International Journal of Research in Orthopaedics
Parhar K et al. Int J Res Orthop. 2024 Mar;10(2):409-415
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20240426

Case Series

Measuring the outcomes of medial meniscectomies with a femoral end medial collateral ligament release and reattachment in patients with a tight knee: a case series

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Received: 11 January 2024
Accepted: 16 February 2024

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ABSTRACT

Partial meniscectomies are the most commonly performed arthroscopic knee procedures, however, are complicated by the presence of a tear in the posterior medial compartment (PMC) in tandem with a "tight knee". This inhibits adequate spacing for instrumentation access, increasing the chances of causing iatrogenic cartilage damage which can progress to early onset osteoarthritis. We present a unique method for increasing the joint space, in such cases, and avoiding cartilage damage, by performing a femoral end medial collateral ligament release and reattachment (MCLR). Patient outcomes were evaluated in two parts. The first part compared the fourteen patients who underwent a MCLR pre- and post-operatively via the Lysholm and Tegner score, VAS pain scale and knee flexion angle. Finally, the MCLR patients were compared via 1:1 propensity score-matching to patients who underwent a valgus maneuver only for a PMC tear. The patients receiving an MCLR showed a statistically significant improvement ($p<0.001$) within each of the pre- and post-operative measured variables. When compared with 1:1 propensity score matched and unmatched patients, no statistically significant difference was seen between the Lysholm, Tegner and Flexion angle while VAS pain scale did show a difference. For patients requiring a PMM with a "tight knee", performing an MCLR provides a clinical and functional improvement in symptoms and showed no statistically significant difference when compared with valgus maneuver only patients. Therefore, it is an effective procedure for increasing the joint space in a patient with a tight knee that requires a partial medial meniscectomy (PMM).

Keywords: Meniscus tear, MCLR, PMM, PMC, Tight knee, Propensity score matching

INTRODUCTION

The meniscus is a fibrous cartilage that covers the majority of the articular surface of the tibial plateau.[1] With lateral and medial portions, the medial portion is more prone to injuries due to its attachment to the medial collateral ligament (MCL), which restricts its mobility.[2] The incidence of medial meniscal injuries is seen to increase with age and is higher in males.[3] Injuries to the menisci present with varying symptoms that include swelling, clicking, catching, locking, pain in the joint line, and knee buckling.[4] Treatment often begins with conservative management; however, if conservative treatment fails to relieve symptoms, a PMM can be performed.

A PMM is the most commonly performed arthroscopic procedure, estimated at 81% of all arthroscopic procedures.[5] When performing a PMM, cartilage preservation is a top priority. Cartilage tissue lacks vascularization, severely limiting its regenerative and healing capabilities. Unfortunately, iatrogenic damage to the cartilage is the most reported complication when performing a PMM.[6] An analysis of 3,714 arthroscopic procedures showed a 2% prevalence rate of iatrogenic chondral lesions.[7] The preservation and prevention of

further damage to the cartilage tissue is vital as its loss has been strongly linked to the early onset of osteoarthritis in adults. Osteoarthritis is one of the most common causes of pain and disability in middle-aged and older adults.[8-10] Therefore, avoiding any iatrogenic chondral damage is crucial for the success of this procedure.

A well-known barrier that can cause such iatrogenic chondral damage and hinder a surgeon's ability to navigate the knee joint space during a PMM properly is the location of the meniscal tear. When performing a valgus maneuver on the knee to open the joint space, posterior horn tears in the PMC of the knee can be difficult to access due to obstruction by the medial femoral condyle. Insertion of arthroscopic instruments into this challenging area has been shown to lead to many complications during surgery, resulting in increased revision rates and damage to the medial femoral condyle and healthy menisci.[11,12] These errors are exacerbated in patients with a "tight knee" where performing a valgus maneuver does not adequately open the joint space to insert the arthroscopic instruments safely. This challenge of performing a PMM in patients with a tight knee has led to the emergence of novel surgical techniques such as the percutaneous pie crusting technique.[6] These techniques release tension in the MCL that stabilizes the medial meniscus. Doing so allows for an adequate joint space to perform a PMM in areas such as the PMC safely.

We present a unique method for releasing the tension in the MCL in patients with a tight knee undergoing a PMM for a meniscus tear in the PMC by performing a femoral end MCLR. This allows adequate femorotibial joint space access to safely perform a PMM while preventing iatrogenic cartilage damage. In this study, we evaluate our approach's clinical and functional effectiveness when performing a PMM in patients who present with a tight knee and compare the outcomes via propensity score matching to patients who underwent a PMM for a PMC meniscus tear without an MCLR.

