

Clinical outcomes following medial meniscus posterior root repairs: A minimum of 5-year follow-up study

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Abstract

Purpose: This study assessed the clinical outcomes of the FasT-Fix dependent modified Mason-Allen suture (F-MMA) and two simple stitches (TSS) on mid-term postoperative outcomes following medial meniscus (MM) posterior root repair.

Methods: Forty-three patients who underwent transtibial pullout repair for MM posterior root tear (PRT) between November 2016 and September 2018 were initially enrolled. Patients with a femorotibial angle $\leq 180^\circ$, Kellgren–Lawrence grade of 0–2, and modified Outerbridge grade I or II cartilage lesions were included. The Lysholm, Tegner activity, International Knee Documentation Committee score, pain visual analogue scale and Knee injury and Osteoarthritis Outcome scores were assessed as clinical outcomes. Conversion surgery to knee arthroplasty was considered as the endpoint. Surgeries other than second-look arthroscopy and plate or screw removal were also recorded.

Results: The mean follow-up period was 5.9 years. All evaluated 5-year postoperative clinical outcomes were significantly improved compared to the preoperative outcomes ($p < 0.001$). Both the F-MMA and TSS significantly improved all clinical scores at 5 years postoperatively in patients with MMPRT, whereas the F-MMA and TSS groups showed no significant differences in the pre- and postoperative clinical scores. None of the patients required ipsilateral knee arthroplasty during the follow-up, and the survival rate after pullout repair was 100%. However, the progression of osteoarthritis could not be completely suppressed, although there were no Kellgren–Lawrence grade 4 cases. The rate of subsequent knee-related surgical treatment was 11.6% in pullout-repaired knees, including arthroscopic debridement for arthrofibrosis with a limited range of motion, an additional all-inside suture repair and partial meniscectomy.

Conclusion: Both F-MMA and TSS pullout repairs yielded satisfactory clinical outcomes in patients with MMPRT with a mean follow-up of 5.9 years, and no conversion to knee arthroplasty was required. Further follow-up is warranted to assess long-term survival rates.

Abbreviations: ADL, activities of daily living; BMI, body mass index; F-MMA, FasT-Fix-dependent modified Mason-Allen; HTO, high tibial osteotomy; IKDC, International Knee Documentation Committee; KL, Kellgren–Lawrence; KOOS, Knee injury and Osteoarthritis Outcome Scores; MCID, minimal clinically important difference; MM, medial meniscus; OA, osteoarthritis; PASS, patient-acceptable symptomatic state; PR, posterior root; PRT, posterior root tear; QoL, quality of life; Sport/Rec, sports and recreational function; TSS, two simple stitches; VAS, visual analogue scale.

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Level of Evidence: Level III.

KEYWORDS

clinical outcome, medial meniscus posterior root tear, mid-term follow-up, survival rate, transtibial pullout repair

INTRODUCTION

Medial meniscus (MM) posterior root tear (PRT) often occurs in middle-aged women, especially with painful popping episodes while descending stairs [11, 14], leading to abnormal tibiofemoral joint biomechanics, MM posteromedial extrusion during knee flexion, and overloading of the articular cartilage due to the inability to convert axial loads into hoop stresses [2, 33–36]. Although high body mass index (BMI) and varus knee alignment are independent risk factors for this condition, MM posterior root (PR) repair is currently the recommended treatment and is preferred over conservative therapies or partial meniscectomies for MMPRTs based on biomechanical and long-term follow-up clinical studies [4–6, 22, 29, 38].

Varus knee alignment is a factor of poor short-, medium- and long-term postoperative clinical outcomes in patients with MMPRTs. A varus alignment of $>5^\circ$ is the principal risk factor for this condition [5, 13, 28, 38]. Therefore, MMPRT with moderate-to-severe varus knee deformity is typically treated with a high tibial osteotomy (HTO), either independently or in combination with MMPR repair [24–26, 30]. Recently, MMPR repair combined with HTO has been used to treat MMPRTs with moderate varus knee alignment [12, 20]. A follow-up >5 years after partial meniscectomy for MMPRT revealed that the radiological progression of osteoarthritis (OA) was more advanced in patients with a knee varus $>3^\circ$ than in those with a neutral alignment $\leq 3^\circ$ [19]. Although there are long-term reports of up to 10 years following pullout repair, these reports also include Kellgren–Lawrence (KL) grade 3 OA [6]. Regarding the configuration, the (modified) Mason–Allen suture has been reported to be superior to two simple stitches (TSS) [7]. However, clinical outcomes following MMPR repair is comparable across different suture configurations [8], and few studies have reported the mid- to long-term outcomes in patients with mild varus alignment without severe knee OA [4].

