Comparison of the clinical outcomes of transtibial pullout repair for medial meniscus posterior root tear: two simple stitches versus modified Mason-Allen suture

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1. Introduction

The medial meniscus (MM) posterior root plays an important role in preserving the meniscal function by serving as an anchor that regulates the meniscal movement. Medial meniscus posterior root tear (MMPRT) causes loss of hoop tension and load-sharing ability, leading to the development of degenerative osteoarthritis in the medial compartment of the knee joint. Past biomechanical studies reveal that an MMPRT has the same consequences as total meniscectomy [1]. If MMPRT remains untreated, the degenerative changes progress within a short period [2]. Therefore, accurate diagnosis and early intervention are crucial for managing MMPRT.

Several techniques have been recently developed for MMPRT repair, and pullout repair of the MMPRT has become the gold standard. A repair technique using the single FasT-Fix all-inside device (Smith & Nephew, Andover, MA) for MMPRT has been previously reported [3]. However, this technique is technically demanding and time-consuming owing to poor visibility and tight medial joint space. To resolve this problem, a new technique, the modified Mason-Allen suture technique, was developed, using the FasT-Fix all-inside suture device combined with Ultrabraid for stronger repair (FasT-Fix modified Mason-Allen technique, F-MMA) [4]. Furumatsu et al. reported that F-MMA suture configuration obtained better meniscal healing and superior clinical outcomes than single FasT-Fix repairs in patients with MMPRTs [5].

Recently, a new simple fixation technique using two simple stitches (TSS) under an expected initial tension was reported [6]. Other studies on transtibial pullout repair using TSS report that it is one of the major repair techniques of MMPRT treatment [7, 8]. The biomechanical study revealed the superiority of F-MMA in the ultimate failure load compared to TSS suture configuration using porcine models [4, 9]. On the other hand, favourable clinical outcomes and high clinical survival rate were reported using TSS technique [8, 10].

In the past, there have been no studies to compare the clinical efficacy between F-MMA and TSS technique in the pullout repair of MMPRT. It was hypothesized that the clinical outcomes of TSS were comparable to those of the F-MMA suture configuration. This study aimed to compare the clinical outcomes, including meniscal healing status at second-look arthroscopy and progression of osteoarthritic change, between the two repair techniques.

2. Materials and methods

This study obtained approval from the Institutional Review Board (approval no. 1857) and written informed consent was obtained from all patients. Sixty-eight patients (53 women and 15 men) who underwent the transtibial pullout repair between January 2016 and September 2018 were retrospectively investigated in this study. All patients were diagnosed with MMPRT based on the characteristic MRI findings [11] and met the operative indications (a femorotibial angle < 180°, Outerbridge grade I or II, and Kellgren-Lawrence grades 0–II) [12]. We excluded patients with radiographic knee osteoarthritis (OA), Kellgren-Lawrence ≥ grade III, and previous history of meniscus injury or knee surgery.

Patients were divided into two groups to compare the clinical efficacy between pullout repairs using the F-MMA (n = 41) and TSS (n = 27) techniques. From October 2016 to January 2018, 41 patients underwent transtibial pullout repair using the F-MMA technique. From February 2018 to November 2018, 27 patients underwent transtibial pullout repair using the TSS technique. Second-look arthroscopic evaluation of the meniscal healing and fixation device removal was performed in all patients one year postoperatively [12].

2.1. Surgical procedures and Postoperative rehabilitation protocols

A standard arthroscopic examination was performed using a 4-mm-diameter 30° arthroscope (Smith & Nephew) for both groups. For cases with a tight medial compartment, the outside-in pie-crusting technique of the medial collateral ligament was used.

F-MMA technique

The F-MMA technique, which is a novel suture technique, has been previously reported. A Knee Scorpion suture passer (Arthrex, Naples, FL) was used to pass a No. 2 Ultrabraid (Smith & Nephew) vertically through the meniscal tissue. The FasT-Fix 360 meniscal repair system (Smith & Nephew) was passed through the superior surface of the MM posterior horn. The first implant was inserted in the posterior horn >10 mm from the torn area. The second implant was inserted into the posterior root of the MM across the Ultrabraid in a modified Mason-Allen configuration (Figure. 1). Tibial fixation was performed using the double-spike plate and screw with the knee flexed at 45° using 20 N of initial tension.