CASE SERIES

Surgical technique

When performing a PMM for a PMC tear to the medial meniscus, an assessment of the accessibility and spacing of the PMC is first conducted. This is performed intra-operatively, whereby the knee is flexed at 0 and 30 degrees, and valgus stress with external rotation is applied to the knee. The arthroscopic shaver is used as a reference to measure the joint space and a tight knee is concluded if the 4 mm shaver cannot be inserted (Figure 1). If the shaver can be comfortably inserted into the joint space, the PMM is continued normally. However, for cases that have a tight knee designation, an MCLR is performed prior to the PMM.

The MCLR is an open approach procedure, and the femoral end of the MCL is the area of interest. The procedure begins by inspecting the knee and marking the incision sites. The tourniquet tied to the lower extremity is then tightened to roughly 300 mmHg. The medial femoral epicondyle is identified, and a 2cm longitudinal incision is created over it. After electrocauterizing any bleeders, a longitudinal incision is made to the pes anserinus to access the superficial MCL (sMCL). The sMCL is partially incised as needed from the femoral end until adequate joint space is achieved (Figure 2).

This is followed by the completion of the PMM. Once the PMM repair is completed, the MCL is reattached to its native site via Arthrex 5.5 mm bio composite corkscrews. A #2 fiber wire is used to provide extra support to this reattachment. After an inspection is performed for any saphenous neurovascular injury, the pes anserinus is sutured back together, followed by the subcutaneous tissue and skin.

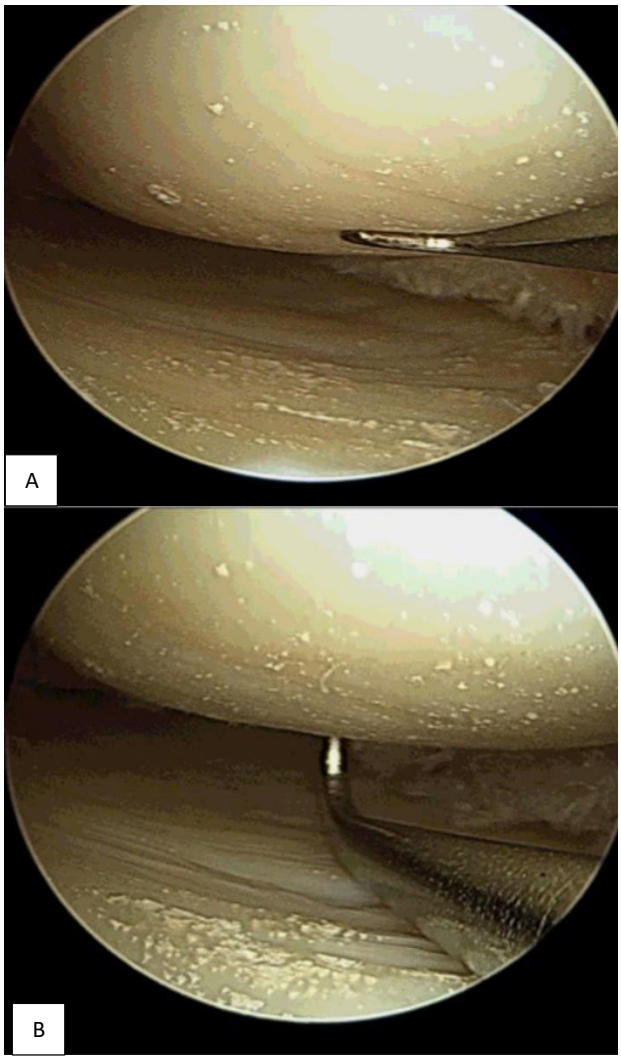

Figure 1 (A and B): Pre-operative arthroscopic images of a patient with a tight knee. These images demonstrate the limited joint space in the PMC on whom an MCLR was performed. Demonstrates the use of the arthroscopic probe as a measurement of joint space.

