Weight loss enhances meniscal healing following transtibial pullout repair for medial meniscus posterior root tears

Abstract

Purpose: This study investigated the impact of weight change on the success of transtibial pullout repair for medial meniscus (MM) posterior root tears (MMPRTs).

Methods: The study included 129 patients diagnosed with MMPRTs who had undergone transtibial pullout repair. The patients were screened between July 2018 and November 2021. Patient-reported outcomes were assessed preoperatively and at 12 months postoperatively using the Knee injury and Osteoarthritis Outcome Score (KOOS). MM extrusion (MME) and ΔMME (postoperative MME–preoperative MME) were calculated preoperatively and at 12 months postoperatively using magnetic resonance imaging.

Results: Patients were divided into weight loss (body mass index [BMI] decrease of at least 0.5 kg/m^2 after primary repair; n=63) and weight gain (BMI increase of at least 0.5 kg/m^2; n=66) groups. Both groups had similar demographic variables and preoperative clinical scores; patient-reported outcomes significantly improved postoperatively. The weight loss group had significantly greater improvement in KOOS–quality of life (weight loss, 29.4 ± 23.7; weight gain, 23.9 ± 27.6; p=0.034), lower postoperative MME (weight loss, 3.9 ± 1.7; weight gain, 4.2 ± 1.2; p=0.043), and lower ΔMME (weight loss, 0.8 ± 0.8; weight gain, 1.2 ± 0.9; p=0.002) than the weight gain group. Total arthroscopic healing scores (weight loss, 7.6 ± 1.0; weight gain, 7.2 ± 1.5; p=0.048) and associated subscales, including anteroposterior bridging tissue width (weight loss, 4.0 ± 0.0; weight gain, 3.8 ± 0.7; p=0.004) and MM posterior root stability (weight loss, 2.6 ± 0.7; weight gain, 2.4 ± 0.7; p=0.041), significantly differed between the groups.

Conclusions: Weight loss was associated with better meniscal healing and less MME progression after MMPRT repair, highlighting the significance of weight management in individuals undergoing meniscal surgery. These findings provide valuable insights into the clinical significance of weight loss in the success of transtibial pullout repair for MMPRTs.

Level of Evidence: Level III

Keywords: weight change; transtibial pullout repair; medial meniscus posterior root tears; clinical outcomes

Introduction

The posterior root of the medial meniscus (MM) is crucial for the connection of the meniscus to the tibial plateau and plays a vital role in distributing axial loads associated with hoop stress during loading [2]. Partial or complete MM posterior root (MMPR) detachment from its attachment site on the tibia is known as an MMPR tear (MMPRT); these tears result in loss of hoop tension and functional load distribution [16]. Such an injury can be caused by trauma or degeneration, particularly in middle-aged patients during activities of daily living such as walking or descending stairs, and can lead to abnormal knee kinematics, increased contact pressure, and cartilage damage [10]. Transtibial pullout repair is the most common method for re-establishing adequate root fixation, as it can restore normal knee function and reduce the risk of degenerative changes in the knee joint [13, 17].

Despite significant improvement in clinical outcome scores following MMPRT repair, there is scope for further progress. A previous study revealed that 49% of patients with MMPRT who underwent pullout repair experienced K–L grade progression (≥1 grade) after approximately 4 years of follow-up [4]. Furthermore, according to a systemic review, 5% of these patients required conversion to total knee arthroplasty during an average follow-up period of 6.3 years [6]. Several factors have been identified as potential predictors of poor postoperative clinical outcomes following MMPRT repair, including older patient age, progressed preoperative meniscus extrusion, more severe chondral lesions, and varus lower limb alignment [5, 14]. Treatment of MMPRT repair is particularly challenging when these risk factors apply. Recent research has focused on the potential impact of body mass index (BMI) on postoperative outcomes following knee surgery [3, 30]. Overweight and obese patients may have an increased risk of complications following knee surgery; elevated BMI levels are also associated with worse clinical outcomes and increased rates of repeat surgery. Therefore, weight loss may be considered a potential modifiable risk factor for improving surgical outcomes following MMPRT repair. Addressing modifiable factors, such as body weight loss through weight management interventions, could contribute to optimizing postoperative results and enhancing the overall efficacy of MMPRT treatment.