This study aimed to investigate the mid-term clinical outcomes following acute MMPR repair using the Fast-Fix-dependent modified Mason–Allen (F-MMA) suture and TSS in patients with no or mild varus knee alignment, as well as the conversion rate to arthroplasty. We hypothesised that the mid-term postoperative clinical outcomes following both F-MMA and TSS suture techniques in these selected patients would be excellent, with an extremely low incidence of conversion to arthroplasty.

MATERIALS AND METHODS

Patients

This study was approved by the Institutional Review Board (#1857). Written informed consent was obtained from all participants before their participation. The study was conducted in accordance with the principles of the Declaration of Helsinki. A total of 48 consecutive participants who underwent transtibial pullout repair for MMPRTs between November 2016 and September 2018 were initially enrolled (Figure 1).

Inclusion criteria were as follows: (1) arthroscopic transtibial pullout repair of MMPRTs; (2) participants with a femorotibial angle (FTA) $\leq 180^\circ$; (3) a KL grade of 0–2; [18] and (4) mild modified Outerbridge grade I or II cartilage lesions [37]. Patients with missing pre-operative or minimum 5-year postoperative clinical outcome data were excluded. Ultimately, 43 patients were included in this study.

Age at the time of surgery, sex, height, weight, BMI, duration from injury to surgery, FTA, and the KL grade were recorded for each patient. The injury date was defined as the date when patients reported experiencing the ‘painful posteromedial popping episode’ [3]. MMPRT types were classified based on tear morphology, as previously described for types 1–5 [23]. The meniscal healing status was evaluated by a senior orthopaedic surgeon during second-look arthroscopy 1 year after arthroscopic transtibial pullout repair [15]. The semi-quantitative scoring system was as follows: (1) anteroposterior width of the bridging tissues between the MM posterior horn and root attachment, broad/narrow/filamentous, scored as 4/2/0; (2) stability of the repaired MMPR, good/fair/loose/useless/detached, scored as 4/3/2/1/0; and (3) synovial coverage of the sutures, good/fair/poor, scored as 2/1/0.

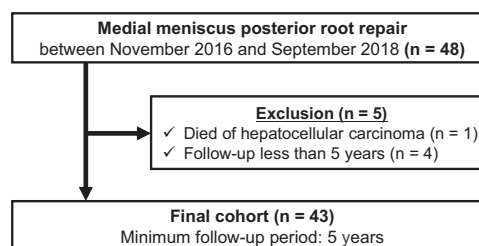


FIGURE 1 Flowchart of patient recruitment.

Meniscal healing was scored on a scale of 0–10 points [9]. An experienced Orthopaedic surgeon performed all the surgeries in this cohort.

Surgical technique and rehabilitation protocol

Patients with MMPRTs underwent arthroscopic transtibial pullout repair and postoperative rehabilitation as previously described [10, 21, 32]. Briefly, the F-MMA or TSS was used to grasp the posterior horn and root. We used a Knee Scorpion suture passer to pass No. 2 Ultrabraid sutures vertically through the meniscal tissue. For F-MMA, the FasT-Fix 360 (Smith & Nephew, London, UK) was inserted crossing over the Ultrabraid, while for TSS, only two Ultrabraid sutures were used (Figure 2). Tibial fixation of the sutures was performed using a double-spike plate (Meira, Aichi, Japan) or a bioabsorbable screw (Smith & Nephew) at 20–45° knee flexion with an initial tension of 20–30 N. Subsequently, the patients were initially kept non-weight-bearing with a knee immobiliser for 2 weeks. Between 2 and 4 weeks, knee flexion exercises gradually increased under partial weight-bearing conditions. After 5 or 6 weeks, the patients were allowed full weight-bearing and 120° of knee flexion.

