

ORIGINAL PAPER

Open Access



# Repair of popliteomeniscal fascicles tear using a posterior transseptal portal fixes hypermobile lateral meniscus

Sohrab Keyhani<sup>1\*</sup>, Mohammad Movahedinia<sup>1</sup>, Mehran Soleymanha<sup>2</sup>, Rene Verdonk<sup>3</sup>, Morteza Kazemi<sup>1</sup> and Mohamad Qoreishy<sup>1</sup>

## Abstract

**Purpose:** This study investigates the effects of the all-inside repair of posterosuperior popliteomeniscal fascicle (PMF) on lateral meniscus stabilization using a posterior arthroscopic approach.

**Methods:** Between 2015 and 2018, 17 patients with hypermobile lateral meniscus (HLM) underwent posterior knee arthroscopy for PMF repair. The all-inside repair was performed through posteromedial transseptal and posterolateral portals using a suture hook technique. Patients were clinically assessed based on IKDC and Lysholm scores.

**Results:** Both IKDC and Lysholm scores improved significantly after an average follow-up of 3.5 years ( $P < 0.001$ ). No patients underwent reoperation, and no complications associated with posterior knee arthroscopy were reported.

**Conclusion:** The all-inside suture hook technique using posterolateral and posteromedial transseptal portals fixes HLM with excellent IKDC and Lysholm scores.

**Level of evidence:** Level IV.

**Keywords:** Hypermobile lateral meniscus, Lateral meniscus, Popliteomeniscal fascicles, Posterolateral portal, Posteromedial portal

## Background

Hypermobile lateral meniscus (HLM) occurs following the disruption of the popliteomeniscal fascicles (PMF), the most frequent cause, near the popliteal tendon [1, 2]. In the case of HLM, the posterior portion of the lateral meniscus shows forward abnormal translation with knee flexion and backward translation with knee extension, opposing its physiological motion [3].

Patients do not typically present a specific history of trauma [4, 5]. A displaced lateral meniscus can be spontaneously reduced without any obvious tears observed via

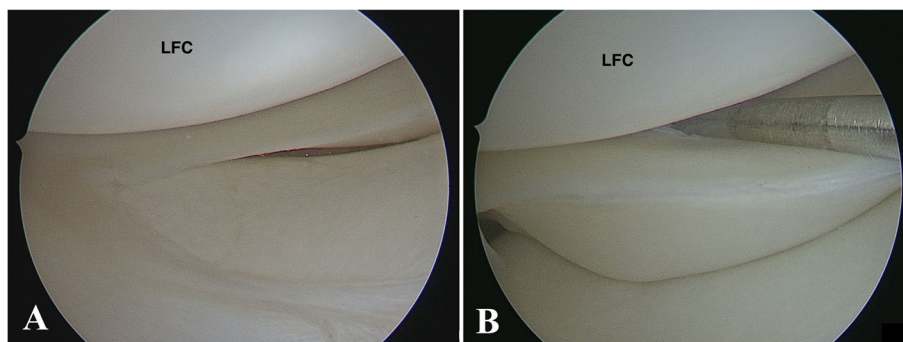
magnetic resonance imaging (MRI) [6–8]. Patients typically complain of knee locking or pain in the absence of a torn or discoid meniscus [9]. LaPrade and Konowalchuk described a clinical test that can reproduce the locking mechanism based on a figure-of-four position related to flexion, varus, and external rotation [10]. However, the gold standard for diagnosis is arthroscopic visualization of the popliteomeniscal ligaments at the popliteal hiatus, combined with an evaluation of lateral meniscal movements [11].

Surgical HLM treatment is generally recommended only for patients whose symptoms have not improved with conservative treatment [12, 13]. Different treatments have been proposed for the recurrent subluxation of the lateral meniscus, including arthroscopic subtotal meniscectomy or meniscus repair and thermal shrinkage of the posterolateral capsule [4, 10, 14, 15]. Osteoarthritic

\*Correspondence: sohrab.keyhani4@gmail.com

<sup>1</sup> Bone Joint and Related Tissues Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Sharifi manesh street, Shariati street, Tehran, Iran

Full list of author information is available at the end of the article



**Fig. 1** Right knee arthroscopy: **A** Anterolateral portal view shows normal lateral meniscus; **B** Abnormal lateral meniscal movement by probing

changes and joint locking have been reported in such treatments [12]. Current studies recommend the direct repair of the popliteomeniscal junction using different arthroscopic repair techniques [16–18].