TSS technique

A fixation technique using TSS was recently reported [6]. A Knee Scorpion suture passer was used to pass two No. 2 Ultrabraid sutures vertically through the meniscal tissue. The first suture was inserted in the outer area of the posterior root of the MM, and the second suture was inserted in the inner area of the MM posterior horn >10 mm from the torn area (Figure. 2). The first Ultrabraid was tensioned throughout an anterolateral portal during placement of the second suture for easy access. After the degree of knee flexion (20°) and the expected tension (30 N) were checked, tibial fixation was performed using a bioabsorbable interference screw with a spring tensioner.

Postoperative rehabilitation protocols

The patient was not permitted to perform weight-bearing on the knee immobilizer for 2 weeks after surgery. Knee flexion exercise was limited to 90° for the first 4 weeks. The patient was allowed full weight-bearing and 120° knee flexion after 6 weeks. Deep knee flexion was permitted 3 months postoperatively.

2.2. Clinical scores

Clinical evaluations were performed at primary surgery and during second-look arthroscopy. We evaluated the clinical outcomes using the Lysholm knee score [13], pain score; visual analogue scale (VAS) [14], International Knee Documentation Committee (IKDC) subjective knee evaluation form [15], and Japanese Knee Injury and Osteoarthritis Outcome Score (KOOS) [16]. The KOOS consists of five subscales: pain, symptoms, activities of daily living, sport, and recreation function (Sport/Rec), and knee-related quality of life (QOL). The pain intensity of the knee was assessed using a 100-mm VAS, ranging from 0 mm (no pain) to 100 mm (worst possible pain).

2.3. Arthroscopic meniscal healing scores

The healing status of the MM posterior horn or root was assessed during the second-look arthroscopy, according to the arthroscopic scoring system reported by Furumatsu et al [12]. This scoring system is composed of three evaluation criteria; (i) anteroposterior width of the bridging tissues between the MM posterior horn and root attachment (0, 2, and 4 points); (ii) stability of the repaired MM posterior root (0, 1, 2, 3, and 4 points); and (iii) synovial coverage of the sutures (0, 1, and 2 points). The total score ranges from 0 to 10 points. Two orthopaedic surgeons retrospectively evaluated the meniscal healing scores in a blinded manner. The mean of each evaluation score was determined as a value for each patient.

2.4 Evaluation of cartilage injury

Cartilage injury was independently evaluated via arthroscopy in the six compartments comprising the patella (P), trochlea (T), medial, and lateral femoral condyle (MFC and LFC), and medial and lateral tibial plateau (MTP and LTP) [17, 18]. Each compartment was evaluated according to the articular cartilage injury classification of the International Cartilage Repair Society (ICRS) [19]. The ICRS grade in each compartment was compared at primary surgery and second-look arthroscopy in both the F-MMA and TSS groups.

2.5. Statistical analysis

Statistical analyses were performed using EZR (Saitama Medical Center Jichi Medical University, Saitama, Japan). The Mann–Whitney U test was used to compare the intergroup differences and cartilage injury between primary surgery and second-look arthroscopy. Fisher's exact test was used to compare genders. Wilcoxon signed-rank tests were used to compare the differences between the preoperative and postoperative clinical outcome scores. Statistical significance was set at $p < 0.05$. To determine the number of test samples, the outcome IKDC score was used for the sample size calculation under a significance level of 0.05 and a power of 0.80. As a result, the required sample size was 27 patients in each group (difference, 10 points; standard deviation, 13 points).