Clinical outcomes

Clinical evaluations were performed at the time of arthroscopic transtibial pullout repair for MMPRT and 5 years postoperatively. The following clinical outcomes were assessed: Lysholm score (0 = worst, 100 = best), Tegner

activity score (0 = worst, 10 = best), International Knee Documentation Committee (IKDC) score (0 = worst, 100 = best), pain visual analogue scale (VAS; 0 = no pain, 100 = worst possible pain), and Knee injury and Osteoarthritis Outcome Scores (KOOS), which comprises five subscales: pain, symptoms, activities of daily living (ADL), sports and recreational function (Sport/Rec) and knee-related quality of life (QOL). In each category, 0 was the worst score and 100 was the best. Conversion to knee arthroplasty was indicated for patients with recurrent or persistent severe knee pain, which was defined as the endpoint. Surgeries other than second-look arthroscopy and plate or screw removal were also recorded.

Statistical analysis

Data are presented as mean ± standard deviation. Statistical analyses and power calculations were performed using EZR software (Saitama Medical Center, Jichi Medical University, Tochigi, Japan) [24]. Intragroup differences were compared using the Wilcoxon signed-rank test. Statistical significance was set at $p < 0.05$. Radiographic findings (KL grade) were assessed by two Orthopaedic surgeons. Interobserver reliability was assessed using ICC and was excellent (0.96).

RESULTS

At 5 years of follow-up, there were 15 cases; at 6 years, 20 cases; at 7 years, 6 cases; and at 8 years, 2 cases, with a mean follow-up of 5.9 years. Table 1 shows patient characteristics at the time of surgery. The mean

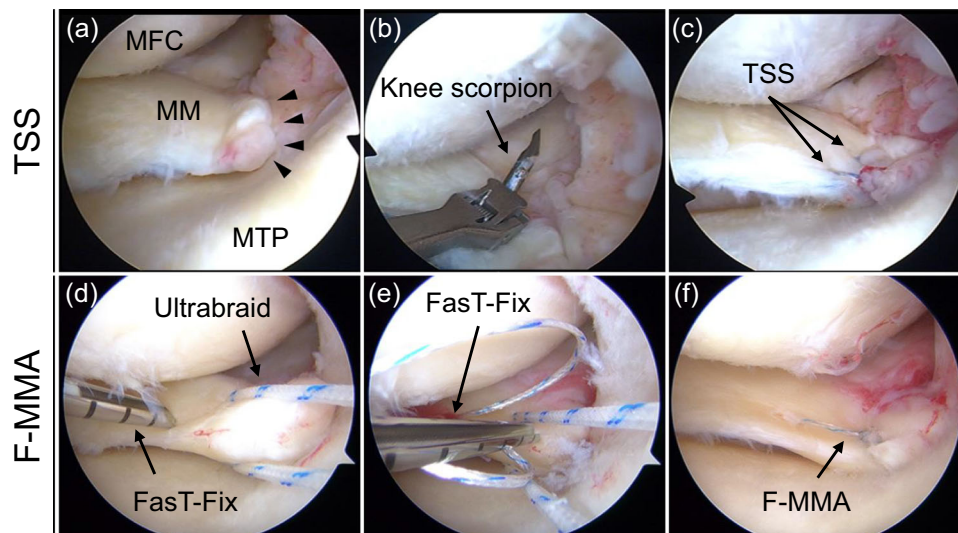


FIGURE 2 Arthroscopic findings of pullout repair for a medial meniscus posterior root tear (MMPRT) in the left knees. The repair included two simple stitches (TSS, a–c) and a FasT-Fix dependent modified Mason-Allen suture (F-MMA, d–f). (a) MMPRT was confirmed. (b) A No. 2 Ultrabraid suture was passed through the meniscal tissue using a Knee Scorpion suture passer. (c) The TSS configuration was confirmed. (d) The first anchor of the FasT-Fix was inserted into the meniscal tissue just lateral to the Ultrabraid. (e) The second anchor of the FasT-Fix was inserted into the meniscal tissue, crossing the Ultrabraid. (f) The F-MMA configuration was confirmed.