The arthroscopic repair of the posterior horn of the lateral meniscus can be challenging because it is difficult to make an arthroscopic assessment in the anatomically narrow posterolateral compartment and because this area is anatomically complex [19, 20]. Although clinical studies have evaluated the role of arthroscopy in the treatment of recurrent lateral meniscus subluxation, the optimal techniques for HLM remains unknown [9].

An ideal treatment involves the anatomical and functional fixation of the lateral meniscus without interfering with the normal movement of the knee [21]. The purpose of this study is to evaluate the role of posterior knee arthroscopy in the all-inside repair of HLM using the suture hook technique. We hypothesized that disrupted PMF could be repaired by all-inside vertical mattress sutures using the posterior transseptal portal, thereby fixing HLM.

### Materials and methods

The indication of the surgery was defined by the experience of knee pain, locking, or snapping despite undergoing 6 months of conservative treatment. Hypermobility was confirmed when the excessive translation of the lateral meniscus was detected during arthroscopic probing. All patients presented a non-locked lateral meniscus with a popliteomeniscal tear in the posterior third portion (zone F0 according to Cooper classification) [22]. Patients with open physis, discoid, or degenerative lateral meniscus were excluded. Clinical follow-up less than 6-month, and unstable knee were the other exclusion criteria.

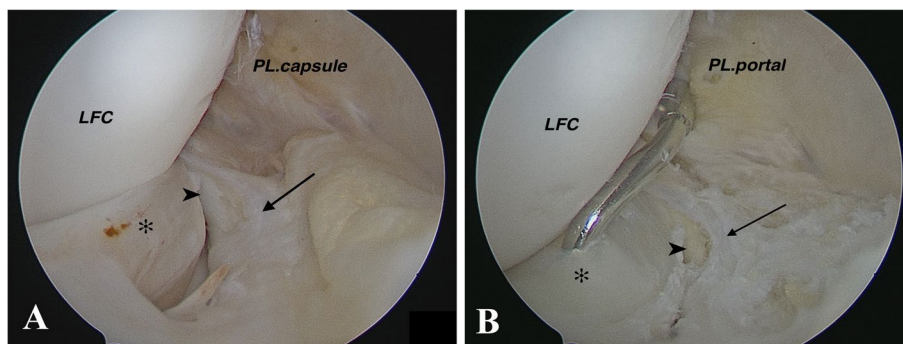
Approval was acquired from the Institutional Research Ethics Committee. Written informed consent was obtained from all patients before the study began. Pre-operative International Knee Documentation Committee

(IKDC) and Lysholm scores were obtained before treatment and again at the final follow-up.

### Surgical technique

Surgical procedures were performed with patients in the supine position and under general anesthesia. The knee was flexed 90 degrees by draping the leg over the edge of the operating table. The meniscus movement was evaluated by a probe from an anteromedial portal in a figure-of-four position. If the meniscus was unstable during probing (Fig. 1) and the trans-notch visualization confirmed the presence of a meniscal tear in the posterior zone (zone F0), fixation surgery was performed. All procedures were carried out with a 30-degree lens. Directly following Gillquist's view, the posteromedial portal was created in a soft spot area. The posteromedial and posterolateral portals were then created according to Keyhani et al.'s description (Fig. 2A) [23]. The instruments were introduced from the posterolateral portal without using a cannula.

The meniscal border and adjacent synovium were abraded to enhance the chance of healing. The all-inside method was performed using a loaded suture hook (Lasso ConMed-Linvatec, Utica, NY, USA) with a No. 1 PDS (Ethicon; Somerville, NJ, USA) according to Keyhani et al.'s description. (Fig. 2B) [24]. Then PDS was replaced with a fiber wire (no. 2) (fiber wire; Arthrex, Naples, Fla). When simultaneous penetration was impossible, a shuttle relay system was used to lift the peripheral sagging fragment. A sliding SMC knot was applied to the meniscus with the help of a knot pusher, followed by three simple knots over the sliding knot in a different direction. This vertical mattress suture was repeated every 5–10 mm as needed. The suture hook was passed from the superficial part of the lateral meniscus to the soft tissue around the popliteus tendon so that the last suture could be placed in the most lateral part of the meniscus and at the point nearest to the popliteus tendon (Fig. 3).



