compared with preoperatively ($P < .05$).

Table 6. *Progression of Cartilage Degeneration of Medial Femoral Condyle on Follow-up MRI*

	Group 1 (17/22)		Group 2 (14/23)	
	Complete Healing	Incomplete Healing	Complete Healing	Incomplete Healing
Grade 1 to 1*	0	0	0	0
Grades 1 to 2†	0	0	0	0
Grades 1 to 3†	0	1	0	0
Grades 1 to 4†	0	0	0	0
Grades 2 to 2*	2	0	2	0
Grades 2 to 3†	0	3	0	1
Grades 2 to 4†	0	0	0	0
Grades 3 to 3*	3	0	3	0
Grades 3 to 4†	0	0	0	1
Total no. with progression*	0	4	0	2

*No progression of cartilage degeneration.
†Progression of cartilage degeneration.

Lawrence grade on simple radiographs was not statistically significant compared with preoperatively in both groups during 2 years of follow-up ($P < .05$). It is conceivable that restored hoop tension by both repair techniques was appropriate, and this could prevent progression of cartilage degeneration and osteoarthritis, but the duration of follow-up was not long enough for definite arthritic progression to have appeared on the simple radiographs (Table 4).

With regard to radiographic comparison of structural healing and cartilage degeneration, post hoc power analysis of our study showed that at least 30 cases in each group were needed to have 80% power and α of 0.05. However, our result was still statistically significant with a power of a little less than 80%.

Currently, measurement of the joint space width on radiographs is accepted as standard for diagnosing knee osteoarthritis and monitoring progression, even though MRI is still evolving.[17] The cartilage is not visible on radiographs, so it is potentially prone to diagnosing the disease relatively late in its course because of its fundamental inability to delineate cartilage directly.[18] The pathology of osteoarthritis involves changes in both the subchondral bone and articular cartilage. Late-stage detection methods such as joint space width or Kellgren-Lawrence score represent subchondral bone changes as well as cartilage thinning.[19] Even early osteoarthritis as detected by the Kellgren-Lawrence score may be the result of longstanding biochemical processes leading to both bone and cartilage alterations. Thus these may not be sufficient to identify cartilage disease. However, regardless of these limitations of the 2-dimensional nature of radiography, it was routine, simple, and inexpensive, so we intended to compare simple radiographs with MRI. Because MRI received much attention in the assessment of the articular cartilage, valuable information with regard to morphologic and possibly biochemical parameters that may be associated with the integrity of the articular cartilage could be provided. From the MRI scans, the articular cartilage can be directly visualized and quantified noninvasively. Quantitative measurements, as well as cartilage volume and thickness measurements, are now being used to monitor progression of osteoarthritis,[20,21] but in our study the quantitative measurement was not preceded by cartilage volume and thickness measurements; rather, it was graded from 0 to 4. However, we considered that this method could be used for monitoring progression of previously evaluated cartilage lesions by comparing differences.

Compared with pullout suture, arthroscopic suture anchor repair has several advantages. One is the elimination of tibial tunneling. The ACL tibial drilling guide is not easy to manipulate in the narrow medial compartment and to locate on the insertion site of the posterior horn of the meniscus, and it also requires another incision in the pretibial area. For reattachment at the accurate meniscal insertion site, repetitive drilling of the tibia may be needed, and this is not possible for small insertion areas. In addition, tibial tunneling is impossible when it is combined with ACL reconstruction. Another advantage is adequate tension control when securing knots on the posterior root of the medial meniscus, and this is a possible reason for better range of motion and a lower rate of incomplete structural healing at the root area in the suture anchor repair group. Vedi et al.[22] studied human meniscal movement using dynamic MRI. They described the mobility of the posterior horn of the medial meniscus, which allows for maximum dynamic congruity. Nha et al.[23] reported the excessive medial tibiofemoral contact pressure after placement of pullout sutures. In their study, lack of normal excursion of the medial meniscus may result in excessive strain on the sutures and proneness to failure in normal clinical situations. With the use of suture anchor, a knot pusher is used for tension control and the knot is directly attached on the repaired posterior meniscal root. However, in pullout suture repair, Ethibond suture materials were sutured through the posterior horn of the medial meniscus and withdrawn to the outside of the tibial tunnel. Because of a longer distance between the posterior root of the medial meniscus and post-tied screw, accurate tension control was more difficult to achieve and adequate pressure on the knot was not ensured.

Our study has some weaknesses. First, it was not randomized. Between the 2 repair techniques, pullout suture repair was more frequently used by the Korean Arthroscopic Society at the beginning of our study, so the study started with the pullout suture technique and then we switched to the suture anchor repair technique. During our study period, we were not certain which method would yield stronger fixation, so we did not choose the method according to needs. What we assumed during the study was that the procedure for suture anchor repair was simpler to perform and more comfortable for patients. Second, this study had a relatively short-term follow-up for evaluation of progression of osteoarthritis after meniscal repair. Third, second-look arthroscopic examination was performed for just a few cases with incomplete healing shown on the MRI studies and only if patients presented with mechanical symptoms postoperatively. Fourth, we did not include any information regarding activity level in this study. It is possible that this may skew the results of overall knee function and healing rate if there were a large number of patients.

To establish the definitive efficacy of arthroscopic suture anchor repair for posterior root tear of the medial meniscus, a prospective randomized study with a longer follow-up period is required.

CONCLUSIONS

For posterior root tear of the medial meniscus, our results show significant functional improvement in both the suture anchor repair and pullout suture repair groups. Reduction of meniscal extrusion seems to be appropriate to preserve its protective role against progression of cartilage degeneration after complete healing at the root area.

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