Title	High body mass index is a risk factor for unfavorable clinical outcomes after medial meniscus posterior root repair in well-aligned knees
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High body mass index is a risk factor for unfavorable clinical outcomes after medial meniscus posterior root repair in well-aligned knees

ABSTRACT

***Background*:** Severe chondral lesions and varus knee alignment are associated with poor outcomes following transtibial pullout repair for medial meniscus posterior root tears and meniscus tear is strongly associated with body mass index. The prognostic factors in well-aligned knees (femorotibial angle < 180º) with mild chondral lesions are unknown. Therefore, we investigated the prognostic factors in these patients. We hypothesized that high body mass index would lead to poor clinical outcomes following pullout repair of medial meniscus posterior root tears.

***Methods*:** We retrospectively reviewed the files of 28 patients who had undergone pullout repair of medial meniscus posterior root tears between October 2016 and December 2017. We recorded the baseline characteristics (age, gender, height, weight, body mass index) and the time between injury and surgery. We recorded the International Knee Documentation Committee scores, Knee injury and Osteoarthritis Outcome Scores, and pain visual analog scale scores. Using magnetic resonance imaging preoperatively and one year after surgery, we measured the medial meniscus body width and absolute and relative medial meniscus extrusion. Pearson correlation and multivariate linear regression analysis were used to assess potential associations between these factors and clinical outcomes.

***Results*:** Age positively correlated (coefficient = 0.49, $P < 0.01$) and body mass index negatively correlated with the postoperative International Knee Documentation Committee score (coefficient = −0.64, $P < 0.01$). In multivariate linear regression analysis, body mass index was a significant factor leading to poor postoperative International Knee Documentation Committee score ($R^2 = 0.29$, $P < 0.05$).

Conclusions**:** Body mass index > 30 kg/m² is a risk factor for poor clinical outcomes following pullout repair of medial meniscus posterior root tears in well-aligned knees.

Level of evidence: III, comparative retrospective study.

1. Introduction

In the knee joint, the menisci protect the articular cartilage by cushioning the weight and absorbing shock during dynamic movement [1]. A medial meniscus posterior root tear (MMPRT) can result in the inability to transform the axial stress to hoop tension and can affect load transmission through the meniscus [2]. This leads to a biomechanical state similar to that after meniscectomy with accelerated degeneration of the articular cartilage [3, 4] after an MMPRT, medial meniscus extrusion (MME) progresses rapidly within a short time [5]. These findings suggest that early diagnosis and treatment of MMPRT are important to prevent cartilage degeneration [5-7].

Many techniques have been described for MMPRT repair. Transtibial pullout repair achieves satisfactory clinical results [8]. Successful transtibial pullout repair reduces knee pain and improves activity levels, possibly delaying the progression of knee osteoarthritis [9]. It has been reported that severe chondral lesions, varus alignment, and old age (>60 years) are risk factors for poor outcomes of MMPRT transtibial pullout repair [10] and that meniscus tear is strongly associated with body mass index (BMI) [11]. However, the risk factors affecting the outcomes in patients with mild cartilage lesions and well-aligned knees (femorotibial angle (FTA) < 180°) are less well understood.

The purpose of this study was to identify the prognostic factors for poor outcomes following MMPRT transtibial pullout repair in the well-aligned knee. Thus, we hypothesized that high BMI might represent a risk for poor clinical outcomes of MMPRT pullout repair in the well-aligned knees.

2. Patients and methods

2.1 Patients

This retrospective study was approved by our institutional review board; informed written consent was obtained from all patients. Thirty-seven patients who underwent MMPRT transtibial pullout repair between October 2016 and December 2017 at our institution were included. The inclusion criteria were: (1) early osteoarthritis; (2) FTA < 180°; (3) follow-up time ≧1 year; and (4) treatment using a modified Mason-Allen suture with the FAST-FIX™ (Smith & Nephew, London, UK) system, as described previously [12, 13]. The exclusion criteria were: (1) severe osteoarthritis; (2) FTA ≥ 180°; (3) follow-up time < 1 year; and (4) concomitant multiple ligament injuries. Two patients were excluded because of multiple ligament injuries, and seven patients were excluded because of the follow-up time of less than 1 year. Finally, 28 patients were enrolled in our study.