age, BMI, and FTA were 63.1 ± 7.4 year, 26.5 ± 4.1 kg/m² and $177.5 \pm 1.5^\circ$, respectively. All evaluated 5-year postoperative clinical outcomes were significantly improved compared with the preoperative outcomes ($p < 0.001$; Table 2, Figure 3), including the KOOS, IKDC, Tegner, Lysholm scores and pain VAS. Both the F-MMA and TSS significantly improved all clinical scores (Lysholm, Tegner, pain VAS, IKDC and KOOS) at 5 years postoperatively in

TABLE 1 Preoperative patient demographics.

Number of patients	43
Gender, men/women	10/33
Age (years)	63.1 ± 7.4 (46–74)
Height (m)	1.58 ± 0.09 (1.41–1.79)
Weight (kg)	66.5 ± 15.6 (48–119)
Body mass index (kg/m ²)	26.5 ± 4.1 (19.4–38.1)
Root tear classification, type 1/2/3/4/5	4/34/1/4/0
Duration from injury to surgery (days, $n = 33$)	92.1 ± 74.4 (19–276)
Duration from surgery to final follow-up (years)	5.9 ± 0.8 (5–8)
Femorotibial angle ($^\circ$)	177.5 ± 1.5 (175–180)
Kellgren–Lawrence, grade 1/2	15/28
Pullout technique, F-MMA/two simple stitches	27/16

Note: Data are presented as number or mean $\pm$ standard deviation (range).

Abbreviation: F-MMA, FasT-fix-dependent modified Mason–Allen suture.

TABLE 2 Comparison of preoperative and postoperative clinical scores following medial meniscus posterior root repair.

	Preoperative	Postoperative	p value
KOOS Pain	55.6 ± 22.0	86.9 ± 14.6	$<0.001^*$
Symptoms	66.8 ± 17.0	87.2 ± 10.1	$<0.001^*$
ADL	68.0 ± 18.3	89.9 ± 10.7	$<0.001^*$
Sport/Rec	30.0 ± 23.9	65.7 ± 29.0	$<0.001^*$
QOL	32.3 ± 16.8	72.0 ± 21.9	$<0.001^*$
IKDC score	39.4 ± 14.9	71.2 ± 17.0	$<0.001^*$
Lysholm score	61.7 ± 10.2	90.3 ± 7.2	$<0.001^*$
Tegner activity score	1.7 ± 1.0	3.3 ± 0.8	$<0.001^*$
Pain visual analogue scale	41.9 ± 25.9	8.7 ± 15.4	$<0.001^*$

Note: Data are expressed as mean $\pm$ standard deviation. Statistical differences between the preoperative and postoperative data were analysed using the Wilcoxon signed-rank test.

Abbreviations: ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, knee-related quality of life; Sport/Rec, sports and recreational function.

* $p < 0.001$.

patients with MMPRT (Table 2), whereas the F-MMA and TSS groups showed no significant differences in pre- and postoperative clinical scores.

However, the progression of OA cannot be completely suppressed. The KL grades at the final follow-up, with a mean duration of 5.9 years, were as follows: KL grade 1, 2 cases; KL grade 2, 19 cases; and KL grade 3, 22 cases. No knees showed complete disappearance of the joint space; in other words, there was no KL grade of 4. During the follow-up period, the rate of subsequent knee-related surgical treatment was 11.6% in pullout-repaired knees and 7.0% in contralateral knees. One patient sustained an anterior cruciate ligament tear in the ipsilateral knee. This case was not included in the above percentage, as conservative treatment was selected because of the patient's age (63 years) and low activity levels. Postoperative surgeries other than second-look arthroscopy and plate/screw removal included arthroscopic debridement for arthrofibrosis with a limited range of motion (one case), additional all-inside suture repair during second-look arthroscopy for poor healing (two cases), and partial meniscectomy during second-look arthroscopy for flap tears (without symptoms, two cases; Table 3). None of the 43 patients required ipsilateral knee arthroplasty during the follow-up, and the survival rate after pullout repair was 100%. Three patients required knee-related surgery on the contralateral knee: one underwent pullout repair for MMPRT, whereas the other two required unicompartmental knee arthroplasty and total knee arthroplasty because of severe osteoarthritis.