3. Results

The patient demographics were similar in the two groups preoperatively (Table 1). TSS group had significantly worse preoperative Lysholm knee score, Tegner activity score, and Sport/Rec and QOL subscale of KOOS than did the F-MMA group (Table 2). All clinical scores improved significantly in both F-MMA and TSS pullout repairs (Figure 3, 4 respectively). No significant difference was seen in each clinical score between the two groups one year postoperatively (Table 3). In addition, no significant difference was seen in arthroscopic meniscal healing scores between the two groups (F-MMA; a mean of 6.1 points vs. TSS; a mean of 6.5 points, Table 3). Failure of the suture bar in FasT-Fix was observed in 14 patients from the F-MMA group. No postoperative complications caused by suture devices or re-ruptures of repaired meniscus were seen in the TSS group.

In F-MMA, the mean ICRS grade in each compartment was 1.9 in P, 2.1 in T, 2.1 in MFC, 1.9 in MTP, 1.5 in LFC, and 2.1 in LTP during primary surgery, and 2.0 in P, 2.5 in T, 2.4 in MFC, 2.1 in MTP, 1.5 in LFC, and 1.8 in LTP at second-look arthroscopy (Figure 5). In TSS, the mean ICRS grade in each compartment was 1.8 in P, 2.1 in T, 2.3 in MFC, 1.8 in MTP, 1.7 in LFC, and 2.0 in LTP during primary surgery, and 1.9 in P, 2.0 in T, 2.0 in MFC, 1.8 in MTP, 1.7 in LFC, and 1.9 in LTP at second-look arthroscopy (Figure 6). No significant change was seen in each compartment between primary and second-look arthroscopy in both groups.

4. Discussion

The most important finding in this study was that the pullout repairs using TSS and F-MMA had similar clinical outcomes and meniscal healing status in patients with MMPRTs. In addition, neither of the two techniques showed significant progression of osteoarthritic change. Thus, our hypothesis was confirmed.

Repair for MMPRT yields satisfactory clinical and radiological outcomes because it restores meniscal function and tibiofemoral joint contact mechanics [5, 7, 20]. Transtibial pullout repair for MMPRT demonstrates a high clinical survival rate and favourable clinical outcomes, and it has become one of the major surgical techniques [8, 20, 21]. There are several techniques for pullout repair of MMPRT, such as single FasT-Fix all-inside suture, F-MMA, and TSS [3, 4, 6, 8, 10]. Regardless of the many suture techniques for transtibial pullout repairs, few studies have compared the clinical outcomes between the transtibial pullout repair techniques [5]. Frumatsu et al. reported that favourable meniscal healing and good clinical outcomes were obtained using F-MMA pullout repair technique in patients with MMPRTs [5]. In that study, the Lysholm score improved significantly from 61 preoperatively to 84 at second-look arthroscopy, and it was superior to the conventional single FasT-Fix pullout repairs. On the other hand, good subjective outcomes using TSS or three simple stitches have been reported. Pullout repair using TSS showed that the Lysholm score improved significantly from 48 preoperatively to 83 at an average follow-up time of 33 months [10] Mid- and long-term follow-up study more than 5 years demonstrated that TSS or three simple stitches showed a clinical survival rate of 92% after the repair at 8 years, and the Lysholm score improved significantly from 52 preoperatively to 83 at the final follow-up [8]. In the current study, the Lysholm score improved significantly from 63.6

preoperatively to 84.7 at the final follow-up in the F-MMA group and from 55.6 to 85.6 in the TSS group. Based on these results, surgeons can choose a repair technique that is easier to perform. Besides, though TSS had some lower preoperative clinical scores than F-MMA, there was no significant difference in postoperative clinical scores, which means TSS might have improved some clinical scores more than F-MMA and might be useful in the patients who had lower preoperative clinical scores.

Though good clinical outcomes were obtained, implant induced postoperative complications, such as suture bar failure, were identified in 14 cases in the F-MMA group. These patients did not complain of the knee symptoms caused by suture bar failure, and there was no significant difference in the clinical outcomes between patients with suture bar failure and those with no complications. However, it might have a negative effect on the knee articular cartilage, for example, if it migrates into the joint contact area during longer follow-up. On the other hand, in the TSS groups, two sutures (No.2 Ultrabraid) were used for repairing MMPRT, and no postoperative complications were reported. The TSS repair technique showed lesser complications and might be safer than F-MMA.

