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Ramp lesion of the medial meniscus

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- Ramp lesion of the medial meniscus used to be completely disregarded in the past.
- Ramp lesion has been now put under the spotlight by orthopaedic and sport medicine surgeons and requires attention.
- It is closely associated with anterior cruciate ligament injury. Major risk factors include chronic laxity, lateral meniscal lesion, anterior cruciate ligament reconstruction revision, anterolateral ligament tear concomitant with anterior cruciate ligament injury, time from injury, pre-operative side-to-side laxity > 6 mm, age < 30 years old, male sex, etc.
- Radiologists attempt to create diagnostic criteria for ramp lesion using magnetic resonance imaging. However, the only definite method to diagnose ramp lesion is still arthroscopy. Various techniques exist, among which posteromedial approach is the most highly recommended.
- Various treatment options are available. The success rate of ramp repair is very high. Major complications are uncommon.

Keywords: literature review; medial meniscus; ramp lesion

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Overview of ramp lesion of the medial meniscus

The medial meniscus is attached to the posterior tibial plateau and articular capsule, serving as the fundamental structure in knee joint kinematics.[1] It has a multitude of functions such as shock absorption, joint lubrication, nutrient supply and stabilization alongside the anterior cruciate ligament (ACL).[2,3] When the latter loses function, the former adopts its role of reducing anterior tibial translation, which eventually leads to overload and injury.[4] This disruption in menisco-capsular junction in patients with ACL injury significantly increases laxity.[5] A lesion in the area stimulates articular cartilage degeneration of the medial compartment of the knee over the course of two years in ACL-deficient knees.[6]

The medial meniscal ramp lesion (MRL) is defined as a detachment between the posterior horn of the medial meniscus (PHMM) and the articular capsule, or a tear of the menisco-tibial ligament (MTL) (Fig. 1).[7,8] This location can be explained by the fact that between the meniscus and the capsule (or to be more precise, the capsular branch of the semimembranosus tendon that is inserted behind the PHMM) lies fragile adipose tissue. Moreover, excessive anterior tibial subluxation secondary to ACL rupture stimulates semimembranosus tendon contraction, putting the posteromedial articular capsule under tension with the meniscus being trapped between the femur and the tibia. As a result of this, a tear of the MTL and/or the menisco-capsular ligament (MCL) occurs.[9] According to different reports, MRL is the most or one of the most common types of lesion in ACL injury.[10,11] Recent studies show contrasting difference in incidence of MRL in ACL injury, ranging from 9%[Keyhani, 2020 #6] to 42%.[12,13] Notably, isolated MRL may exist even in the absence of obvious ACL rupture, possibly as a sequalae of ACL longitudinal splits or degeneration.[14] MRL is also seen alongside root, horizontal and other types of medial meniscal tears.[15] However, the true incidence of MRL is unknown due to the high rate of mis or underdiagnosis resulting from low sensitivity of imaging modalities,[16] poor intra-operative visualization and surgical skills.[17] A rather low rate of successful diagnosis made by radiologists via magnetic resonance imaging (MRI) is the main reason as to why MRI should not be used as a single tool for establishing diagnosis of MRL.[18] Various treatments of MRL exist, but the most definite and frequently applied is lesion repair.[19]

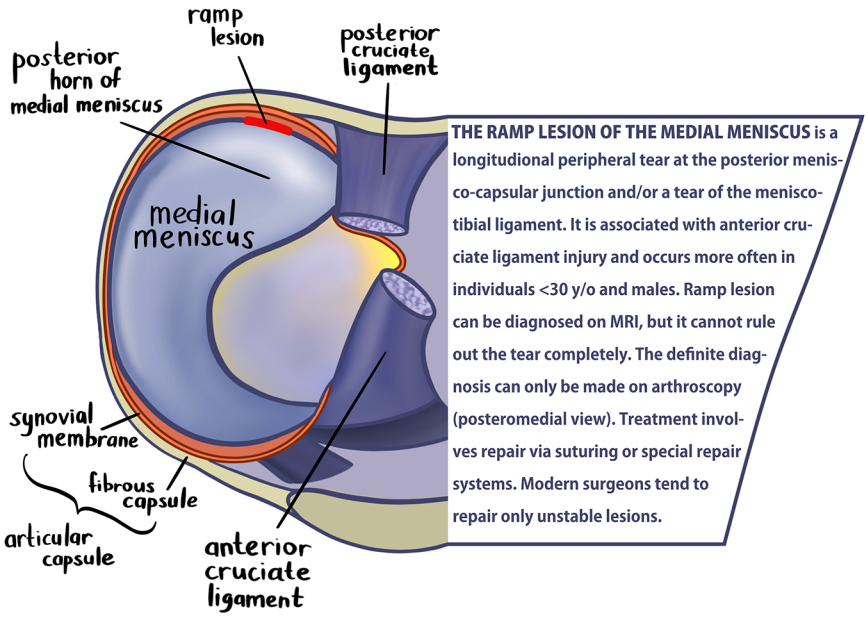

Fig. 1 Ramp lesion of the medial meniscus and its features.