**Fig. 2** Right knee arthroscopy: **A** Posteromedial transseptal view with a 30-degree lens that shows popliteomeniscal fascicle tear (**B**) repair by using suture hook technique from posterolateral portal. Asterisk: Lateral meniscus; Arrow: Posterosuperior popliteomeniscal tear; Arrow head: Popliteus tendon

After meniscal fixation, the adequate stability of the meniscus was confirmed with the probe in a figure-of-four position from the anterior. Finally, a 7-mm tunnel was created in the notch area using a femoral ACL reamer to further enhance healing potential and create a condition similar to ACL reconstruction [25].

A limited-motion brace was applied after 4 weeks of using the full-extension splint. The affected knee joint was allowed a gradual range of motion to achieve at least 90 degrees of flexion over 8 weeks. Patients were encouraged to walk with crutches 2 weeks after the surgery with partial weight-bearing. Full weight-bearing was allowed 12 weeks after the operation. A return to the pre-injury status and normal sports activities was allowed after 6 months of rehabilitation.

#### Statistical analysis

SPSS software version 16 (IBM; Armonk, NY, USA) was used. The paired t-test was employed to compare the pre- and postoperative parametric variables (IKDC and Lysholm scores).  $P < 0.001$  was considered as a significant threshold.

#### Results

This study includes 17 patients—10 men and seven females—diagnosed with HLM. They were operated on between 2015 and 2018, with an average follow-up of 3.5 years (ranging from 3 to 5 years). The mean age at the time of operation was  $34 \pm 6$  years (range 18–42 years). A PMF tear was evident from MRI for three patients. For all other patients, the diagnosis was confirmed by surgery, as there was no evidence of PMF tearing from their MRI scans.

International knee documentation committee (IKDC) score increased almost 26.5 grades postoperatively, which

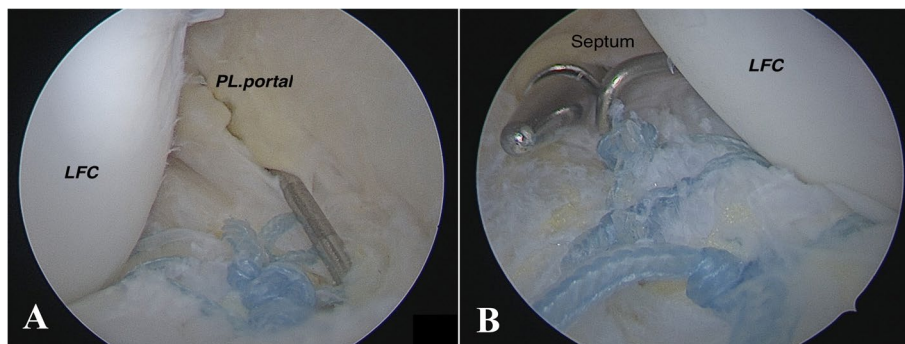
is statistically significant ( $85 \pm 3$  Vs.  $58.5 \pm 5$ ,  $P < 0.001$ ). The mean Lysholm score significantly improved by 27.5 grades at the last follow-up ( $63.5 \pm 3$  Vs.  $91 \pm 2$ ,  $P < 0.001$ ) (Fig. 4).

All patients had returned to their previous activity levels by the final follow-up. One patient suffered from sporadic pain 2 years after the surgery, which was resolved within the following year. No patients reported any recurrence of locking. Moreover, no patients underwent reoperation, and no complications associated with posterior arthroscopy were reported.