We recorded the baseline characteristics (age, gender, height, weight, BMI) as well as the time elapsed between injury and surgery (waiting time) for all the patients.

2.2. Clinical outcomes

We assessed the clinical outcomes by comparing the preoperative International Knee Documentation Committee (IKDC) scores, Knee injury and Osteoarthritis Outcome Scores (KOOS), Lysholm scores, Tegner activity scores, and the pain visual analog scale (VAS) scores with the respective scores at the 1-year follow-up.

2.3. Radiographic evaluation

We used a picture archiving and communication system (FUJIFILM Holdings Corporation, Tokyo, Japan) to measure the Kellgren-Lawrence grade and FTA on the preoperative anteroposterior and lateral radiographs. Magnetic resonance imaging (MRI) of the knee was performed preoperatively and at the 1-year follow-up using the Achieva 1.5 T system (Philips, Amsterdam, Netherlands) under non-weight-bearing standardized conditions, as described previously [14]. The MRI-based medial meniscus body width (MMBW) was defined as the distance from the inner boundary to the outer boundary on a line passing through the anterior and posterior midpoint of the medial meniscus on a coronal slice. The absolute medial meniscus extrusion (aMME) was measured between the most medial margin of the meniscus and the most medial aspect of the tibia. The relative MME (rMME) was calculated using the following formula: 100 × aMME / MMBW (%) [5].

The MMBW, aMME, and rMME were calculated preoperatively and at the 1-year follow-up. Two orthopedic surgeons performed each measurement twice with a 2-week interval between measurements in a blinded manner. Intra- and interobserver reliability for MMBW and MME were 0.93/0.89 and 0.92/0.88, respectively.

2.4. Statistical analysis

The data were presented as the mean ± standard deviation. Statistical analysis was performed using EZR software (Saitama Medical Center Jichi Medical University, Tochigi, Japan) [15]. The paired t-test and Mann–Whitney U test were used to compare the preoperative and 1-year postoperative values of the clinical scores. Statistical significance was set at $p < 0.05$. Pearson correlation analysis was used to compare the clinical scores with each factor. Multiple linear

regression analysis was used to analyze the potential correlations between the clinical outcomes and each factor.

3. Results

The demographic and baseline characteristics of the 28 patients are shown in Table 1. The clinical outcomes are shown in Table 2. In Table 3, postoperative MME of patients like aMME, rMME, and MMBW did not change significantly in one year. In the Pearson correlation analysis (Table 4 and Figure 1), age positively correlated with the IKDC score (coefficient = 0.49, $P < 0.01$). BMI negatively correlated with the IKDC (coefficient = -0.64, $P < 0.01$) and Lysholm (coefficient = -0.40, $P < 0.05$) scores. Age negatively correlated with the BMI (coefficient = -0.41, $P < 0.05$). The time elapsed before surgery did not significantly correlate with the IKDC or Lysholm scores. The aMME, rMME, and MMBW did not significantly correlate with the 1-year outcomes (Table 4).

In the multivariate linear regression analysis (Table 5), BMI significantly correlated with the low IKDC score ($R^2 = 0.29$, $P < 0.05$). Patients with BMI > 30 kg/m² had significantly lower postoperative IKDC scores (44.7 ± 11.3) than patients with BMI ≤ 30 kg/m² (68.9 ± 10.2, $P < 0.01$, power > 0.95). For patients with IKDC scores ≤ 50, the BMI (32.4 ± 3.9 kg/m²) was significantly higher than that for patients with IKDC scores > 50 (26.0 ± 2.9 kg/m², $P < 0.01$, power > 0.95; Figure 2).

