

Arthroscopic Repair of the Medial Meniscus Radial/Oblique Tear Prevents the Progression of Meniscal Extrusion in Mildly Osteoarthritic Knees

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Extrusion of the medial meniscus (MM) is associated with knee joint pain in osteoarthritic knees. The relationships among MM radial/oblique tears, MM extrusion (MME), and the effect of arthroscopic meniscal repair are not established. Here we evaluated the effects of arthroscopic all-inside MM repair on MME and the clinical outcomes in patients with radially oriented MM tears and mildly osteoarthritic knees. Twenty patients with a symptomatic radial or oblique tear of the MM posterior segment, $MME \geq 2.5$ mm, and mildly osteoarthritic knees were treated using FasT-Fix 360 All-inside Meniscal Suture devices. We used magnetic resonance imaging (MRI) to measure the patients' MM body width (MMBW), absolute MME, and relative MME. The Japanese Knee Injury and Osteoarthritis Outcome Score, Lysholm, Tegner, IKDC Subjective Knee Evaluation, and Visual Analogue Scale scores were obtained. Arthroscopic all-inside MM repair prevented increases of absolute and relative MME. The preoperative and 3- and 12-month MRI-based MMBW values were similar. Over a 24-month follow-up after the MM repairs, the clinical scores showed significant improvements. Our results suggest that all-inside meniscal repairs would be useful in preventing the progression of MME in patients suffering from symptomatic MM radial/oblique tears associated with mildly osteoarthritic knees.

Key words: medial meniscus, radial/oblique tear, meniscal repair, meniscal extrusion, osteoarthritic knee

Extrusion (also called subluxation, bulging, and radial/extra-articular displacement) of the human knee's medial meniscus (MM) is associated with a loss of medial compartment cartilage volume [1], medial joint space narrowing [2], the severity of osteoarthritis as reflected by radiographic Kellgren-Lawrence grade [3, 4], degenerative knee abnormalities [5], and knee joint pain [6] in patients with osteoarthritic knees. Meniscal extrusion predicts an increase in subchondral bone lesions and tibial plateau expansion in osteoarthritic knees [7]. Meniscal repair by an arthroscopic pullout technique can decrease meniscal extrusion accompanied by the MM posterior root tear and can restore cir-

cumferential hoop tension of the MM [8].

In human cadaveric knees, an inside-out repair of an MM radial tear was observed to decrease the mean contact pressure [9]. However, surgical treatments of the MM body tear involved in a rupture of the circumferential fiber, which predisposes patients to increased meniscal extrusion, have not been well documented. We conducted the present study to evaluate the effects of arthroscopic all-inside MM repair on MM extrusion (MME) and postoperative clinical outcomes in patients with radially oriented MM tears and mildly osteoarthritic knees. We hypothesized that the arthroscopic repair of radial/oblique MM tears may result in favorable postoperative clinical outcomes by preventing the

Received March 29, 2017; accepted May 24, 2017.

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Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

progression of MME in mildly osteoarthritic knees.

Patients and Methods

Patients. This study was approved our Institutional Review Board (Okayama University No. 1857), and written informed consent was obtained from all patients. Arthroscopic all-inside MM repairs were performed in patients with a symptomatic tear of the MM posterior segment and extrusion of the MM (≥ 2.5 mm). Radial and oblique (vertical flap) tears that cut the circumferential meniscal fibers were included, with the exception of root ligament tears. The other types of MM tears, lateral meniscus tears, and severe osteoarthritic knees were excluded. Between September 2013 and February 2015, 20 knees in 20 patients (8 men and 12 women; mean age 60 years, range 48-70 years) with mildly osteoarthritic knees were each treated with the use of FasT-Fix 360 All-inside Meniscal Suture devices (Smith & Nephew, Andover, MA, USA). The radiographic femorotibial angle and Kellgren-Lawrence grade were assessed preoperatively [10]. We reviewed the patients' medical records to determine the values of age, gender, height, body weight, body mass index (BMI), and arthroscopic findings of the MM and lateral meniscus. The patient demographics are summarized in Table 1.