Despite the growing interest in the role of weight loss in improving outcomes following knee surgery, data describing the impact of weight loss specifically on outcomes of transtibial pullout repair for the MMPR remain limited. To address this gap in the literature, this study aimed to investigate the impact of weight loss on the clinical outcomes following transtibial pullout repair for MMPRTs. This research is important to advance our understanding of patient outcomes, focusing not only on patient demographics and surgical techniques but also on the significance of patient-initiated modifiable factors—specifically weight management. We hypothesised that there are significant differences in meniscal healing status, medial meniscus extrusion (MME) progression, and postoperative clinical values between patients with weight loss and those with weight gain.

Materials and Methods

This retrospective study was conducted in accordance with institutional guidelines and was approved by the institutional review board of our hospital (ID number: XXXX). All patients provided written informed consent. In total, 277 patients with MMPRTs—determined based on magnetic resonance imaging (MRI) findings—were screened between July 2018 and November 2021. Indications for transtibial pullout repair of the MMPRT were as follows: continuous knee pain, femorotibial angle ≤ 180˚, and Kellgren–Lawrence grade 0–2 in the absence of subchondral insufficiency fracture and severe cartilage degeneration. The following patients were excluded: patients who did not meet the surgical indications for arthroscopic pullout repair of MMPRTs (n=31), patients with BMI changes of <0.5 kg/m^2 (n=71), patients with a history of knee surgery (n=3), and patients with unavailable postoperative clinical and MRI data (n=43). Finally, 129 patients with MMPRT with posteromedial painful popping sensation, isolated MM posterior root repair, and second-look arthroscopy were included in the analysis. The patients were then retrospectively divided into weight loss and weight gain groups, and the postoperative clinical outcomes were compared between the two groups. The weight loss group was defined as that including patients with a decrease in BMI of at least 0.5 kg/m^2 12 months after primary repair, while the weight gain group was defined as that including patients with an increase in BMI of at least 0.5 kg/m^2 12 months after primary repair [25]. All patients underwent an arthroscopic second-look evaluation of meniscal healing 1 year postoperatively.

Surgical techniques and postoperative care

A single surgeon performed each transtibial pullout repair procedure for MMPRTs and subsequent second-look arthroscopic evaluations to determine the meniscal healing status; MMPRT types were classified in detail. Different suture configurations were employed for transtibial pullout repairs performed during different time periods. Specifically, between July 2018 and July 2019, a pullout technique involving two simple stitches using no. 2 polyethylene sutures was used in 37 patients. Between August 2019 and May 2020, a technique involving two simple stitches combined with an additional posteromedial pullout repair using an all-inside meniscal repair device was used in 47 patients. Between June 2020 and November 2021, a pullout technique using two cinch stitches with no. 2 polyethylene sutures was used in 46 patients. Tibial fixation of pullout sutures was then performed using an interference screw with an initial tension of 10–30 N at 20°–30° of knee flexion. Aiming devices were used to create a tibial tunnel at the location of the root attachment for all tear types. The patients were initially kept non-weightbearing with a knee immobiliser for 2 weeks after surgery. Between 2 and 4 weeks postoperatively, knee flexion was gradually increased to 30°, 60°, and 90° under partial weight-bearing conditions (1/3, 1/2, and 2/3 of the patient's body weight). After 5 or 6 weeks, the patients were allowed full weight-bearing and 120° of knee flexion.

Patient-reported outcomes

All patients underwent clinical evaluation at the time of initial surgery and during second-look arthroscopy (mean time from initial arthroscopy, 12 months; range, 11 to 14 months for both groups). Patient-reported outcomes were obtained through pre- and postoperative clinical scores using the Japan Knee Injury and Osteoarthritis Outcome Score (KOOS), International Knee Documentation Committee (IKDC) subjective knee evaluation form, and visual analogue scale (VAS) for pain assessment. Pain intensity was rated on a 100-mm VAS, ranging from 0 (no pain) to 100 (worst pain). The postoperative change in each clinical score was calculated by subtracting the preoperative score from the postoperative score. The postoperative change in VAS scores was represented as a positive value when pain decreased and as a negative value when pain increased.