Risk factors

A large multivariate analysis established the following risk factors. Presence of lateral meniscal lesion is the major risk factor of MRL (1.9), followed by ACL reconstruction (ACLR) revision (1.8). The risk of presenting with MLR is 1.6 times higher among individuals below 30 years old than in those over 30 years old. Males were found to be 1.5 times more likely to develop MLR than females (all $p < 0.001$). In addition, time from injury and pre-operative side-to-side laxity exceeding 6 mm were also found to be significantly associated with MRL ($p = 0.047$ and $p = 0.002$, respectively). Finally, MRL was observed in almost every fourth patient (23.9%) with ACL injury.[15] Furthermore, incidence of ramp lesions significantly increases in nearly complete or complete anterolateral ligament (ALL) tears concomitant with ACL injuries ($p = 0.043$).[20] A cross-sectional study identified delay in injury-to-surgery time of more than three months as a significant risk factor ($p < 0.001$) of increased incidence of meniscal injury including ramp lesion.[13] Other risk factors include bone contusion involving the posterior portion of the medial tibial plateau on MRI ($p < 0.001$), varus knee exceeding 3° ($p = 0.038$), steep medial tibial ($p = 0.049$) and meniscal slopes ($p = 0.003$). Contact knee injury ($p = 0.03$) and lateral meniscal tear ($p = 0.02$) were also found to be associated with MRL.[21,22]

Paediatric patients may be at increased risk of developing meniscal tears due to increased joint laxity.[23] However, a study with level I evidence showed that the number of children and adolescents diagnosed with ramp lesion in ACL-deficient knee does not exceed that of adults, reaching 23%.[24]

Pre-operative evaluation

Based on the affected structures, MRL can be divided into five types.[25] Type 1 is a peripheral menisco-capsular tear, Type 2 is a partial lesion predominantly found in the superior portion, Type 3 is a partial inferior lesion that is also known as a hidden lesion, Type 4 is a complete longitudinal vertical tear involving the red-red zone, and Type 5 is characterized by the presence of two tears (Fig. 2). Types 1 and 2 are regarded as stable lesions, whereas Types 3 and 4 are not, and stability of Type 5 was not originally mentioned. A new study sought to improve and expand the existing classification by including findings from studies done on cadaveric specimens and hospitalized patients.[26] Type 1 is characterized by peripherally located menisco-capsular tear involving synovial sheath resulting in posterior MCL detachment from the PHMM. Fluid-sensitive MRI may reveal vertical hyperintense signal extending to the superior margin of the articular surface. This is one of the most difficult types to register even arthroscopically due to extremely low mobility when advancing the probe. The probe mobility increases with the type number, but surgical duration and difficulty may also be higher due to a larger injured area. Type 2 involves the superior portion of the PHMM tear with posterior MCL and PHMM still being connected. MRI scan demonstrates vertical hyperintense signal consistent with fluid signal reaching the superior margin of the red-red zone. Type 3 involves the inferior portion of the PHMM. Such a location makes these lesions 'hidden', accounting for their rareness. It is suggested to be divided into two subtypes for the sake of better demonstration of lesion location. Type 3A unites peripheral

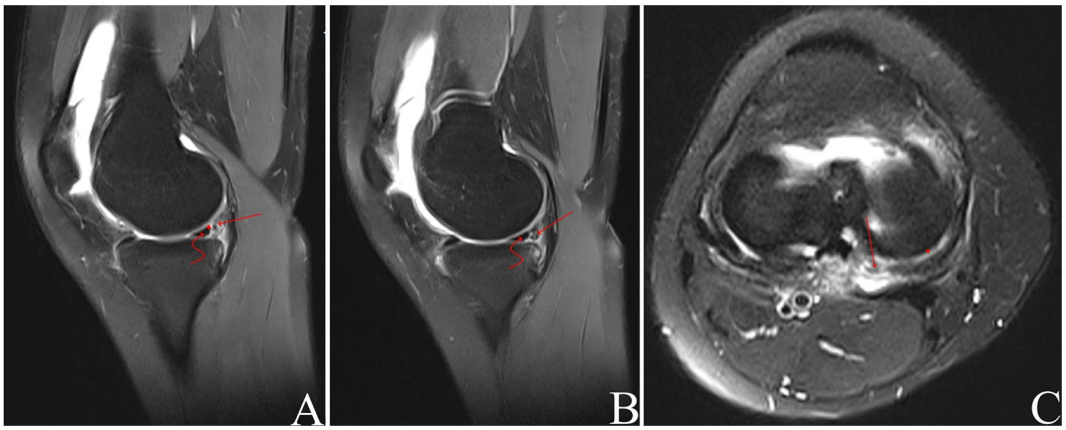

Fig. 2 Twenty-year-old female with anterior cruciate ligament (ACL) injury diagnosed two years ago. (A) T2 scan. (B) Fat-suppressed proton density-weighted imaging (FS-PDWI) scan. Linear hyperintense signal (arrowhead) reaching articular surface (arrow) is seen at the posterior horn of medial meniscus (curved arrow).