DISCUSSION

This study demonstrated that all parameters of the 5-year postoperative clinical outcomes in both the F-MMA and TSS cohorts significantly improved compared with those in the preoperative cohorts. Furthermore, there was no progression to KL grade 4 or conversion to arthroplasty in the knees treated with pullout repair. Therefore, our hypothesis is confirmed.

The results of our study are consistent with those of previous studies with mid- to long-term follow-up after MMPR pullout repair, demonstrating comparable or even superior outcomes. Krych et al. followed 47 patients (21 men and 26 women) with degenerative MMPRT nonoperatively for a mean of 14 years (range, 11–18 years) [22]. At the final follow-up, 25 patients (53%) had progressed to total knee arthroplasty, 8 patients (17%) had died, and 14 patients (30%) had not progressed to total knee arthroplasty. At a minimum 10-year follow-up, 37 of 39 living patients (95%) had failed nonoperative treatment. A short-term study also demonstrated good results, showing that the F-MMA pullout repair improved all clinical evaluation scores in 32 patients who underwent MMPR repair, with a mean follow-up of 36.1 months. The F-MMA pullout repair

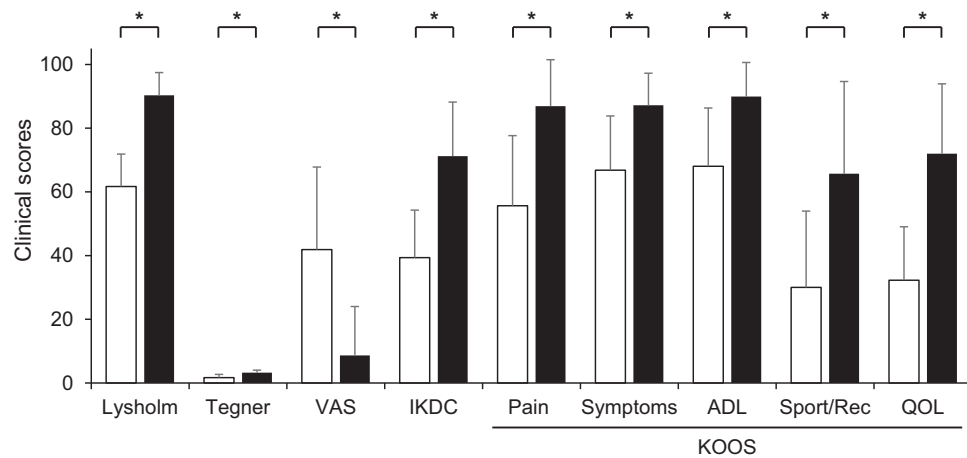


FIGURE 3 Comparison of preoperative and postoperative clinical scores. All scores significantly improved at final follow-up period (Wilcoxon signed-rank test). ADL, activities of daily living; IKDC, International Knee Documentation Committee subjective knee evaluation form; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life; Sport/Rec, sport and recreation function; VAS, pain visual analogue scale * $p < 0.001$.

TABLE 3 Postoperative knee surgeries other than second-look arthroscopy and screw/plate removal.

	Ipsilateral knee	Contralateral knee
Arthroscopic debridement (arthrofibrosis)	1	0
MM partial meniscectomy (flap tear)	2	0
MM repair (poor healing)	2	0
Transtibial pullout repair (MMPRT)	0	1
Unicompartmental knee arthroplasty	0	1
Total knee arthroplasty	0	1
Total	5 (11.6%)	3 (7.0%)

Abbreviations: MM, medial meniscus; MMPRT, medial meniscus posterior root tear.

yields satisfactory clinical outcomes [10]. The demographic data of patients in this study were slightly different from those in other studies, including differences in age (63.1 years) and BMI (26.5 kg/m²). However, the clinical outcomes of this study were comparable to those of previous studies [10, 22].