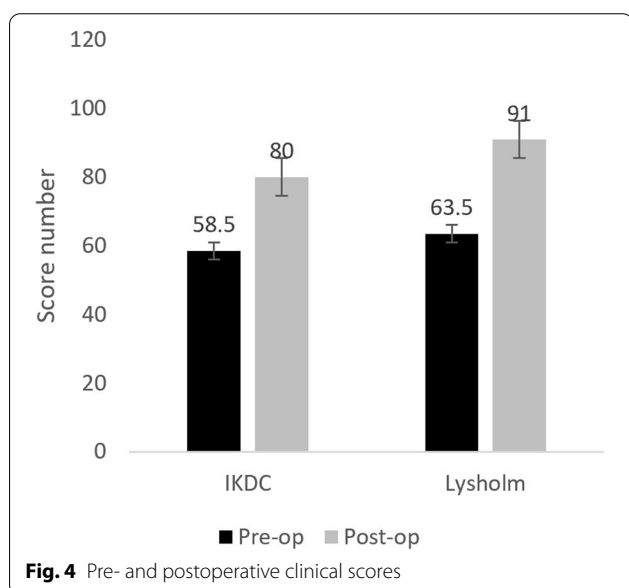
#### Discussion

This study showed that posterior knee arthroscopy facilitates the safe and effective all-inside repair of PMF tears using a suture hook technique. To the best of our knowledge, this is the first study to evaluate HLM repair using posteromedial transseptal and posterolateral portals.

The loose attachment of the lateral meniscus to the capsule is interrupted by the popliteal hiatus [9, 26]. At the popliteal hiatus, three PMFs (i.e., anteroinferior, posterosuperior, and posteroinferior) [8, 18, 27], along with the popliteus tendon, attach to the lateral meniscus [10]. These PMFs prevent the anterior displacement of the posterolateral corner of the lateral meniscus during knee flexion [28]. Disruption of the posterosuperior PMF is required to induce hypermobility in the lateral meniscus [2]. Meanwhile, the disruption of PMF in MRI is specified as the absence of continued linear structures or water-signal areas between the posterior horn of the lateral meniscus and the joint capsule [29, 30]. However, it is challenging to define PMF tears using MRI [31], meaning that high clinical suspicion is needed to ensure accurate diagnoses.



**Fig. 3** Repaired lateral meniscus: **A** Posteromedial transseptal and **B** posterolateral views



**Fig. 4** Pre- and postoperative clinical scores

The complete repair of an abnormal posterosuperior PMF could cause locking symptoms to disappear permanently [8]. Due to improvements in arthroscopic techniques, the recommended treatment for HLM is to preserve the lateral meniscus using various arthroscopic techniques [32, 33]. Inside-out and outside-in techniques have yielded favorable outcomes when the lateral meniscus tear is in the posterior position. However, such techniques are associated with a risk of injury to nerves and blood vessels. At the same time, it is difficult to achieve anatomical reductions or vertical suturing [34–37]. Non-anatomical repair of the lateral meniscus causes excessive stretching and reduced lateral meniscus mobility over time [38].

The all-inside suturing technique provides surgeons with a relatively easy way to suture vertically in posterior horn tears [39, 40]. However, some concerns

have arisen regarding complications such as implant irritation, cystic formation, and high costs [26, 36, 37, 41, 42]. In 2006 and 2017, Ahn et al. [31, 43] reported encouraging results associated with the suture hook technique for repairing HLM using the arthroscopic all-inside method through the posterolateral portal. They used 30- and 70-degree lenses sequentially. However, changing the lens during operation can waste time. Also, 70-degree lenses are costly and not available in all operating rooms.

We used only a 30-degree lens to treat cases. The anteromedial portal was used as a viewing portal following Ahn’s technique. We used the posteromedial transseptal and posterolateral portals as viewing and working portals, respectively, making our technique more convenient than Ahn’s technique. The two studies are similar in that both employed the suture hook technique to make the vertical mattress sutures as strong as possible. Like Ahn et al., we could assess the full extent of the lesion and lift the sagging to improve repair accuracy [24].

Steinbacher et al. [13] and Simonetta et al. [44] reported promising clinical results with arthroscopic all-inside lateral meniscus fixation to the posterior capsule using FasT-Fix from anterior portals in the figure-of-four position. In the present study, there is no need to apply the figure-of-four position to elevate the sagging fragment and achieve anatomic reduction. The present technique allowed the surgeon to view the posterolateral compartment easily to anatomically reduce the torn lateral meniscus with the capsule using a vertically oriented suture. Theoretically, this technique allows for strong knot tying while avoiding neurovascular damage and creating a comfortable working position for the surgeon.