vertical tears of the inferior part of the PHMM with the MTL still connected to its part, but not to the medial meniscus. A linear vertical oblique hyperintense fluid-like signal can be observed on MRI. On the other hand, Type 3B represents an MTL tear as it detaches from the PHMM. A typical finding on MRI is hyperintense T2 signal with ligament disruption. Definition of Type 4 is a longitudinal vertical tear situated in the red-red zone. Just like Type 3, it also received revision and was divided into two subtypes, which are Type 4A and Type 4B. The former is classified as a complete longitudinal vertical tear located in the red-red zone without any damage in the MCL and MTL. The ligaments are attached solely to the PHMM, which is unattached to the meniscus itself. MRI reveals a linear hyperintense fluid-like signal on T2 between inferior and superior articular surfaces. Type 4B presents a complete junctional tear between both the MCL and MTL and the PHMM. MRI scan shows the same features as in Type 4A, but with the addition of ligament disruption. Finally, in Type 5, two tears with some distance between each other are located in the red-red zone. Both the MCL and MTL are spared, but they still lack stability as they are attached to a disrupted PHMM. On MRI, it can be diagnosed by two linear hyperintense T2 fluid-like signals going parallel to each other below the menisco-capsular junction (Table 1).

MRI cannot solely be used for MRL diagnosis. It has proved to be rather challenging due to its diagnostic specifics and results in missing a tremendous number of patients that actually have MRL.[27] Until now, MRI remains controversial because of fluctuating sensitivity and specificity among various studies.[28–31] In spite of this fact, radiologists continuously make attempts to set criteria for diagnosing MRL with MRI scan and increase its performance.[29] The most significant findings include peripheral irregularities and hyperintensity (posterior medial tibial plateau oedema) in adults,[30,32] whereas MRI scan in children may show medial meniscus and capsular ligament tears in addition to the aforementioned findings (all $p < 0.05$).[33] Moreover, in order to increase diagnostic accuracy, a knee should be placed in flexed position whenever feasible.[16] Incidence of MRL increases with the duration of ACL injury.[11] One of the possible explanations may be that MRL is being diagnosed more on MRI scan when chronic ACL injury is present because the tissues are not as firmly attached, it becomes easier to differentiate between the structures and identify the abnormality.[34]

Although not usually applied in clinics, Finochietto sign[35] can be positive in some patients with MRL.[36] It is a highly specific sign of meniscal posterior longitudinal tear. It may appear useful in the diagnosis of MRL in the outpatient department, but one must keep in mind that patients often complain of discomfort or pain during and after performing the manoeuvre. Furthermore, a negative Finochietto sign cannot confirm or rule out MRL, so the diagnosis still needs to be confirmed arthroscopically. Other tests used for diagnosis of meniscal injuries have not yet been studied in MRL patients.

Arthroscopy and repair

Only arthroscopy can diagnose or rule out MRL (Fig. 3). Untreated MRL leads to decrease in patient life quality, loss of function and inability to perform daily activities or sports in full. That is why prompt identification and treatment are of utmost importance. As chronic ACL injury is most commonly associated with MRL, ACLR should be performed within three months of the time of onset to minimize the risk of developing MRL.[37] A posteromedial portal with the knee being flexed to 90° allows complete reveal of certain types of MRL, its subsequent treatment and prevents damage to surrounding structures.[38] Other methods to visualize the lesion are available including