MRI evaluation. MRI scans were performed three times (preoperatively and at 3 months and 12 months postoperatively). All MRI scans were obtained using an EXCELART Vantage MRI system powered by Atlas 1.5 T (Toshiba Medical Systems, Tochigi, Japan) with a coil. The standard sequence, slice thickness, and field of view were as described [11, 12]. The MRI-based MM body width (MMBW) and absolute MME were assessed. The MMBW was measured from the inner border to the

outer border of the MM on the coronal image that crossed the midpoint of the anteroposterior length of the MM. The absolute MME was measured from the osteophyte-excluded outer margin of the medial tibial plateau to the outer edge of the MM. We defined the relative MME ($100 \times \text{absolute MME/MMBW}$) as the percentage of absolute MME compared with the MMBW.

Surgical procedure. A standard anterolateral portal was used for arthroscopic visualization using a 30° arthroscope (Smith & Nephew). A standard anteromedial portal was used for the instruments. Radial and/or oblique tears of the MM were confirmed by arthroscopic probing from the middle to the posterior segment of the MM (Fig. 1A). Scar tissue removal was performed using a 45° diamond rasp and shaver (Smith & Nephew). Thereafter, arthroscopic MM repair was performed using the FasT-Fix 360 All-inside Meniscal Suture device through the anteromedial portal (Fig. 1B,C). A single horizontal suture or cross-suture [13] was used for the MM repair. The postoperative rehabilitation protocol was similar for all patients. All patients began knee motion exercise and partial weight bearing at 2 weeks postoperatively. Full weight-bearing was allowed 1 month postoperatively.

Clinical outcome assessment. The Japanese Knee Injury and Osteoarthritis Outcome Score (KOOS) [14], Lysholm Knee Scoring Scale, Tegner Activity Score [15], IKDC Subjective Knee Evaluation form, and a Visual Analogue Scale (VAS) were obtained from the patients preoperatively and at 3, 6, 12, and 24 months postoperatively. A mean follow-up period was 33.3 ± 7.2 months (range 24-49 months).

Statistical analysis. Data are presented as the mean \pm standard deviation (SD). We performed a repeated-measures analysis of variance (ANOVA) to

Table 1 Demographics and clinical characteristics

No. of patients (knees)	20	(20)
Age, years (range)	60	(48-70)
Gender, men/women	8/12	
Height, m (range)	1.60	(1.49-1.77)
Body weight, kg (range)	65	(41-88)
Body mass index, kg/m ² (range)	25.3	(18.5-34.2)
Femorotibial angle, ° (range)	177	(172-179)
Kellgren-Lawrence grade, knees, Grade I/II	7/13	
Medial meniscus radial tear, knees (treatment)	12	(meniscal repair)
Medial meniscus oblique tear, knees (treatment)	8	(meniscal repair)

compare differences between each value. Significance was set as $p < 0.05$. Two orthopedic surgeons (T.H. and Y.K.) independently measured the MRI-based MM values in a blinded manner. Each observer performed each measurement twice, ≥ 2 weeks apart. Two surgeons (Y.K. and Y.K.) scored the patients' clinical results in a blinded manner. We assessed the inter-observer and intra-observer reliabilities with the intra-class correlation coefficient (ICC). An ICC > 0.80 was considered to represent a reliable measurement.

Results

For the 20 patients, the average number of Fast-Fix suture devices used was 1.3 (range 1-2) for meniscal repairs of the MM radial/oblique tears. The preoperative and 3- and 12-month postoperative MRI-based MMBW measurements were similar to each other (Table 2). The absolute and relative MME values were not significantly altered after the MM repairs (Table 2). The Fast-Fix-dependent all-inside MM repairs prevented the increase of absolute and relative MME during the 12-month follow-up periods. The inter-observer and intra-observer reliabilities for the measurements

were considered satisfactory (mean ICC value > 0.93).

The arthroscopic repairs of the MM radial/oblique tears improved the Japanese KOOS subscale scores involved in pain, activities of daily living (ADLs), sport and recreation function (Sport/Rec), and knee-related quality of life (QOL) at 24 months postoperatively (Fig. 2). The patients' values on the Lysholm Knee Scoring Scale, Tegner Activity Score, IKDC Subjective Knee Evaluation, and VAS showed significant improvements at 6 months after the MM repairs (Fig. 3).