The firm attachments of the MMPR to the tibia help to prevent hoop stress and distribute the load well during axial loading [22]. MMPRT leads to accelerated degeneration of the knee joint articular cartilage by disrupting the meniscal functions [23]. Pullout repair of MMPRT can prevent the progression of the arthritic change by increasing the tibiofemoral contact area and reducing the mean tibiofemoral contact pressure [24]. In the current study, although no significant progression of chondral damage was observed in both groups in the short postoperative period, good clinical results were seen. However, the TSS repair technique prevented the progression of the chondral damage more than the F-MMA technique (Figure 5, 6). This result may be related to the meniscal healing status at second-look arthroscopy. No significant differences in the meniscal healing score were seen between the two groups; however, better meniscal healing was observed in the TSS group than that in the F-MMA group. Better healing may reduce the MM extrusion, which is a risk for osteoarthritis progression and may retain the biomechanical articular conditions more closely to the native conditions. Therefore, no significant difference in clinical outcomes was seen between the two repair techniques. Nevertheless, attention should be paid to the appearance of the knee symptoms caused by osteoarthritis, especially in the F-MMA groups.

This study had several limitations. First, the postoperative follow-up period was short for evaluating the clinical outcomes following the pullout repair of the MMPRT. Second, this study had a non-randomised retrospective design without a pre-established protocol. Third, semi-quantitative evaluation of the healing status of the MM was not evaluated, owing to the difficulty in semi-quantitative evaluation using standard MRI. Fourth, there were significant differences in preoperative clinical scores, which might have induced some biased results. However, all patients who had undergone primary surgeries were included and allocated according to the period; thus, selection bias would be excluded. Finally, the two groups showed different knee-flexion angles and initial tension during tibial fixation (45°-20 N in F-MMA and 20°-30 N in TSS). This difference might have affected the meniscal healing status or progression of the chondral damage. Further evaluation with a larger sample size and longer follow-up will be needed to expand on our findings.

5. Conclusions

This study demonstrated that the TSS technique had similar postoperative clinical outcomes and meniscal healing status as the F-MMA technique. Besides, they prevented the significant progression of chondral damage. Both these techniques are clinically useful for the treatment of MMPRTs in a short postoperative period. Surgeons can select an easy-to-perform repair technique, but the complications of suture bars should be kept in mind when using the F-MMA technique.

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Informed consent

Informed consent was obtained from all patients for being included in this study.

Conflict of interest

The authors have no conflict of interest.

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Figure legends

Fig. 1 FasT-Fix modified Mason-Allen (F-MMA) technique. (a) Arthroscopic view of the medial meniscus (MM) posterior root tear. (b) The FasT-Fix implants are inserted in the posterior root of the MM across the Ultrabraid. (c) Arthroscopic view of the MM posterior root after fixation. MFC, medial femoral condyle; MTP, medial tibial plateau; PR, posterior root.

Fig. 2 Two simple stitches (TSS) technique. (a) Arthroscopic view of the medial meniscus (MM) posterior root tear. The first suture is inserted in the outer area of the posterior root of the MM. (b) The second suture is inserted in the inner area of the MM posterior horn. (c) Arthroscopic view of the MM posterior root after fixation. MFC, medial femoral condyle; MTP, medial tibial plateau; PR, posterior root.

Fig. 3 Clinical scores of FasT-Fix modified Mason-Allen suture (F-MMA) technique at preoperative and postoperative evaluation. The white and light grey bars denote the preoperative and postoperative scores, respectively. ADL, activities of daily living; Sport/Rec, sport and recreation function; QOL, knee-related quality of life; IKDC, International Knee Documentation Committee; VAS, visual analogue scale; ** $P < 0.01$.

Fig. 4 Clinical scores of two simple stitches (TSS) technique at preoperative and postoperative evaluation. The dark grey and black bars denote the preoperative and postoperative scores, respectively. ADL, activities of daily living; Sport/Rec, sport and recreation function; QOL, knee-related quality of life; IKDC, International Knee Documentation Committee; VAS, visual analogue scale; ** $P < 0.01$.

