# Posterior Lateral Meniscal Root and Oblique Radial Tears: The Biomechanical Evidence Supports Repair of These Tears, Although Long-Term Clinical Studies Are Necessary

We read with interest the recent study titled "Stable Lateral Meniscus Posterior Root Tears Left in situ at Time of Anterior Cruciate Ligament Reconstruction are of Minimal Long-Term Clinical Detriment" by Shumborski, Salmon, Monk, and Pinczewski.[1] Long-term patient-reported outcomes (PROs) in subjects undergoing anterior cruciate ligament (ACL) reconstruction with an intact lateral meniscus were compared with those with untreated "stable" lateral meniscal posterior root (LMPR) tears. The authors concluded that "there was no adverse clinical outcome to leaving a stable LMPR tear in situ at the time of ACL reconstruction" and that outcomes are similar in patients with these tears to those that had an intact meniscus. In response to the article by Shumborski et al., Dr. Shelbourne wrote an editorial commentary titled "Meniscus Tears Seen at the Time of Anterior Cruciate Ligament Reconstruction Are Overtreated."[2] We have concerns about the clinical implications of accepting the conclusions of these articles without appropriate contextualization.

To provide a framework for discussion of our concerns, the posterior lateral meniscal anatomy and tear classification systems are reviewed. We then discuss the biomechanical influence of these tears in the context of knee laxity and contact mechanics. Next, the epidemiology of this tear type and the clinical importance of meniscal preservation in the setting of concomitant ACL reconstruction is discussed. The conclusions by Shumborski et al.[1] are discussed in this context along with the recommendations from Shelbourne.[2] Lastly, we share our rationale for treatment of these tears as well as recommendations for future communication and research on this important tear pattern.

## Posterior Lateral Meniscal Anatomy and Tear Classification

The lateral meniscus is stabilized by multiple structures in the posterolateral knee. The root attachment is of primary importance for discussion of the articles by Shumborski et al. and Shelbourne, and it is located posteromedial to the lateral tibial eminence apex and anterolateral to the medial meniscus posterior root attachment.[3] The adjacent anatomy is complex and has been described in detail recently by Aman et al.[4] and Masferrer-Pino et al.[5]

Several posterior lateral meniscus tear classification systems have been described. In 2004, West et al.[6] categorized posterior lateral meniscal tears based on the location in relation to the root attachment as well as tear complexity. LaPrade et al.[7] provided an expanded classification of meniscal root tears based on tear completeness, proximity to the root attachment, tear obliquity, and adjacent meniscal integrity. Forkel et al.[8,9] described tears with regard to their involvement of the root and meniscofemoral ligaments. Krych et al.[10] classified the posterior lateral meniscus oblique radial tear that occurs between the root attachment and the meniscofemoral ligaments.

The classification systems by West, LaPrade, Forkel, and Krych categorize tears anatomically, which is necessary for the discussion of tear subtypes, biomechanical consequences, clinical importance, and surgical repair techniques. Shumborski et al.[1] grouped "root avulsion[s] within 9 mm of [the bony] insertion and parrot beak tears with the integrity of the root attachment maintained" and referred to them collectively as "lateral meniscal posterior root (LMPR)" tears, although we would argue that they are anatomically distinct. This grouping may be convenient due to the anatomic proximity, although it oversimplifies the injury pattern and applicable repair techniques. Therefore, for the purposes of this letter to the editor and to avoid confusion regarding nomenclature, we will refer to specific posterior lateral meniscal tear subtypes and will not use the "LMPR" abbreviation.

## Influence of Posterior Lateral Meniscus Tears on Knee Biomechanics

Several studies have evaluated the influence of lateral meniscus sectioning, often in the setting of ACL deficiency, leading to increased knee laxity and deleterious changes in lateral compartment contact mechanics. An early study by Musahl et al.[11] reported increased anterior tibial translation with lateral meniscal deficiency during a simulated pivot shift test, although this study was not solely focused on the root attachment. More recently, studies have evaluated the influence of sectioning directly at the root attachment,[12,13] at a measured distance away from the root attachment,[7] root and meniscofemoral ligaments,[8,13] and oblique radial tears between the root and meniscofemoral ligaments.[14]

The importance of the lateral meniscus for knee stability has been widely studied in the context of tibial translation and rotation. Although the study designs and individual results varied, multiple biomechanical studies in the last decade have reported increased knee laxity after lateral meniscal root sectioning.[12,15-17] Smith et al.[14] studied the lateral meniscus oblique radial tear in a biomechanical model and reported increased anterior laxity and meniscal extrusion compared to the intact state.