Discussion

Our findings demonstrated that all-inside meniscal repairs would be useful in preventing the postoperative progression of MME and improve clinical scores in patients suffering from symptomatic MM radial/oblique tears associated with mildly osteoarthritic knees.

The Fast-Fix all-inside meniscal repair (mean of 2.7 sutures) was shown to induce a 9% reduction in MMBW (which is also called MMBW reduction/shrinkage/shortening) of the middle and posterior torn segments [16]. However, the postoperative change in MME associated with all-inside meniscal repair has not been

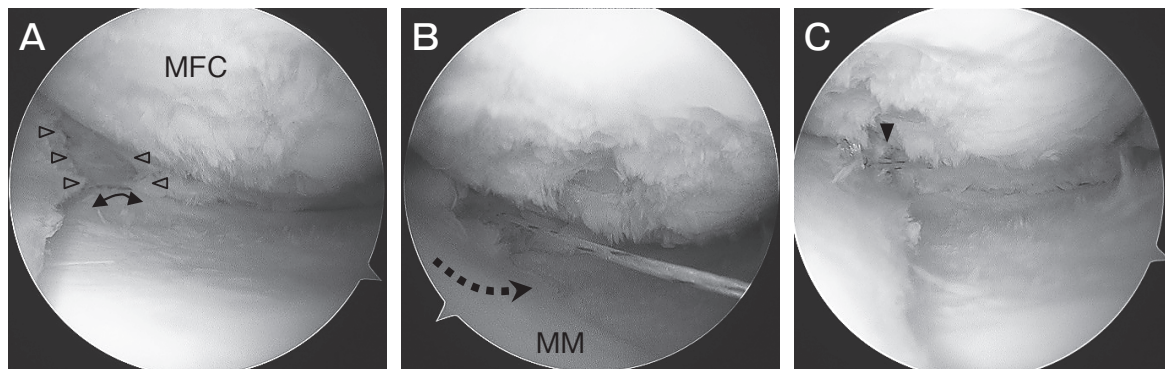


Fig. 1 Arthroscopic MM repair. (A) A full-thickness radial tear (defect) of the MM was observed (open arrowheads). The double-headed arrow denotes the gap at the mid-posterior segment of the MM. (B) Horizontal sutures that crossed over the gap were performed using the Fast-Fix 360 device. The middle segment of the MM was slightly shifted (dashed arrow). (C) Two all-inside meniscal sutures reduced the meniscal gap (arrowhead).

Table 2 Medial meniscus body width (MMBW) and medial meniscus extrusion (MME) values in the 20 knees

	Preoperative	Postoperative 3 months	Postoperative 12 months	<i>p</i> -value
MMBW (mm)	8.8 \pm 1.6	8.0 \pm 1.5	8.1 \pm 1.7	0.163
Absolute MME (mm)	3.7 \pm 1.2	3.2 \pm 1.0	3.8 \pm 1.4	0.097
Relative MME (%)	43.3 \pm 15.8	38.7 \pm 11.1	48.2 \pm 20.0	0.153

Data are mean \pm SD.