The present study has some limitations. For instance, this study lacks biomechanical testing or dynamic MRI for evaluating meniscal excursion after surgery. Another major limitation of this study is the lack of a

control group—because of this, the present technique could not be compared with other techniques. Finally, because of the low incidence rate of HLM, the data presented in this study are not sufficient to conclude that the presented technique is the best choice for treating HLM.

## Conclusion

Posterior knee arthroscopy using posteromedial (trans-septal) and posterolateral portals facilitates the all-inside repair of disrupted posterosuperior PMF. The favorable clinical results presented in this study show that this repair technique effectively and sufficiently fixes HLM.

## Abbreviations

HLM: Hypermobile lateral meniscus; PMF: Popliteomeniscal Fascicles; IKDC: International knee documentation committee.

## Authors' contributions

Sohrab Keyhani designed the study and was the main surgeon of the patients. He carried out the post-operative visits and drafted the manuscript and has given final approval of the version to be published. Mohammad Movahedinia participated in its drafting and design. He revised the manuscript critically for important intellectual content. Mehran Soleymanha carried out data acquisition and analysis and interpretation of data. Rene Verdonk helped to draft the manuscript and revised the study design. Morteza Kazemi helped to design the study. Mohamad Qoreishy was participated in the post-operative visits and helped to revise the manuscript. All authors read and approved the final manuscript.

## Declarations

### Ethics approval and consent to participate

The study protocol was reviewed and approved by the local Ethics Committee.

### Consent for publication

Written informed consent was obtained from all patients before initiation of the study.

### Competing interests

All authors declared no conflict of interest.

### Author details

<sup>1</sup>Bone Joint and Related Tissues Research Center, Akhtar Orthopedic Hospital, Shahid Beheshti University of Medical Sciences, Sharifi manesh street, Shariati street, Tehran, Iran. <sup>2</sup>Guilan University of Medical Sciences, Rasht, Iran. <sup>3</sup>Department of Orthopedics and Traumatology, Gent University, Ghent, Belgium.