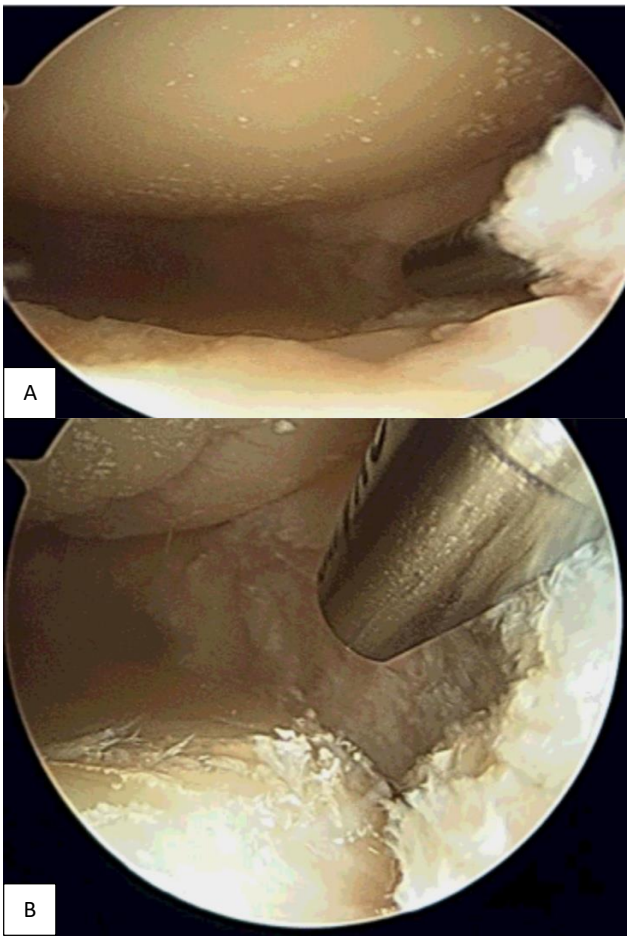

Figure 2 (A and B): Post-operative arthroscopic images of the same patient in Figure 1 after performing an MCLR. These images demonstrate the increase in joint space of the PMC.

Patient assessment

Immediately following the surgery, patients are assigned a post-operative MCLR rehabilitation protocol consisting of a knee brace locked in full extension for up to 4-6 weeks. Follow-up evaluations are then performed every four weeks for a period of three months, after which follow-up is on a case-by-case basis. After 1-month post-operative assessment, a physical therapy and weight-bearing plan is made. During each visit, knee functionality and a thorough MCL ligament assessment are conducted via: Lysholm and Tegner score, VAS pain scale, knee flexion angle and duration of follow-up and post-operative complications

To help avoid bias in the study, the patients privately filled out post-operative Lysholm and Tegner scores and the VAS pain scale questionnaires, which were then directly stored within the database.

Database search

Patient selection began with a database search from the Alpine orthopedic and spine research database (AOSRD). The AOSRD consists of patients who had surgeries done by a single surgeon between 2010 and 2022. Patients with a PMM performed were identified in the database using the following CPT codes: 29880, 29881, 29882. Patients aged from 18 to 85 years were selected. A total of 188 patients were identified (Figure 3). From these, 32 patients had a partial lateral meniscectomy (PLM) performed, and the remaining 156 had either a PMM or both a PMM and PLM. Of the 156 patients, 14 underwent an MCLR to safely perform a PMM (MCLR group), while the remaining 142 simply required a valgus maneuver of the knee to achieve adequate joint space (Valgus group). The 14 patients who underwent an MCLR were selected, and a retrospective chart review was performed. Data regarding their demographics, surgical history, past medical history, follow-ups, and assessments were recorded and stored safely in a 2-factor authenticated database.

All analyses were performed in R version 4.2.2. Two separate analyses were run in this study. The first compared the pre-operative and post-operative assessment scores between patients who underwent an MCLR. This comparison was conducted via a paired two-tailed t-test between both groups.

The second analysis compared the post-operative scores of the patients who underwent an MCLR for PMC tears to 1:1 propensity score-matched patients and unmatched patients who underwent a valgus maneuver for PMC tears. This analysis began by first matching patients in the MCLR group to patients in the valgus group. A logistical regression model was used to calculate a propensity score for each patient in both groups. When calculating the propensity score, the covariates we used are as follows: body mass index (BMI), type of tear, history of ipsilateral knee pathology, and secondary surgeries. To use age and BMI as covariates, we converted these continuous variables into categorical variables with specific cutoffs. For BMI, we used the CDC-recommended classification of BMI, and patients were grouped into underweight, normal, overweight, and obese. Many patients had an associated secondary procedure that was done along with the PMM, which was also considered when matching patients. These secondary surgeries included procedures such as chondroplasties and ligament reconstructions, categorized as cartilage or ligament surgery for the propensity score calculation. Once a score was calculated for a patient, matching was done to the closest neighboring score to create the best possible 1:1 matched group. Comparison between the post-operative measurements in both groups was done via an unpaired two-tailed t-test, with a $p<0.05$ recognized as statistically significant. The unpaired two-tailed t-test was then run between the valgus group and an unmatched group that contained all the valgus group patients.