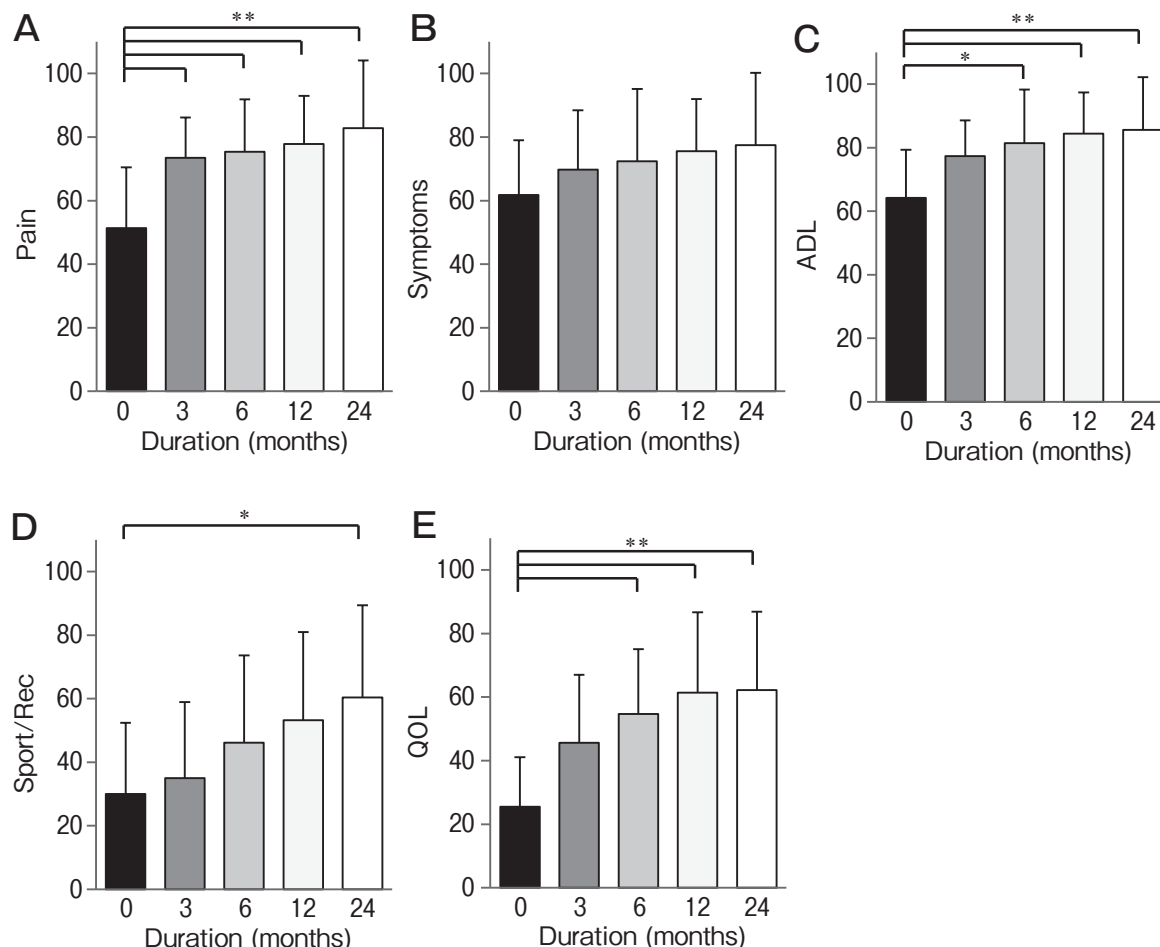


Fig. 2 Pre- and post-operative KOOS subscale scores: **A**, Pain; **B**, Symptoms; **C**, Activities of daily living (ADLs); **D**, Sport and recreation function (Sport/Rec), and **E**, Knee-related quality of life (QOL). Black bars denote preoperative scores (0 month). * $p < 0.05$. ** $p < 0.01$.

evaluated. It has also been unclear whether MMBW reduction is due to meniscal abrasion, suture tightening, or healing process-dependent shrinkage. In our present study, the MMBW, absolute MME, and relative MME were not significantly affected by the FasT-Fix-dependent MM repair (Table 2).

Several authors have reported that in meniscal repairs, the vertical suture is superior in terms of load-to-failure strength compared to the horizontal suture [17, 18]. The higher rupture load of the vertical suture seems to be caused by tighter bridging of the longitudinal meniscal tear, which may induce MMBW shrinkage. We speculate that a horizontal suture-mediated meniscal repair may restore meniscal coverage of the articular surface without reducing the MMBW. Further investigations are needed to determine the relationships

among suture orientation, the number of meniscal sutures, and the prevention of an increase in MME.