Table 1. Classification of ramp lesion of the medial meniscus

Type	Definition	Main features	MRI findings	Probe mobility	Stability
Type 1	Peripheral tear of the MCL involving the synovium	Detachment of posterior MCL from the PHMM	Peripheral vertical tear at the MCL, hyperintense signal on T2 extending to superior portion of the PHMM	Very low	Stable
Type 2	Partial superior peripheral tear of the PHMM	MCL is still attached to the PHMM	Linear vertical hyperintense signal on T2 that reaches the superior margin of the articular surface of the PHMM	Low	
Type 3A	Partial inferior vertical peripheral tear of the PHMM with MTL still attached to part of the PHMM	Hidden lesion. Although undamaged, the MTL's attachment to the medial meniscus is disrupted	Linear vertical oblique hyperintense signal on T2 that reaches the inferior margin of the articular surface of the PHMM	Moderate	Unstable
Type 3B	Tear of the MTL at the base	Hidden lesion. Attachment between the MTL and PHMM is torn, so they are no longer connected. Meniscus does not present with any damage	Ligament breakage with hyperintense signal on T2 possibly accompanied by bone marrow oedema	Moderate-to-high	
Type 4A	Full thickness longitudinal vertical tear of the red-red zone	MCL and MTL are attached to the part of PHMM unconnected to the rest of the meniscus	Hyperintense signal on T2 stretching from inferior to superior margins of the articular surface showing complete vertical tear	High	
Type 4B	Full thickness vertical tear involving the junction between the MTL with MCL and PHMM	Medial meniscus does not present with any damage	Linear hyperintense signal on T2 stretching from inferior to superior margins of the articular surface accompanied by ligament breakage. Bone marrow oedema in the medial tibial plateau may be present		
Type 5	Double red-red zone tear	Unconnected two tears parallel to each other. The MCL and MTL remain attached to the PHMM, but the latter's structure is disrupted	Two linear hyperintense signals on T2 aligned in a parallel manner stretching from inferior to superior margins of the articular surface occupying the red-red zone and base of ligament attachment	Very high	

Note. PHMM, posterior horn of the medial meniscus; MTL, menisco-tibial ligament; MCL, menisco-capsular ligament.

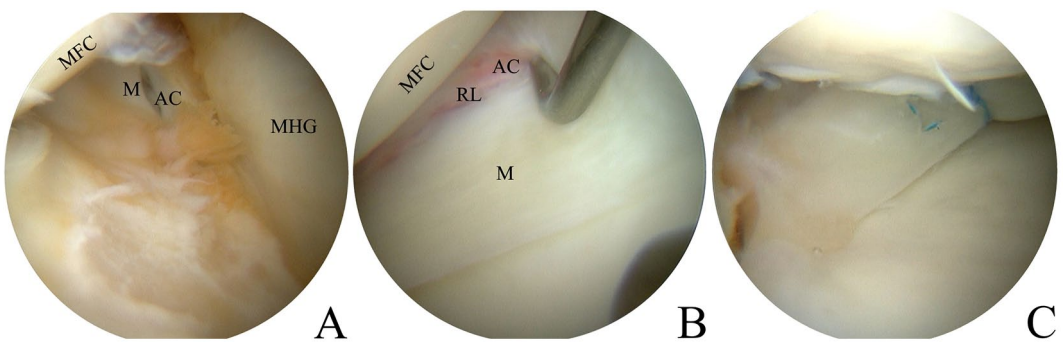

Fig. 3 Typical findings on arthroscopy (the patient is described in Fig. 2). (A) Posteromedial view. (B) Anterolateral approach. (C) Repair using FAST-FIX™.

Note. MFC, medial femoral condyle; M, meniscus; AC, articular capsule; MHG, medial head of gastrocnemius muscle; RL, ramp lesion.

posterolateral transeptal,[39,40] transnotch view,[41] etc. Probing and visualization of the inferior surface of the medial meniscus via anterior approach may reveal Type 3 MRL, whereas the transnotch or posteromedial view shows an intact posterior capsule. With the knee at 90° and via transnotch view, internal rotation of the leg may help finding Type 4 and 5 MRL. Nevertheless, posteromedial portal approach can never be ignored. It is required to nullify the possibility of any missed lesion and to successfully carry out the repair.[42] The posteromedial portal technique should become a mandatory procedure in patients with ACL, both acute and chronic, because of its close association with MRL and high rate of diagnostic errors of the latter.[43] A prospective consecutive single-surgeon study was conducted to compare the effectiveness of several arthroscopic approaches in MRL diagnosis.[44] A 70° arthroscope inserted into intercondylar space was able to diagnose 100% of ramp lesions (the results were reconfirmed through posteromedial inspection). Anterior inspection and insertion of a 30° arthroscope had much lower detection rates of 38% and 48%, respectively. Alternatively, a 70° arthroscope can be inserted into intercondylar space when a patient is at high risk of further tear or saphenous nerve injury.[25,44] Nonetheless, a problem arises

when the length of arthroscope is insufficient to confirm the presence of MRL. This is typical in patients with massive knees, large deposition of subcutaneous fat, etc. The only way to minimize the risk of diagnosis and treatment failure is careful pre-operative preparation with detailed plan and risk assessment. Using a longer arthroscope is essential in such patients, but unfortunately many hospitals lack them as they are still not widely manufactured.