With this, we recognize the limitation of using this model as the MCLR procedure was only done on patients who presented with a tight knee. The propensity score matching was not used in this study to deduct a causal inference

between both groups. Its use is limited to finding a matching pair in both groups with similar characteristics to create a base for comparison.

Descriptive statistics were performed on each variable. Each continuous variable was categorized into a normal distribution, and the mean ± standard deviation as well as the median (interquartile ranges) were used to describe each.

The first analysis consisted of the 14 patients that required an MCLR, consisting of seven males and seven females. The mean age of the patients in years was 52.0±23.0 (18.2-83.4). The mean BMI was 27.2±4.8 (20.5-35.1). The average number of follow-up appointments was 4±1.7 (2.0-7.0). The average follow-up duration in months was 4.5±2.7 (3.0-11.0). Twelve patients had the procedure performed on the right knee, while the other two were on the left. Six patients had a history of ipsilateral knee surgery. In addition to the primary PMM surgery, one patient underwent an ACL reconstruction, two patients also underwent a PLM, and two patients had a chondroplasty. All patients had meniscus tears in the PMC, and the tear types were as follows-bucket-handle tear: 1, horizontal tear: 1, vertical tear: 1, complex tear: 3, flap tear: 4, radial tear: 4 (Table 1). When comparing the pre-operative to the post-operative measurements, the patients showed a statistically significant improvement within each measured category. The mean values improved as follows: Tegner score improved from 1.6 to 3.7 (difference of 2.1) ($p<0.001$), Lysholm score improved from 36.3 to 69.9 (difference of 33.6) ($p<0.001$), VAS pain scale score improved from 6.7 to 3.1 (difference of 3.6) ($p<0.001$), and flexion angle improved from 112.1 to 125.7 degrees (difference of 13.6) ($p<0.001$) (Table 2). No post-operative complications were observed in any of the patients. No difference in correlation was seen when comparing the presence of ipsilateral knee pathologies to the change in pre-operative and post-operative scores within the patients.

The demographics and assessment scores of patients for the 1:1 matched valgus group and the non-matched valgus group are shown in Table 3. For the matched pair, the 3-month post-operative outcome scores were compared between the MCLR group and the valgus group. The analysis showed no statistically significant difference between the measured post-operative scores among both groups: for the Tegner ($p=0.843$), Lysholm ($p=0.107$), and flexion angle ($p=0.306$.). The VAS pain scale did show a statistically significant difference between both these groups ($p=0.026$) (Table 3). Now, for the unmatched valgus group comparison, no statistically significant difference was seen in any of the measured variables ($p>0.05$).

When comparing the follow-up duration and number of appointments of the MCLR group to both the matched and unmatched valgus group, no statistically significant difference was seen between them.