The arthroscopic meniscal centralization technique using a suture anchor centralizes the middle segment of the extruded lateral meniscus [19]. However, arthroscopic centralization for the treatment of the extruded MM body has not been reported, except for a repair of the posterior root tear of the MM [20]. Several authors have reported that absolute MME and the medial tibial plateau covered by the MM are associated with cartilage volume loss and medial joint space narrowing of the knee [1, 2]. Badlani *et al.* stated that MM tears with greater radial involvement and extrusion are at greater risk for the later development of radiographic knee osteoarthritis [21]. In asymptomatic knees of individuals at the mean age of 55 years, a slight increase (0.27

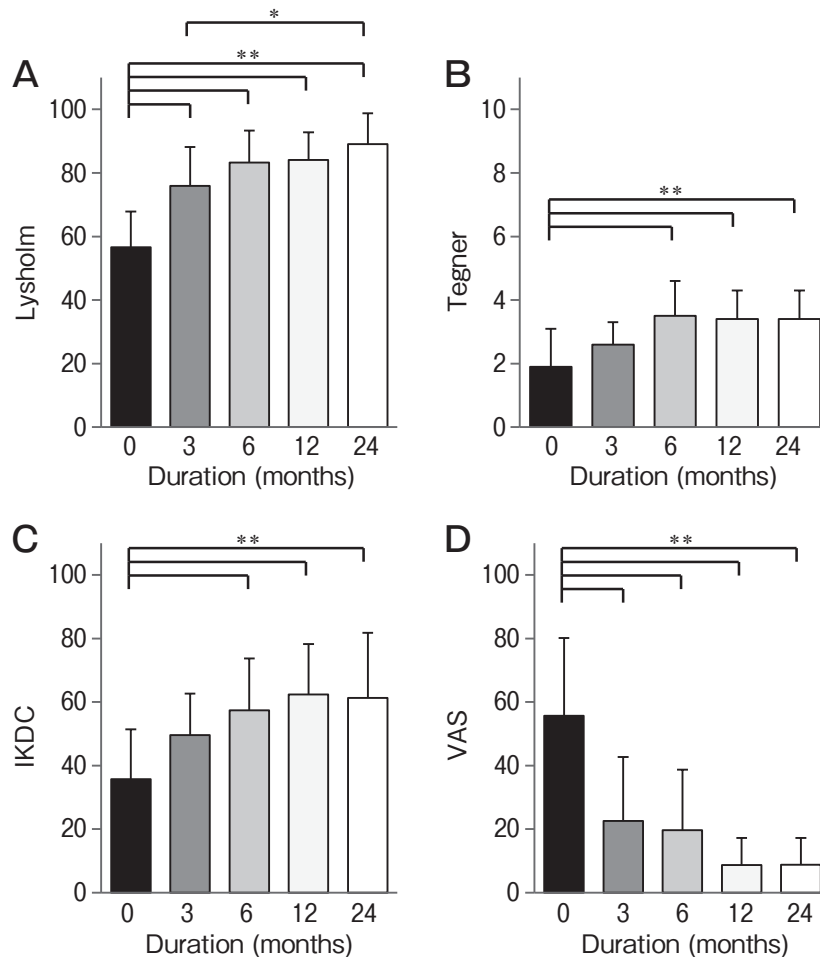


Fig. 3 Pre- and post-operative scores on the Lysholm, Tegner, IKDC, and VAS. **A**, Lysholm Knee Scoring scale; **B**, Tegner Activity Score; **C**, IKDC Subjective Knee evaluation, and **D**, VAS. Black bars denote preoperative scores (0 month). * $p < 0.05$. ** $p < 0.01$.

mm) in the MME over 4 years was reported [22]. Taken together, these past findings and our present results indicate that preventing an MMBW decrease and MME increase using an arthroscopic meniscal repair for the treatment of MM radial/oblique tears may recover the physiological function of the MM and prevent the progression of knee osteoarthritis.

There are several limitations in this study. First, the sample size was small. Further investigations with larger patient numbers are required. Second, this study was not a prospective/comparative analysis that included partial meniscectomy or conservative treatment. Further MRI examinations and clinical assessments based on longer follow-up periods are required to evaluate the effects of all-inside MM repair on the prevention of the progression of MME and degenerative knee abnormalities. The identification of these effects will also be useful in understanding whether MME precedes

or follows progressive osteoarthritic changes in the knee.

In conclusion, arthroscopic all-inside meniscal repair improved clinical scores and prevented the MME progression in 20 patients suffering from symptomatic MM radial/oblique tears associated with mildly osteoarthritic knees.

Acknowledgments. We thank Drs. Shinichi Miyazawa and Takaaki Tanaka for their cooperation. This work was supported by JSPS KAKENHI Grant No. JP16K10904.

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