The repair is the most popularly used technique to treat MRL, largely owing to its high efficacy and safety.[45,46] When MRL is located, the tear is often chosen to be closed. An all-inside suture with hook device remains the most popular choice among surgeons. In case of MRL extending medially into the meniscus, a hybrid technique can be applied in order to enhance structural stability by adding outside-in, inside-out or all-inside repair.[47] A new cadaveric study established that all-inside suture devices and other horizontal trajectory MRL repair techniques cannot anatomically repair the MTL as they cannot capture the tibial stump. In order for the MTL to be anatomically repaired, techniques such as suture hook repair that allow capturing both the meniscus and the MTL should be used.[9]

MRL repair failure after ACLR is remarkably lower in inside-out sutures (2%) than in all-inside (11%), which was recorded by another research group.[48] However, an earlier comparative study with a higher level of evidence showed that there is no statistical difference in healing status between these two techniques following ACLR.[49] Some studies claim that small and stable MRL does not have to be sutured.[50,51] These findings were supported by a recent randomized controlled trial that concluded that stable asymptomatic lesions do not require treatment at all.[52] In this trial patients who received surgical treatment had no significant difference in outcome (healing status, knee stability, subjective score) compared with a control group receiving conservative treatment consisting of abrasion and trephination ($p = 0.543$). The vast majority of modern US surgeons tend to rely on extent and stability of the tear during assessment of the need for ramp repair.[53]

To conclude it all, patients who underwent MRL repair show significantly higher subjective scores, healing rates and significantly lower anterior laxity than those who did not.[19] Thus, surgical treatment should be advocated in all unstable lesions.[43]

Post-operative period

Ramp repair regardless of technique used shows enormous improvement in Lysholm Knee Score and subjective scores.[54] One study evaluated implementation of the FAST-FIX™ technique (all-inside) in MRL repair.[55] Arthroscopy was performed post-operatively to evaluate treatment efficacy in patients requiring removal of tibial staples or presenting symptoms. Forty out of 46 patients showed complete healing, and five healed only partially. The success rate of 87% was consistent with results obtained in other research.[45] A cadaveric study showed a failure rate as low as 1.25% after ramp repair with ULTRA FAST-FIX™, which was found to be lower than the failure rate in lesions repaired with FAST-FIX™ 360 (6.25%).[56] Another report revealed a significantly improved Lachman and pivot-shift scores in patients who underwent ACLR combined with MRL repair compared with patients who underwent ACLR alone ($p < 0.05$).[48] According to a cohort study with two-year follow-up, there is no significant difference in outcome between two matched cohorts of patients that underwent ACLR with bone–patellar tendon–bone autograft and inside-outside MRL repair and isolated ACLR. Notably, a more than two-fold reduction in the re-operation risk for failure of MRL repair was recorded in patients who received ACLR combined with ALL reconstruction and ramp repair than in those that had ACLR combined with MRL repair alone. Therefore, ALL reconstruction exhibits protective properties on MRL repair when undergoing ACLR.[15] A laboratory study discovered that anterior translation was significantly reduced after MRL repair at 90 N anterior load ($p < 0.05$).[57]

Risk of repair failure does not exceed 5%, but it increases in larger tears.[46] Rather low failure rate may be a result of abundant vascularity found in the location of occurrence of MRL.[9] Past history of ACLR is associated with a more than three-fold increased risk of re-operation for meniscal repair ($p < 0.016$), which may be a result of inadequate ACLR graft, but this hypothesis requires further confirmation.[58] Complications following ramp repair are rare and there are not many different types. Most common complications include symptoms related to inflammatory processes such as swelling, pain, nerve irritation, etc.[45] More rarely seen complications are neurovascular damage from creating additional portals (e.g. posteromedial portal), post-operative haematoma, injury of articular surface and collateral ligaments.[51,55] Complications occur in all types of sutures, though nerve-associated complications are more frequent in patients with inside-out suturing, whereas all-inside repair more often produces implant-associated ones.[59]

There is no specific post-operative management for MRL repair. It was adopted from protocols applied in other types of surgeries. This has led to doctors advocating different post-operative management plans based on their experience, knowledge exchange with other orthopaedicians, etc. Generally, knee flexion past 90° is prohibited for a minimum of two weeks. Non-weight-bearing or toe-touch weight-bearing is started immediately after surgery until approximately the second week, followed by partial weight-bearing for at least four weeks. Full

weight-bearing can be allowed at the 4–12th week post-operatively. Patients are allowed to resume full range of motion six weeks after surgery and to perform any sort of strenuous activity (e.g. running, swimming) six months after surgery.[47] However, as mentioned earlier, there still is no consensus as to post-operative care. For instance, many doctors allow full weight-bearing directly after surgery and so on.

Conclusion

Long negligence of MRL created scarcity of information regarding this entity. The small amount of existing literature does not allow to make any sort of significant conclusion in terms of epidemiology, diagnostics, standard of care, etc. As the wheels of research into MRL have begun to turn and more orthopaedic and sports medicine doctors are becoming aware of what it is, things are expected to change and more research is expected to be published in the near future. We are sincerely looking forward to reading more interesting reports on MRL and encouraging more doctors to turn their attention to this somewhat 'novel' topic.