Arthroscopic meniscal healing status and scores

On second-look arthroscopy, the arthroscopic healing status of MMPRs was assessed using a scoring system previously reported in the literature [9]. This system comprised three evaluation criteria, including the anteroposterior width of the bridging tissue between the MM posterior horn and root attachment (scored as 0, 2, or 4 points), repaired MMPR stability (scored as 0–4 points), and synovial coverage of the sutured area (scored as 0–2 points). Total scores ranged from 0 to 10 points, with higher scores indicating better outcomes with respect to the evaluated criteria. Additionally, the absolute value of the anteroposterior width of the bridging tissue was measured in millimetres.

Radiographic measurement

An MRI evaluation was performed using the Achieva 1.5T system (Philips, Amsterdam, the Netherlands) with a knee coil. MRI-based measurements of MME were performed by determining the distance from the medial margin of the tibial plateau to the MM outer border, crossing the midpoint in its anteroposterior length. MME were calculated preoperatively and 12 months postoperatively using MRI. In cases where an osteophyte was present in the medial tibial plateau, the tibial margin was not determined. MME progression was defined as delta-MME (ΔMME) and calculated as the difference between the pre-and postoperative MME values. All measurements were rounded to one decimal place.

Statistical analysis

Statistical analyses were conducted using SPSS version 29.0 (IBM Corp., Armonk, NY, USA). For between-group comparisons of clinical scores, arthroscopic healing, and MME, a one-way analysis of variance (ANOVA) with Tukey's post hoc test was employed. Furthermore, Fisher's exact test was used to assess differences in the sex ratio. Values of $p < 0.05$ were considered statistically significant. The interrater reliability of the measurements was evaluated by two examiners who retrospectively assessed MME in a blinded manner. Additionally, to assess test–retest reliability, MME was re-measured after 2 weeks. Each observer measured MME twice, with a minimum interval of 2 weeks between measurements. Moreover, measurement reliability was assessed by calculating intraclass correlation coefficients (ICCs); a value of >0.80 indicated that the measurement was reliable. In this study, the statistical power of one-way ANOVA was calculated using the mean value, overall standard deviation, and sample size ratio of each group. Sample size calculations were performed to determine the minimum number of patients required to achieve 80% statistical power, with an alpha value of 0.05 for detecting postoperative ΔMME differences using a one-way ANOVA. Based on the sample size calculations, a minimum of 114 patients were required to achieve 80% statistical power with an alpha value of 0.05 for detecting postoperative ΔMME differences using one-way ANOVA; post hoc power analysis showed that the achieved power was 0.84, with an alpha value of 0.05 for ΔMME (effect size: 0.47). Interrater and test–retest reliability of MME measurements was satisfactory, with mean ICC values of 0.84 and 0.85, respectively.

Results

All demographic variables of the weight loss and weight gain groups were similar at baseline (Table 1). Furthermore, no significant between-group differences in pre- or postoperative clinical scores were observed (Figures 1, 2). However, all clinical scores improved significantly postoperatively in both groups. The present study revealed a significant difference between the two groups ($p=0.034$). This suggests that weight loss (29.4 ± 23.7) had a more pronounced influence on postoperative changes in the KOOS-QOL scores compared to that of weight gain (23.9 ± 27.6). No significant differences between the groups were observed in postoperative changes in other clinical scores (Figure 3).

A significant between-group difference was observed in the total arthroscopic healing score (weight loss, 7.6 ± 1.0; weight gain, 7.2 ± 1.5; p=0.048) and related subscales, including the anteroposterior width of bridging tissues (point) (weight loss, 4.0 ± 0.0; weight gain, 3.8 ± 0.7; p=0.004) and MMPR stability (weight loss, 2.6 ± 0.7; weight gain, 2.4 ± 0.7; p=0.041) (Table 2). Additionally, there was a significant between-group difference in postoperative MME (weight loss, 3.9 ± 1.7; weight gain, 4.2 ± 1.2; p=0.043) and ΔMME (weight loss, 0.8 ± 0.8; weight gain, 1.2 ± 0.9; p=0.002), while there were no differences in preoperative MME values between the groups (Table 3).

Discussion

The most important findings of the present study were that patients with weight loss during the postoperative period after arthroscopic MMPRT repair exhibited better meniscal healing and better prevention of MME progression than those with weight gain; therefore, our hypothesis was partially validated. This underscores the crucial role of weight management in patients undergoing meniscal repair and highlights the potential benefits of incorporating weight management interventions into postoperative care.