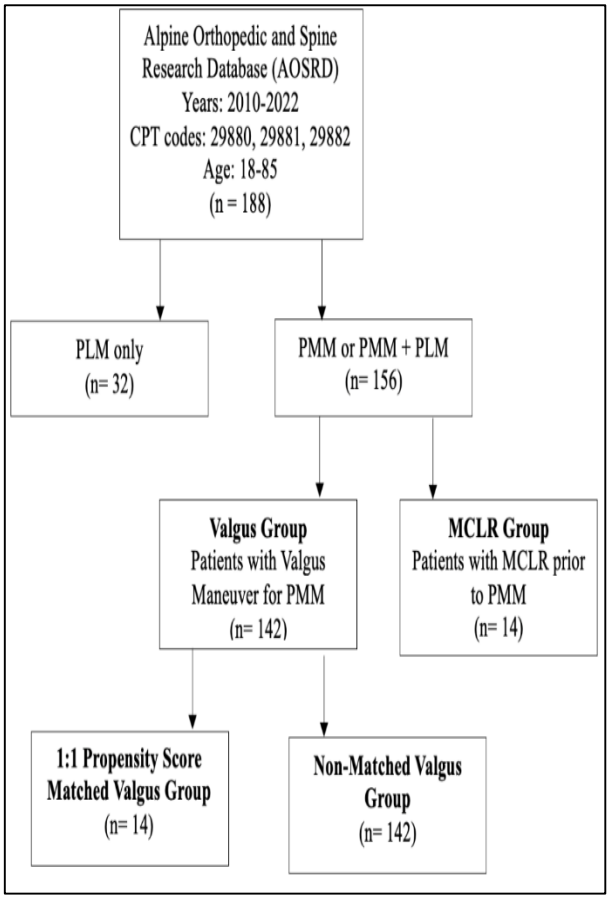

Figure 3: This figure walks over the patient selection pool for the different groups within the study. The groups of interest being the MCLR group (n=14), the 1:1 propensity score matched valgus group (n=14) and the non-matched valgus group.

Table 1: MCLR group patient demographics.

Variables	N (%)
Number of patients	14
Age (In year)	52±23
BMI (kg/m^2)	27.2±4.8
Follow-up duration	4.5±2.7
Follow up appointments	3.8±1.7
Gender	
Female	7 (50)
Male	7 (50)
Type of tear	
Radial tear	4 (28.6)
Flap tear	4 (28.6)
Horizontal tear	1 (7.1)
Vertical tear	1 (7.1)
Complex tear	3 (21.4)
Bucket handle tear	1 (7.1)
Associated procedures	
Cartilage surgery	2 (14.2)
Ligament surgery	3 (21.4)
None	9 (64.3)
Ipsilateral knee surgery history	6 (42.8)

Table 2: MCLR group pre-operative and post-operative score comparison.

Variables	Pre-op	3 months post-op	P value	95% CI
Flexion angle	112.1±4.8	125.7±4.7	0.0015	8.12, 21.48
Lysholm score	36.3±3.1	69.9±4.4	0.0000023	29.92, 46.08
Tegner score	1.6±0.8	3.7±1.8	0.00014	0.90, 2.70
VAS pain score	6.7±2.3	3.1±0.8	0.00012	2.63, 4.58

Table 3: MCLR and valgus group matched and non-matched post-operative score comparison.

Variables	MCLR group	Matched valgus group (1:1)	P value (MCLR to matched)	Non-matched valgus group	P value (MCLR to non-matched)
Number of patients	14	14		142	
Age (In year)	52±23	53±22		54±21	
BMI (kg/m^2)	27.2±4.8	26.8±5.2		28.3±5.9	
Follow-up duration	4.5±2.7	3.7±2.1	0.056	5.9±2.9	0.479
Follow up appointments	3.8±1.7	3.1±2.2	0.196	4.1±1.4	0.533
Gender					
Female	7	7		78	
Male	7	7		64	
Type of tear					
Radial tear	4	2		35	
Flap tear	4	3		20	
Horizontal tear	1	2		32	
Vertical tear	1	1		16	
Complex tear	3	3		27	
Bucket handle tear	1	3		12	
Secondary surgeries					
Cartilage surgery	2	3		48	
Ligament surgery	3	2		30	
None	9	9		64	
Ipsilateral knee surgery history	6	3		24	
Pre-operative Lysholm score	36.3±3.1	34.1±5.1			
Post-operative Lysholm score	69.9±4.4	71.7±4.9	0.107	74.4±3.6	0.155
Pre-operative Tegner score	1.6±0.8	1.8±1.1			
Post-operative Tegner score	3.7±1.8	3.6±1.5	0.843	3.7±2.9	0.997
Pre-operative VAS pain score	6.7±2.3	6.9±1.8			
Post-operative VAS pain score	3.1±0.8	2.5±1.3	0.026	2.0±1.3	0.074
Pre-operative flexion angle	112.1±4.8	110.1±4.4			
Post-operative flexion angle	125.7±4.7	124.3±4.4	0.306	125.9±4.1	0.940

DISCUSSION

PMM is the most common arthroscopic procedure performed by surgeons.[5] However, significant care must be taken to prevent iatrogenic cartilage damage during the procedure to improve surgical outcomes and avoid progression to osteoarthritis. This procedure is complicated in some patients by the presence of a tight knee, making accessing parts of the meniscus difficult and prone to injury during surgery.[11]

We, therefore, implemented a femoral end release to the MCLR to open the joint space and improve arthroscopic instrument access when performing a PMM. This allows us to safely perform a PMM in the PMC, even in patients with a tight knee.