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REFERENCES

1. **Johnson DL, Swenson TM, Livesay GA, Aizawa H, Fu FH, Harner CD.** Insertion-site anatomy of the human menisci: gross, arthroscopic, and topographical anatomy as a basis for meniscal transplantation. *Arthroscopy* 1995;11:386–394.

2. **Mouton C, Magosch A, Pape D, Hoffmann A, Nührenbörger C, Seil R.** Ramp lesions of the medial meniscus are associated with a higher grade of dynamic rotatory laxity in ACL-injured patients in comparison to patients with an isolated injury. *Knee Surg Sports Traumatol Arthrosc* 2020;28:1023–1028.

3. **Allen CR, Wong EK, Livesay GA, Sakane M, Fu FH, Woo SL-Y.** Importance of the medial meniscus in the anterior cruciate ligament-deficient knee. *J Orthop Res* 2000;18:109–115.

4. **Ahn JH, Bae TS, Kang K-S, Kang SY, Lee SH.** Longitudinal tear of the medial meniscus posterior horn in the anterior cruciate ligament-deficient knee significantly influences anterior stability. *Am J Sports Med* 2011;39:2187–2193.

5. **Stephen JM, Halewood C, Kittl C, Bollen SR, Williams A, Amis AA.** Posteromedial meniscocapsular lesions increase tibiofemoral joint laxity with anterior cruciate ligament deficiency, and their repair reduces laxity. *Am J Sports Med* 2016;44:400–408.

6. **Guimaraes JB, Schwaiger BJ, Gersing AS, et al.** Meniscal ramp lesions: frequency, natural history, and the effect on knee cartilage over 2 years in subjects with anterior cruciate ligament tears. *Skeletal Radiol* 2021;50:551–558.

7. **Strobel MJ.** Knee joint – special part. In: Strobel MJ, ed. *Manual of arthroscopic surgery*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2002:671.

8. **DePhillipo NN, Moatshe G, Chahla J, et al.** Quantitative and qualitative assessment of the posterior medial meniscus anatomy: defining meniscal ramp lesions. *Am J Sports Med* 2019;47:372–378.

9. **Cavaignac E, Sylvie R, Teulières M, et al.** What is the relationship between the distal semimembranosus tendon and the medial meniscus? A gross and microscopic analysis from the SANTI Study Group. *Am J Sports Med* 2021;49(2):459-466.

10. **Cain EL Jr, Fleisig GS, Ponce BA, et al.** Variables associated with chondral and meniscal injuries in anterior cruciate ligament surgery. *J Knee Surg* 2017;30:659–667.

11. **Smith JP III, Barrett GR.** Medial and lateral meniscal tear patterns in anterior cruciate ligament-deficient knees: a prospective analysis of 575 tears. *Am J Sports Med* 2001;29:415–419.

12. **Tashiro Y, Mori T, Kawano T, Oniduka T, Arner JW, Fu FH, et al.** Meniscal ramp lesions should be considered in anterior cruciate ligament-injured knees, especially with larger instability or longer delay before surgery. *Knee Surg Sports Traumatol Arthrosc* 2020;28:3569–3575.

13. **Keyhani S, Esmailiejah AA, Mirhoseini MS, Hosseininejad SM, Ghanbari N.** The prevalence, zone, and type of the meniscus tear in patients with anterior cruciate ligament (ACL) injury: does delayed ACL reconstruction affect the meniscal injury? *Arch Bone Jt Surg* 2020;8:432–438.

14. **Jiang J, Ni L, Chen J.** Isolated meniscal ramp lesion without obvious anterior cruciate ligament rupture. *Orthop Surg* 2020;0s.12860.

15. **Sonnery-Cottet B, Praz C, Rosenstiel N, et al.** Epidemiological evaluation of meniscal ramp lesions in 3214 anterior cruciate ligament-injured knees from the SANTI Study Group database: a risk factor analysis and study of secondary meniscectomy rates following 769 ramp repairs. *Am J Sports Med* 2018;46:3189–3197.

16. **Okazaki Y, Furumatsu T, Okamoto S, et al.** Diagnostic performance of open MRI in the flexed knee position for the detection of medial meniscus ramp lesions. *Skeletal Radiol* 2020;49:1781–1788.

17. Peltier A, Lording TD, Lustig S, Servien E, Maubisson L, Neyret P. Posteromedial meniscal tears may be missed during anterior cruciate ligament reconstruction. *Arthroscopy* 2015;31:691–698.

18. DePhillipo NN, Cinque ME, Chahla J, Geeslin AG, Engebretsen L, LaPrade RF. Incidence and detection of meniscal ramp lesions on magnetic resonance imaging in patients with anterior cruciate ligament reconstruction. *Am J Sports Med* 2017;45:2233–2237.