BMI has been recognised as a critical factor in orthopaedic surgery, including meniscal surgery. In this study, a sub-analysis using Spearman's rank correlation was performed to assess the correlation between preoperative BMI and clinical outcomes, including clinical scores, the arthroscopic healing score, and postoperative MME. No significant correlation between BMI and postoperative clinical outcomes was observed. This finding contradicts the results of previous studies and may be explained by the short-term follow-up and small sample size of the present study. Several studies have explored the impact of BMI on meniscal surgery outcomes, revealing significant differences in the BMI levels of patients with and without unfavourable clinical outcomes after undergoing pullout repair of MMPRTs [30]. For example, Brophy et al. observed that an elevated BMI is linked to worsened clinical outcomes and higher rates of subsequent surgery following MMPRT repairs [3]. Novaretti et al. also found a positive association between BMI elevation and the correction of preoperative MME in patients who underwent meniscal surgery after a minimum follow-up period of 5 years [21]. Furthermore, patients with elevated BMI experienced worsened preoperative knee pain and functioning after MM partial meniscectomy [28]. Lizaur-Utrilla et al. reported an increased odds ratio for the progression of osteoarthritis (OA) in obese patients, as measured by a change in the Kellgren–Lawrence grade both pre- and postoperatively [18]. Obese patients are also known to be at a significantly increased risk of experiencing unspecified complications in the early postoperative period [7] and high failure rates, including progression to knee arthroplasty or worsened IKDC scores after meniscectomy [15]. These findings indicate that high BMI values may be a risk factor for adverse outcomes, including worsened clinical scores, meniscal extrusion, OA progression, and increased failure rates following meniscal surgery.

The impact of BMI on meniscal surgery outcomes is well-established; however, the effect of changes in BMI following meniscal surgery remains unclear. However, several studies have examined the relationship between changes in body weight—BMI in particular—and meniscal repair outcomes. In a meta-analysis, Ahmad et al. investigated intrasubstance meniscal changes and showed that weight gain is associated with an increased risk of knee OA, which underscores the need for early detection and management [1]. Accordingly, weight loss in overweight or obese individuals may slow down the progression of cartilage degeneration [11] and reduce the risk of meniscal intrasubstance degeneration progression [12] in the knee joint. Munugoda et al. analysed data from the Intensive Diet and Exercise for Arthritis trial and found that weight loss reduced the progression of meniscal extrusion in patients with knee OA [20]. Additionally, Teichtahl et al. found that weight loss was associated with reduced knee pain and cartilage loss in community-based adults with or without meniscal tears [26]. These findings indicate that changes in body weight may significantly impact meniscal repair outcomes, which supports the findings of the current study.

This study is the first to describe the clinical impact of weight change following MMPRT repair and emphasises the importance of weight management in patients undergoing meniscal repair. The specific mechanisms by which weight changes impact meniscal or articular cartilage conditions and symptoms in the knee joint are not yet fully understood. However, it is postulated that biomechanical factors play a significant role in this process. One potential explanation for this is that a decrease in BMI reduces the mechanical load on the menisci, which can help to prevent degeneration and injury [27]. In overweight and obese older adults with knee OA, each pound of weight lost leads to a four-fold decrease in knee joint loads during activities of daily living, indicating that weight loss can significantly reduce knee joint stress [19]. Another potential mechanism for the observed findings is BMI reduction, as it may have anti-inflammatory effects that protect the menisci because weight loss decreases the production of inflammatory cytokines such as interleukin (IL)-6 and tumour necrosis factor α and increases the production of anti-inflammatory cytokines such as IL-10 in subcutaneous adipose tissue [23]. Furthermore, a study by Richette et al. demonstrated that significant weight loss in obese patients with knee OA led to improvements in systemic inflammation and cartilage turnover, potentially reducing clinical symptoms and improving meniscal integrity [24]. Overall, current evidence suggests that BMI reduction may have multiple benefits for meniscal health through both mechanical and biological pathways. However, further research is needed to identify the specific mechanisms underlying these effects and determine optimal BMI reduction strategies for preserving meniscal health. In this study, patients with weight loss during the postoperative period after arthroscopic MMPRT repair exhibited better meniscal healing and better prevention of MME progression than those with weight gain, which is consistent with previous reports. This study did not conduct a detailed evaluation of the progression of the cartilage condition. However, weight loss after MMPRT repair will have the potential to prevent OA progression, according to evidence suggesting that MME is a risk factor for the initiation and progression of OA and that prevention of MME progression and better meniscus healing are associated with prevention of OA progression [22, 29].