Received: 13 August 2021 Accepted: 1 October 2021

Published online: 21 October 2021

## References

- Garofalo R, Kombot C, Borens O, Djahangiri A, Mouhsine E (2005) Locking knee caused by subluxation of the posterior horn of the lateral meniscus. *Knee Surg Sports Traumatol Arthrosc* 13:569–571
- Simonian PT, Sussmann PS, Wickiewicz TL, Potter HG, van Trommel M, Weiland-Holland S et al (1997) Popliteomeniscal fasciculi and the unstable lateral meniscus: clinical correlation and magnetic resonance diagnosis. *Arthroscopy* 13:590–596
- Vedi V, Spouse E, Williams A, Tennant S, Hunt D, Gedroyc W (1999) Meniscal movement: an in-vivo study using dynamic MRI. *J Bone Surg Brit* 81:37–41
- Higuchi H, Kimura M, Kobayashi A, Hatayama K, Takagishi K (2004) A novel treatment of hypermobile lateral meniscus with monopolar radio-frequency energy. *Arthroscopy* 20:1–5
- Tegner Y, Lysholm J (1985) Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*:43–49
- Makdissi M, Eriksson KO, Morris HG, Young DA (2006) MRI-negative bucket-handle tears of the lateral meniscus in athletes: a case series. *Knee Surg Sports Traumatol Arthrosc* 14:1012–1016
- Sakai H, Sasho T, Yi W, Sano S, Ji I, Morita F et al (2006) MRI of the popliteomeniscal fasciculi. *Am J Roentgenol* 186:460–466
- Suganuma J, Mochizuki R, Inoue Y, Yamabe E, Ueda Y, Kanauchi T (2012) Magnetic resonance imaging and arthroscopic findings of the popliteomeniscal fascicles with and without recurrent subluxation of the lateral meniscus. *Arthroscopy* 28:507–516
- Van Steyn MO, Mariscalco MW, Pedroza AD, Smerek J, Kaeding CC, Flanigan DC (2016) The hypermobile lateral meniscus: a retrospective review of presentation, imaging, treatment, and results. *Knee Surg Sports Traumatol Arthrosc* 24:1555–1559
- LaPrade RF, Konowalchuk BK (2005) Popliteomeniscal fascicle tears causing symptomatic lateral compartment knee pain: diagnosis by the figure-4 test and treatment by open repair. *Am J Sports Med* 33:1231–1236
- Sta H-U, Birrer S (1990) The popliteus tendon and its fascicles at the popliteal hiatus: gross anatomy and functional arthroscopic evaluation with and without anterior cruciate ligament deficiency. *Arthroscopy* 6:209–220
- Ohtoshi K, Kimura M, Kobayashi Y, Higuchi H, Kikuchi S (2004) Arthroscopic thermal shrinkage for hypermobile lateral meniscus. *Am J Sports Med* 32:1297–1301
- Steinbacher G, Alentorn-Geli E, Alvarado-Calderón M, Barastegui D, Álvarez-Díaz P, Cugat R (2019) Meniscal fixation is a successful treatment for hypermobile lateral meniscus in soccer players. *Knee Surg Sports Traumatol Arthrosc* 27:354–360
- George M, Wall EJ (2003) Locked knee caused by meniscal subluxation: magnetic resonance imaging and arthroscopic verification. *Arthroscopy* 19:885–888
- Kimura M, Shirakura K, Hasegawa A, Kobayashi Y, Udagawa E (1992) Anatomy and pathophysiology of the popliteal tendon area in the lateral meniscus: 1. Arthroscopic and anatomical investigation. *Arthroscopy* 8:419–423
- Ahn JH, Kim K-I, Wang JH, Kyung BS, Seo MC, Lee SH (2015) Arthroscopic repair of bucket-handle tears of the lateral meniscus. *Knee Surg Sports Traumatol Arthrosc* 23:205–210
- D'Addona A, Izzo A, Di Vico G, Rosa D, Maffulli N (2021) The popliteomeniscal fascicles: from diagnosis to surgical repair: a systematic review of current literature. *J Orthop Surg Res* 16:1–9
- Park J-H, Ro K-H, Lee D-H (2012) Snapping knee caused by a popliteomeniscal fascicle tear of the lateral meniscus in a professional taekwondo athlete. *Orthopedics* 35:e1104–e1107
- Austin KS, Sherman OH (1993) Complications of arthroscopic meniscal repair. *Am J Sports Med* 21:864–869
- Small NC (1988) Complications in arthroscopic surgery performed by experienced arthroscopists. *Arthroscopy* 4:215–221
- Thompson WO, Thaete FL, Fu FH, Dye SF (1991) Tibial meniscal dynamics using three-dimensional reconstruction of magnetic resonance images. *Am J Sports Med* 19:210–216
- Cooper DE, Arnoczky SP, Warren RF (1990) Arthroscopic meniscal repair. *Clin Sports Med* 9:589–607
- Keyhani S, Ahn JH, Verdonk R, Soleymanha M, Abbasian M (2017) Arthroscopic all-inside ramp lesion repair using the posterolateral transseptal portal view. *Knee Surg Sports Traumatol Arthrosc* 25:454–458
- Keyhani S, Soleymanha M, Verdonk R, Amouzadeh F, Movahedinia M, Kazemi SM (2021) Posterior knee arthroscopy facilitates the safe and effective all-inside repair of locked bucket-handle medial meniscal tear using a suture hook technique. *Knee Surg Sports Traumatol Arthrosc* 19:1–5
- Woodmass JM, LaPrade RF, Sgaglione NA, Nakamura N, Krych AJ (2017) Meniscal repair: reconsidering indications, techniques, and biologic augmentation. *J Bone Joint Surg Br* 99:1222–1231