In this technique, the proximal end of the sMCL was the area of choice for the release. This portion of the ligament is known to be the primary stabilizer of the knee and plays a vital role in providing resistance against valgus forces to the knee.[13] Furthermore, the ease of its access made it the perfect candidate. The advantage of an open approach to an MCLR is the ability to visualize internal structures. This visualization is crucial in avoiding complications related to the saphenous neurovasculature. Moreover, it allows for the proper repair of the MCL after the release.

Our study showed a statistically significant improvement in the patient outcomes following the PMM, including the femoral end approach to an MCLR. With a mean follow-up duration of 4.5 months, improvement values included an increase in flexion angle by 13.6 degrees, a Lysholm

score by 35.6 points, a Tegner score by 2.1 points, and the VAS pain scale decreased by 3.6 points. These values are comparable to the more common Percutaneous pie-crusting technique. Fakioglu et al in their study, showed a 42-point increase in the Lysholm knee score with a median follow-up of 8.3 months.[14] Similarly, Zhu et al in their Percutaneous Pie Crusting technique study, showed a 2.8-point decrease in the VAS pain scale score and a 40.9 and 1.4-point increase in the Lysholm and Tegner knee scores, respectively, after a follow-up duration of 6 months.[15] When evaluating post-operative complications after performing an MCLR, Da Silva Campos et al. stated the most reported complications to be residual knee instability/pain and saphenous neurovascular injury.[6] No such complications were seen in any of the patients in our study.

The second goal of this study was to evaluate if there was any functional difference and lasting morbidity when comparing patients who did receive an MCLR for a PMC meniscus tear to those who did not. We compared the post-operative measurements of the MCLR group to two separate groups: 1) A 1:1 propensity-score matched group who underwent a valgus maneuver to open the joint space and 2) an unmatched group with all of the selected patients for this study. The propensity scores matching algorithm allowed us to control different co-variates to get the closest possible patient pairs for comparison. The outcomes in both groups showed no statistically significant difference in all comparison areas: Tegner score, Lysholm score, VAS pain scale, and flexion angle, signifying that no significant difference was noted in healing when an MCLR was performed.

This technique of performing an MCLR does not come without its risks, the most important being the potential for long-term damage to the MCL. To mitigate this risk and support healing, a post-operative brace was considered. Currently, in the medical literature, there is conflicting evidence on the use of a post-operative brace for patients undergoing an MCLR.[14,16-18] Moreover, these studies discuss bracing after performing the percutaneous pie crusting technique, as the literature on the femoral end approach to an MCLR is scarce. To aid in this decision, the MCL injury classification system implemented by Makhmalbaf et al was used to classify the damage of our MCLR.[19] The fiber damage, diffuse tenderness, and slight instability to the MCL classified our MCLR procedure as a grade 2 injury to the MCL. A review of the management of grade 2 MCL injuries recommended the use of bracing to reduce the risk of future MCL injuries.[20] Therefore, a 4-week knee brace locked in full extension was prescribed to all the patients to ensure proper healing.

This study does not come without its limitations. Firstly, there is no objective measurement when determining the knee joint space. From our experience, using the arthroscopic probes as a measurement reference proved to be a great indicator of the extent to which the MCL required release. Second, the healing of the MCL was assessed during follow-up visits via a thorough physical exam. No pre-surgery or post-surgery MRIs were taken of the MCL to determine the extent of healing, as no case warranted its necessity. However, evaluating objective data, such as the use of MRIs, on the healing of the MCL for this approach is something that should be explored in future studies. Third, expanding the sample size would increase the power of our study. Future studies should include a more diverse population to improve the generalizability of the findings. Finally, longer follow-ups would need to be performed to evaluate the patients for potential long-term complications.

CONCLUSION

From the results of our analysis, performing a PMM using a femoral end approach MCLR showed improvement in the patient's symptoms, comparable to other methods in the literature. Moreover, no difference in clinical and functional outcomes was seen when comparing patients with and without a femoral end MCLR for a PMC meniscus tear. Therefore, performing an MCLR via an open femoral end approach is an effective procedure for increasing the joint space in a patient with a tight knee that requires a PMM in the PMC to prevent iatrogenic cartilage damage.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Parhar K, Frolov D, Tapio R, Slack K, Schmitz MA. Measuring the outcomes of medial meniscectomies with a femoral end medial collateral ligament release and reattachment in patients with a tight knee: a case series. Int J Res Orthop 2024;10:409-15.