4. Discussion

The most important finding of this study was that BMI is a significant risk factor leading to

poor clinical outcomes in well-aligned knees after MMPRT pullout repair. This confirms our hypothesis.

The contact area and pressure between the femur and the tibia in a knee with an MMPRT are similar to those in a knee after meniscectomy [16]. Transtibial pullout repair is recommended for an MMPRT because it restores the pressure, contact area, and even rotation to the pre-injury levels [2, 17]. A study reported that pullout repair prevented the development of osteoarthritis in patients during a short-term follow-up, leading to good clinical outcomes [18]. Our results also suggest that pullout repair achieves good postoperative clinical outcomes after 1 year.

Pullout repair should be performed as early as possible because of MME and cartilage injury progress rapidly after an MMPRT [14]. In the present study, we believe that the duration of the waiting time that elapsed between injury and surgery was not related to the 1-year clinical outcomes because the operations were performed as soon as possible, and MME does not progress severely over a short time-course [14].

There is a strong relationship between meniscal tears and BMI [19]. As the BMI increases, the strain and rotational stress in the knee joint also increase, resulting in high risk or high frequency of meniscus tears [19]. Moreover, high BMI shows a stronger correlation with MMPRT than with any other type of medial meniscus tears [20]. High BMI was not found to predict unfavorable clinical outcomes when patients with BMI > 30 kg/m^2 were excluded in Korean studies, where there was a comparably low mean BMI [21, 22]. Conversely, high BMI correlated with worse clinical outcomes in a North American population with a mean BMI of 34.4±7.3 kg/m^2 [23]. These findings suggest that pullout repair should be carefully considered in patients with very high BMI.

In our study, patients aged less than 60 years tended to have low IKDC scores following MMPRT pullout repair. This differs from results of previous studies where older age (> 60 years) was identified as a risk factor for poor outcomes. Older age (> 60 years) was strongly associated with radial tears of the posterior horn of the medial meniscus [24]. However, studies did not report a significant relationship between older age and clinical outcomes after meniscal root repair [9, 22, 25, 26]. A recent systematic review concluded that age a) might be related to clinical outcomes in the long, but not in the short term, and b) might be a factor related to poor clinical outcomes; however, it is not a decisive risk factor [27]. In the present study, patients with high BMI (> 30 kg/m²) tended to have MMPRT from a young age, caused by the increased load on the posterior root of the medial meniscus.

Extrusion did not correlate with the clinical outcomes when the follow-up time was short [28]. However, at the 5-year follow-up, reduced meniscus extrusion may lead to more favorable midterm outcomes after pullout fixation for MMPRTs [29]. In our study, preoperative and postoperative MME did not significantly correlate with the clinical outcomes. Our findings suggest that MME is not a prognostic factor in patients with well-aligned knees 1 year after MMPRT transtibial pullout repair.

There are several limitations to this study. First, it had a retrospective design, the follow-up period was short, the sample size was relatively small to analyze only patients younger than 60 years, and smoking status could not be analyzed because the number of smokers among patients was too small (two patients). Second, we did not consider bone morphology in the knee joint such as a posterior slope of the medial tibial plateau [30]. A long-term follow-up study in a larger population is needed to validate our findings.

5. Conclusions

High BMI (> 30 kg/m²) is a risk factor for poor clinical outcomes following MMPRT pullout repair in the well-aligned knee. Therefore, the indications for pullout repair in patients with high BMI must be carefully considered.

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Figure legends

Figure 1. Pearson correlation analysis in patients who underwent MMPRT pullout repair.

(A) Correlation between the BMI and age.

(B) Correlation between the BMI and the IKDC score.

(C) Correlation between the BMI and the Lysholm score.

Figure 2. Correlation between BMI and postoperative IKDC score in patients who underwent MMPRT pullout repair.

(A) Comparison of postoperative IKDC score between patients with BMI < 30 kg/m^2 and others.

(B) Comparison of BMI between patients with postoperative IKDC score < 50 and others.