Limitations

This study has several limitations. First, the follow-up period after MMPRT pullout repair was relatively short, which may have limited our ability to fully evaluate clinical outcomes. Second, the study had inherent limitations because of its retrospective design. Third, the mean age of patients in this study was higher than that in other reports, which may have introduced selection bias. Fourth, different suture configurations were used during transtibial pullout repairs, which could have introduced bias. However, no significant difference in postoperative outcomes was observed in this study, consistent with previous reports [8]. Fifth, patients with no BMI change postoperatively were excluded from this study. The exclusion of these patients is a limitation, constraining a holistic understanding of its potential impact on observed distinctions. Finally, the study did not consider the potential impact of the tibial tunnel aperture, which may have influenced the clinical results.

Conclusions

In summary, this study showed that patients who underwent weight loss had better meniscal healing and less MME progression after MMPRT repair, which underscores the significance of weight management in individuals who undergo meniscal surgery. These findings provide valuable insights regarding the clinical significance of weight loss in the success of transtibial pullout repair for MMPRTs.

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Figure legends

Figure 1. Clinical scores of weight loss at preoperative and postoperative evaluation. The light blue and dark blue 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. ** $p < 0.01$.

Figure 2. Clinical scores of weight gain at preoperative and postoperative evaluation. The light orange and dark orange 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. ** $p < 0.01$.

Figure 3. Difference in postoperative changes in clinical scores. The blue bars denote the weight loss group, and orange bars denote the weight gain group. 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. * $p < 0.05$.

Table 1. Patient demographic information

	Weight loss	Weight gain	p-value
Cases (number)	63	66	
Sex (male/female)	8/55	7/59	0.788
Age (years)	64.9 ± 8.4	66.0 ± 9.2	0.250
Height (m)	1.56 ± 0.1	1.55 ± 0.1	0.944
Weight at primary repair (kg)	63.8 ± 12.1	60.3 ± 12.9	0.065
Weight at 2nd-look arthroscopy (kg)	61.4 ± 11.8	62.7 ± 13.1	0.938
Weight change (kg)	-2.4 ± 1.8	2.4 ± 1.4	< 0.001*
BMI at primary repair (kg/m^2)	26.2 ± 4.3	24.9 ± 3.9	0.429
BMI at second-look arthroscopy (kg/m^2)	25.1 ± 4.1	25.9 ± 3.9	0.332
BMI change (kg/m^2)	-1.1 ± 0.7	1.1 ± 0.5	< 0.001*
Duration from injury to operation (days)	62.5 ± 55.7	68.0 ± 59.9	0.328

Values are presented as mean ± standard deviation or numbers.

BMI body mass index, n.s. not significant

*$p < 0.05$

Table 2. Comparison of meniscal healing status at second-look arthroscopy in the weight loss and gain groups

Meniscal healing status	Weight loss	Weight gain	p-value
Arthroscopic healing score (points)	7.6 ± 1.0	7.2 ± 1.5	0.048*
• Anteroposterior width of bridging tissues (points)	4.0 ± 0.0	3.8 ± 0.7	0.004*
• Stability of the medial meniscus posterior root (points)	2.6 ± 0.7	2.4 ± 0.7	0.041*
• Synovial coverage of the sutures (points)	1.0 ± 0.5	0.9 ± 0.6	0.402
Anteroposterior width of bridging tissues (mm)	7.3 ± 1.7	6.8 ± 2.1	0.221

Values are presented as mean ± standard deviation. Arthroscopic healing score, 0–10 points; anteroposterior width of bridging tissues, 0/2/4 points; stability of the medial meniscus posterior root, 0/1/2/3/4 points; synovial coverage of the sutures, 0/1/2 points

n.s.: not significant

*$p < 0.05$

Table 3. Comparison of the MME measurements in the weight loss and gain groups

MME measurement type	**Weight loss**	**Weight gain**	**p-value**
Preoperative MME	3.1 ± 1.1	3.0 ± 1.2	0.208
Postoperative MME	3.9 ± 1.7	4.2 ± 1.2	0.043*
ΔMME	0.8 ± 0.8	1.2 ± 0.9	0.002*

Values are presented as mean ± standard deviation.

MME, Medial meniscus extrusion; n.s., not significant