26. Servien E, Acquitter Y, Hulet C, Seil R (2009) Lateral meniscus lesions on stable knee: a prospective multicenter study. *Orthop Traumatol Surg Res* 95:60–64
27. Suganuma J, Inoue Y, Tani H, Sugiki T, Sassa T, Shibata R (2017) Reconstruction of the popliteomeniscal fascicles for treatment of recurrent subluxation of the lateral meniscus. *Arthrosc Tech* 6:e283–e290
28. Kamiya T, Suzuki T, Otsubo H, Kuroda M, Matsumura T, Kubota C et al (2018) Midterm outcomes after arthroscopic surgery for hypermobile lateral meniscus in adults: restriction of paradoxical motion. *J Orthop Sci* 23:1000–1004
29. Ahn SJ, Jeong YM, Lee BG, Sim JA, Choi H-Y, Kim JH et al (2016) Using three-dimensional isotropic SPACE MRI to detect posterolateral corner injury of the knee. *Acta Radiol Suppl* 57:1251–1260
30. Temponi EF, de Carvalho Júnior LH, Saithna A, Thauan M, Sonnerly-Cottet B (2017) Incidence and MRI characterization of the spectrum of posterolateral corner injuries occurring in association with ACL rupture. *Skelet Radiol* 46:1063–1070
31. Ahn JH, Lee SH, Kim KI, Nam J (2018) Arthroscopic meniscus repair for recurrent subluxation of the lateral meniscus. *Knee Surg Sports Traumatol Arthrosc* 26:787–792
32. Brown GC, Rosenberg TD, Deffner KT (1996) Inside-out meniscal repair using zone-specific instruments. *Am J Knee Surg* 9:144–150
33. Horibe S, Shino K, Nakata K, Maeda A, Nakamura N, Matsumoto N (1995) Second-look arthroscopy after meniscal repair. Review of 132 menisci repaired by an arthroscopic inside-out technique. *J Bone Joint Surg Br* 77-B:245–249
34. Cuéllar A, Cuéllar R, Heredia JD, Cuéllar A, García-Alonso I, Ruiz-Ibán MA (2018) The all-inside meniscal repair technique has less risk of injury to the lateral geniculate artery than the inside-out repair technique when suturing the lateral meniscus. *Knee Surg Sports Traumatol Arthrosc* 26:793–798
35. Sanz-Perez M, Garcia-German D, Ruiz-Diaz J, Navas-Pernía I, Campo-Loarte J (2015) Location of the popliteal artery and its relationship with the vascular risk in the suture of the posterior horn of the lateral meniscus. *Rev Esp Cir Ortop Traumatol* 59:165–171
36. Seo S-S, Kim C-W, Lee C-R, Park D-H, Kwon Y-U, Kim O-G et al (2020) Second-look arthroscopic findings and clinical outcomes of meniscal repair with concomitant anterior cruciate ligament reconstruction: comparison of suture and meniscus fixation device. *Arch Orthop Trauma Surg* 140:365–372
37. Westermann RW, Duchman KR, Amendola A, Glass N, Wolf BR (2017) All-inside versus inside-out meniscal repair with concurrent anterior cruciate ligament reconstruction: a meta-regression analysis. *Am J Sports Med* 45:719–724
38. Aman ZS, DePhillipo NN, Storaci HW, Moatshe G, Chahla J, Engebretsen L et al (2019) Quantitative and qualitative assessment of posterolateral meniscal anatomy: defining the popliteal hiatus, popliteomeniscal fascicles, and the lateral meniscotibial ligament. *Am J Sports Med* 47:1797–1803
39. Barber FA, Bava ED (2012) Meniscal repair: the newest fixators. *Sports Med Arthrosc Rev* 20:95–100
40. Goodwillie AD, Myers K, Sgaglione NA (2014) Current strategies and approaches to meniscal repair. *J. Knee Surg* 27:423–434
41. Warth LC, Bollier MJ, Hoffman DF, Cummins JS, Hall MM (2016) New complication associated with all-inside meniscal repair device: ultrasound-aided diagnosis and operative localization of foreign body reaction. *J Sports Med* 4:2325967116664882
42. Terai S, Hashimoto Y, Yamasaki S, Takahashi S, Shimada N, Nakamura H (2019) Prevalence, development, and factors associated with cyst formation after meniscal repair with the all-inside suture device. *Arch Orthop Trauma Surg* 139:1261–1268
43. Ahn JH, Oh I (2006) Arthroscopic all-inside lateral meniscus suture using posterolateral portal. *Arthroscopy* 22:572. e571–572. e574
44. Simonetta R, Di Vico G, Papalia R, Vasta S, Denaro V (2016) Arthroscopic all-inside treatment of popliteomeniscal fascicles tears: surgical technique and results from the first 6 consecutive patients. *J Biol Regul Homeost Agents* 30:91–97

### Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Submit your manuscript to a SpringerOpen® journal and benefit from:**

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

---

Submit your next manuscript at ► [springeropen.com](https://www.springeropen.com)

---