19. Hatayama K, Terauchi M, Saito K, Takase R, Higuchi H. Healing status of meniscal ramp lesion affects anterior knee stability after ACL reconstruction. *Orthop J Sports Med* 2020;8:2325967120917674.

20. Ahn JH, Lee SK, Mun JW, Kim SW. Degree of anterolateral ligament injury impacts outcomes after double-bundle anterior cruciate ligament reconstruction. *Arthroscopy* 2020. doi:10.1016/j.arthro.2020.09.003 [Epub ahead of print].

21. Kim SH, Seo HJ, Seo DW, Kim K-I, Lee SH. Analysis of risk factors for ramp lesions associated with anterior cruciate ligament injury. *Am J Sports Med* 2020;48:1673–1681.

22. Balazs GC, Greditzer HG IV, Wang D, et al. Ramp lesions of the medial meniscus in patients undergoing primary and revision ACL reconstruction: prevalence and risk factors. *Orthop J Sports Med* 2019;7:2325967119843509.

23. Bordoni V, di Laura Frattura G, Previtali D, et al. Bone bruise and anterior cruciate ligament tears: presence, distribution pattern, and associated lesions in the pediatric population. *Am J Sports Med* 2019;47:3181–3186.

24. Malatray M, Raux S, Peltier A, Pfirrmann C, Seil R, Chotel F. Ramp lesions in ACL deficient knees in children and adolescent population: a high prevalence confirmed in intercondylar and posteromedial exploration. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1074–1079.

25. Thaunat M, Fayard JM, Guimaraes TM, Jan N, Murphy CG, Sonnery-Cottet B. Classification and surgical repair of ramp lesions of the medial meniscus. *Arthrosc Tech* 2016;5:e871–e875.

26. Greif DN, Baraga MG, Rizzo MG, et al. MRI appearance of the different meniscal ramp lesion types, with clinical and arthroscopic correlation. *Skeletal Radiol* 2020;49:677–689.

27. Bollen SR. Posteromedial meniscocapsular injury associated with rupture of the anterior cruciate ligament: a previously unrecognised association. *J Bone Joint Surg Br* 2010;92:222–223.

28. Koo B, Lee SH, Yun SJ, Song JG. Diagnostic performance of magnetic resonance imaging for detecting meniscal ramp lesions in patients with anterior cruciate ligament tears: a systematic review and meta-analysis. *Am J Sports Med* 2020;48:2051–2059.

29. Greenaway M, Walton E, Gibson D, et al. Meniscal 'ramp' lesions: surgical incidence and the development of magnetic resonance imaging diagnostic criteria. *Arthrosc Sports Med Rehabil* 2020;2:e309–e314.

30. Yeo Y, Ahn JM, Kim H, et al. MR evaluation of the meniscal ramp lesion in patients with anterior cruciate ligament tear. *Skeletal Radiol* 2018;47:1683–1689.

31. Arner JW, Herbst E, Burnham JM, et al. MRI can accurately detect meniscal ramp lesions of the knee. *Knee Surg Sports Traumatol Arthrosc* 2017;25:3955–3960.

32. Kumar NS, Spencer T, Cote MP, Arciero RA, Edgar C. Is edema at the posterior medial tibial plateau indicative of a ramp lesion? An examination of 307 patients with anterior cruciate ligament reconstruction and medial meniscal tears. *Orthop J Sports Med* 2018;6:2325967118780089.

33. Nguyen JC, Bram JT, Lawrence JTR, et al. MRI criteria for ramp lesions of the knee in children with anterior cruciate ligament tears. *AJR Am J Roentgenol* 2021;216(3):791-798.

34. Vogel LA, Edgar CM, Arciero RA. Surgical treatment of combined anterior cruciate ligament and lateral-side injures: acute and chronic. In: Fanelli GC, ed. *The multiple ligament injured knee: a practical guide to management*. Cham: Springer International Publishing, 2019:153–168.

35. Finochietto R. Semilunar cartilages of the knee. The 'jump sign'. *JBJS* 1935;17:916–921.

36. Espejo-Baena A, Espejo-Reina A, Espejo-Reina MJ, Ruiz-Del Pino J. The Finochietto sign as a pathognomonic finding of ramp lesion of the medial meniscus. *Arthrosc Tech* 2020;9:e549–e552.

37. Papastergiou SG, Koukoulias NE, Mikalef P, Ziogas E, Voulgaropoulos H. Meniscal tears in the ACL-deficient knee: correlation between meniscal tears and the timing of ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2007;15:1438–1444.

38. Sonnery-Cottet B, Conteduca J, Thaunat M, Gunepin FX, Seil R. Hidden lesions of the posterior horn of the medial meniscus: a systematic arthroscopic exploration of the concealed portion of the knee. *Am J Sports Med* 2014;42:921–926.

39. Ahn JH, Ha CW. Posterior trans-septal portal for arthroscopic surgery of the knee joint. *Arthroscopy* 2000;16:774–779.