Several studies have reported survival rates using arthroplasty as an endpoint. Bernard et al. reported a survival rate of 100% in a cohort of 15 patients (10 women and 5 men) with an average age of 46.1 years and BMI 32.0, followed for 5 years [4]. Chung et al. reported a survival rate of 97.3% in a cohort of 37 patients (32 women and 5 men) with an average age of 56.8 years and BMI of 26.2, followed for 5 years, and 79.6% at 10 years [6]. In the latter study, the survival rate decreased over time, underscoring the need for

long-term follow-up of the patients included in this study. Chung et al. included patients from 2005 to 2009 [6], Krych et al. included those from 2005 to 2013 [22] and Bernard et al. from 2005 to 2016 [4]. Patients treated between 2016 and 2018 were included in this study. Between 2012 and 2015, risk factors leading to poor clinical outcomes were reported, with findings indicating that chondral lesions, such as Outerbridge grades 3 or 4 and varus alignment $>5^\circ$, were independent predictors of inferior clinical outcomes [1, 28]. Therefore, by excluding patients with these risk factors and implementing more stringent patient selection criteria, we believe that excellent clinical outcomes and 100% joint preservation rates were achieved in the present study.

The minimal clinically important difference (MCID) threshold values for each subjective score at 2 years after arthroscopic meniscal repair were reported to be 10.9, 12.3, 11.8, 11.4, 16.7 and 16.9 for the IKDC score, KOOS symptoms, pain, ADL, sport and QOL subscales, respectively [27]. In this study, at 5 years postoperatively, all clinical scores showed improvements that exceeded the MCID thresholds reported in a previous study (Table 2). The patient-acceptable symptomatic state (PASS) values for each subjective score at 2 years postoperatively in the same study were 69.0, 75.0, 80.6, 92.6, 80.0 and 56.3, for the IKDC score and KOOS symptoms, pain, ADL, sports and QOL subscales, respectively [27]. Thus, the 5-year postoperative KOOS ADL and Sport/Rec subscale scores in the present study were lower than the PASS values determined in a previous study (Table 2). It should be noted that the previous study [27] involved a much younger cohort than that in this study, with an average age of 34.0 (range, 19.5–49.5) years. Moreover, the KOOS Sport/Rec subscale includes questions

on sports activities such as jumping and running. Regarding ADL, due to cultural practices and daily activities in our region (Asia), deep knee flexion (such as in *seiza* sitting) is often required at home, which may contribute to relatively lower KOOS ADL scores.

This study had several limitations. First, this was a retrospective study conducted without blinding for the surgical techniques. Second, the sample size was relatively small and may only be applicable to Asian populations. Third, given the good clinical outcomes and high levels of satisfaction among all patients 5 years postoperatively, radiologic evaluations such as MRI examinations performed to assess joint space narrowing, progression of knee OA, and the status of the MMPR in every case would have been impractical from a healthcare economics perspective. Therefore, MRI evaluations were not performed, and MM extrusion was not assessed at the final follow-up. This omission represents a major limitation of the present study, especially given that factors such as age, BMI, healing status and alignment have been reported to correlate with MM extrusion [16, 31]. Additionally, the tibial tunnel position was not evaluated. Accurate anatomic placement of the tibial tunnel has been shown to delay the progression of medial joint space narrowing [17], highlighting another limitation of the study. Finally, the minimum 5-year postoperative follow-up period may be too short to evaluate clinical outcomes and subsequent knee-related surgical treatments following pullout repair in patients with MMPRT.

CONCLUSION

This study demonstrated that both F-MMA and TSS pullout repairs yielded satisfactory clinical outcomes in patients with MMPRT with a mean follow-up of 5.9 years, and that no conversion to knee arthroplasty was required. However, the progression of OA could not be completely suppressed, although there were no KL grade 4 cases, and subsequent knee-related surgical treatments were necessary in 11.6% of repaired knees during the follow-up period. Further follow-up is warranted to assess long-term survival rates.

AUTHOR CONTRIBUTIONS

Takayuki Furumatsu designed this study. Material preparation, data collection and analysis were performed by Kazuhisa Sugiu, Yuki Okazaki and Yusuke Kamatsuki. The first draft of the manuscript was written by Yuki Okazaki, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

ETHICS STATEMENT

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study was approved by the Ethics Committee of Okayama University (No. 1857). Written informed consent was obtained from all patients.

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