Fig. 5 Mean International Cartilage Repair Society classification (ICRS) grade in each compartment at primary surgery (a) and second-look arthroscopy (b) for the FasT-Fix modified Mason-Allen suture (F-MMA) group. Articular cartilage is divided into six compartments comprising the patella (P), trochlea (T), medial and lateral femoral condyle (MFC and LFC), and medial and lateral tibial plateau (MTP and LTP).

Fig. 6 Mean International Cartilage Repair Society classification (ICRS) grade in each compartment at primary surgery (a) and second-look arthroscopy (b) for the two simple stitches (TSS) group. Articular cartilage is divided into six compartments comprising the patella (P), trochlea (T), medial and lateral femoral condyle (MFC and LFC), and medial and lateral tibial plateau (MTP and LTP).

Table 1. Patient demographics

	F-MMA	TSS	P-value
Number of patients	41	27	
Gender, men/women	10/31	5/22	0.568[a]
Age, years	63.7 ± 8.7	65.4 ± 6.4	0.701
Height, m	1.6 ± 0.1	1.6 ± 0.1	0.787
Body weight, kg	65.5 ± 13.5	61.6 ± 12.1	0.298
Body mass index, kg/m^2	26.2 ± 4.0	24.9 ± 3.0	0.252
Duration from injury to pullout repair, days	88.3 ± 60.7	80.3 ± 68.1	0.138

F-MMA, FasT-Fix-dependent modified Mason-Allen. TSS, two simple stitches. Data are displayed as mean ± standard deviation. Statistical differences analysed using Mann–Whitney U-test. [a] Fisher's exact test.

Table 2. Preoperative clinical characteristics

	F-MMA	TSS	P-value
KOOS			
Pain	52.8 ± 25.5	53.6 ± 17.2	0.957
Symptoms	66.0 ± 20.5	63.4 ± 19.4	0.512
ADL	68.0 ± 20.3	60.9 ± 19.0	0.158
Sport/Rec	29.9 ± 25.8	22.4 ± 22.9	0.047*
QOL	35.1 ± 19.8	25.5 ± 16.1	0.006*
Lysholm knee score	63.6 ± 11.1	55.6 ± 7.8	0.006*
IKDC score	41.0 ± 17.8	32.7 ± 13.9	0.087
Pain score (VAS)	43.9 ± 29.5	45.7 ± 22.2	0.866

F-MMA, FasT-Fix-dependent modified Mason-Allen. TSS, two simple stitches. KOOS, Knee Injury and Osteoarthritis Outcome Score. ADL, activities of daily living. Sport/Rec, sport and recreation function. QOL, knee-related quality of life. IKDC, International Knee Documentation Committee. VAS, visual analogue scale.

Data are displayed as mean ± standard deviation. * $P < 0.05$.

Table 3. Clinical characteristics at second-look arthroscopy (1 year postoperatively).

	F-MMA	**TSS**	**P-value**
KOOS			
Pain	82.1 ± 14.3	78.9 ± 17.0	0.491
Symptoms	75.6 ± 15.2	76.8 ± 17.8	0.744
ADL	86.1 ± 11.0	82.7 ± 17.7	0.756
Sport/Rec	54.2 ± 26.9	46.0 ± 25.5	0.241
QOL	56.9 ± 21.4	58.4 ± 24.5	0.523
Lysholm knee score	84.7 ± 10.3	85.6 ± 7.9	0.967
IKDC score	63.2 ± 15.4	63.1 ± 12.3	0.964
Pain score (VAS)	11.2 ± 13.0	15.3 ± 16.8	0.201
Arthroscopic score [a]	6.1 ± 2.7	6.5± 2.1	0.221

F-MMA, FasT-Fix-dependent modified Mason-Allen. TSS, two simple stitches. KOOS, Knee Injury and Osteoarthritis Outcome Score. ADL, activities of daily living. Sport/Rec, sport and recreation function. QOL, knee-related quality of life. IKDC, International Knee Documentation Committee. VAS, visual analogue scale. Data are displayed as mean ± standard deviation. [a] Meniscal healing score at second-look arthroscopy (total, 10 points).