40. Keyhani S, Ahn JH, Verdonk R, Soleymanha M, Abbasian M. Arthroscopic all-inside ramp lesion repair using the posterolateral transseptal portal view. *Knee Surg Sports Traumatol Arthrosc* 2017;25:454–458.

41. Mostafa Zaky Abdelrazek BH, Waly MR, Abdel Aziz MA, Abdel Aziz A. Different techniques for the management of meniscal ramp lesions using standard anterior portals. *Arthrosc Tech* 2019;9:e39–e44.

42. Lee SH, Ahn JH, Yoon KH, Kim SH. Diagnostic accuracy of medial meniscus posterior horn longitudinal tear an anterior cruciate ligament deficient knee with different arthroscopic approaches. *Arthroscopy* 2017;33:e124–e125.

43. Bumberger A, Koller U, Hofbauer M, et al. Ramp lesions are frequently missed in ACL-deficient knees and should be repaired in case of instability. *Knee Surg Sports Traumatol Arthrosc* 2020;28:840–854.

44. Kim SH, Lee SH, Kim KI, Yang JW. Diagnostic accuracy of sequential arthroscopic approach for ramp lesions of the posterior horn of the medial meniscus in anterior cruciate ligament-deficient knee. *Arthroscopy* 2018;34:1582–1589.

45. Ahn JH, Wang JH, Yoo JC. Arthroscopic all-inside suture repair of medial meniscus lesion in anterior cruciate ligament-deficient knees: results of second-look arthroscopies in 39 cases. *Arthroscopy* 2004;20:936–945.

46. Thaunat M, Jan N, Fayard JM, et al. Repair of meniscal ramp lesions through a posteromedial portal during anterior cruciate ligament reconstruction: outcome study with a minimum 2-year follow-up. *Arthroscopy* 2016;32:2269–2277.

47. Alessio-Mazzola M, Lovisolo S, Capello AG, et al. Management of ramp lesions of the knee: a systematic review of the literature. *Musculoskelet Surg* 2020;104:125–133.

48. DePhillipo NN, Dornan GJ, Dekker TJ, Aman ZS, Engebretsen L, LaPrade RF. Clinical characteristics and outcomes after primary ACL reconstruction and meniscus ramp repair. *Orthop J Sports Med* 2020;8:2325967120912427.

49. Choi NH, Kim TH, Victoroff BN. Comparison of arthroscopic medial meniscal suture repair techniques: inside-out versus all-inside repair. *Am J Sports Med* 2009;37:2144–2150.

50. Duchman KR, Westermann RW, Spindler KP, et al; MOON Knee Group. The fate of meniscus tears left in situ at the time of anterior cruciate ligament reconstruction: a 6-year follow-up study from the MOON cohort. *Am J Sports Med* 2015;43:2688–2695.

51. Balazs GC, Greditzer HG IV, Wang D, et al. Non-treatment of stable ramp lesions does not degrade clinical outcomes in the setting of primary ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2020;28:3576–3586.

52. Liu X, Zhang H, Feng H, Hong L, Wang XS, Song GY. Is it necessary to repair stable ramp lesions of the medial meniscus during anterior cruciate ligament reconstruction? A prospective randomized controlled trial. *Am J Sports Med* 2017;45:1004–1011.

53. DePhillipo NN, Engebretsen L, LaPrade RF. Current trends among US surgeons in the identification, treatment, and time of repair for medial meniscal ramp lesions at the time of ACL surgery. *Orthop J Sports Med* 2019;7:2325967119827267.

54. Gülenç B, Kemah B, Yalçın S, Sayar Ş, Korkmaz O, Erdil M. Surgical treatment of meniscal RAMP lesion. *J Knee Surg* 2020;33:255–259.

55. Chen Z, Li WP, Yang R, et al. Meniscal ramp lesion repair using the FAST-FIX technique: evaluating healing and patient outcomes with second-look arthroscopy. *J Knee Surg* 2018;31:710–715.

56. Heilpern G, Stephen J, Ball S, Williams A. 0076 – The ramp lesion – is it safe to use an all inside repair technique? *Knee* 2017;24:IV.

57. Naendrup JH, Pfeiffer TR, Chan C, et al. Effect of meniscal ramp lesion repair on knee kinematics, bony contact forces, and in situ forces in the anterior cruciate ligament: response. *Am J Sports Med* 2020;48:NP25–NP27.

58. Walter RP, Dhadwal AS, Schranz P, Mandalia V. The outcome of all-inside meniscal repair with relation to previous anterior cruciate ligament reconstruction. *Knee* 2014;21:1156–1159.

59. Grant JA, Wilde J, Miller BS, Bedi A. Comparison of inside-out and all-inside techniques for the repair of isolated meniscal tears: a systematic review. *Am J Sports Med* 2012;40:459–468.