Several studies have evaluated the influence of the lateral meniscal posterior root attachment on contact mechanics in response to a compressive load.[7,8,13,18,19] Loss of the meniscal root attachment reduced contact area due to displacement of the meniscus resulting in increased peak contact pressure, which is known to have deleterious long-term effects on articular cartilage. Anatomic root repair was found to restore contact mechanics to the near normal state which may reduce the risk of developing post-traumatic osteoarthritis (PTOA).

## Clinical Importance of Posterior Lateral Meniscus Root and Oblique Radial Tears

Laboratory studies are able to precisely evaluate the biomechanical influence of these tear patterns and overwhelmingly support repair in the setting of ACL reconstruction and epidemiological studies demonstrate a relatively high incidence of this tear pattern. Several clinical studies have been performed that in essence provide in vivo support of the in vitro findings.[20-22] Although short-term clinical studies are available and support repair of these tear patterns, most long-term clinical studies only evaluate nonrepair without comparison to repair and to our knowledge there are no randomized studies. Therefore, synthesis of the previously reviewed biomechanical investigations supports the clinical rationale for meniscal preservation through repair of these tear types when combined with the available epidemiologic data, in vivo studies using examination and magnetic resonance imaging (MRI), short-term clinical outcome studies, and long-term studies on this tear type and meniscal tears in general. These findings are then considered in the context of restoring knee structural stability (translation and rotation) and preventing PTOA.

The epidemiologic data regarding these lateral meniscal tear types underscore the importance of further clinical study of repair. Up to one-sixth of patients with ACL tears have a concomitant posterior lateral meniscal root tear with a greater incidence in injuries related to a contact mechanism.[9,10,23,24] In a series of patients with revision ACL reconstruction, lateral meniscal root tears were present in one-fifth of patients.[25] The majority of ACL-injured patients are quite young. Data from the Mayo Clinic reported a peak incidence in male patients between ages 19 and 25 years and in female patients between ages 14 and 18 years.[26] The development of PTOA after ACL injury is a major concern, with several studies reporting a high prevalence, and concomitant meniscus injuries are an additional risk factor.[27-30] There is currently no treatment for early PTOA; therefore, initial injury treatment should focus on mitigating the risk and delaying the development of PTOA. Given that posterior lateral meniscus root and oblique radial tears have been biomechanically demonstrated to lead to altered contact mechanics and repair has been shown to improve contact area and pressure when compared with the sectioned state, strong consideration should be given to concomitant repair of these tears in the setting of ACL reconstruction.

In an innovative 2016 clinical study, Musahl et al.[21] evaluated 41 patients with ACL tears and documented the presence of concomitant injuries to the menisci and extra-articular structures. During the examination under anesthesia, a quantitative pivot shift maneuver was performed and increased anterior tibial translation was identified in patients with meniscal tears and anterolateral complex injuries. A persistent asymmetric pivot shift has been characterized as a clinical failure in patients with ACL reconstruction,[31] and methods for objective measurement have been described.[32]

In a clinical study by Minami et al.,[20] patients with lateral meniscal root tears were evaluated using MRI and on the pivot shift examination. Increased meniscal extrusion and anterolateral rotatory laxity were demonstrated in patients with lateral meniscal root tears compared with controls. Anterior translation of the lateral tibial plateau on MRI has been documented in patients with ACL tears, and in a unique study by Zheng et al.,[22] increased anterior translation was identified in patients with combined ACL and posterior lateral meniscal root avulsions compared with controls with isolated ACL tears.

Two recent clinical studies report early outcomes following combined ACL reconstruction and repair of posterior lateral meniscal root or oblique radial tears. Shekhar et al.[33] described a series of 25 patients and reported significant improvement in PROs with no revision surgeries for failed ACL reconstruction or meniscal repair failure at a mean follow-up of 37 months. Zhuo et al.[34] reported results for 31 patients who underwent repair of posterior lateral meniscal root tears with a pull-out technique; 26 of the patients in this series underwent concomitant ACL reconstruction. MRI revealed 90% of the root tears healed and second-look arthroscopy in 23 patients demonstrated stable healing in 78% of patients; improved outcomes were reported in patients with complete healing of the meniscal repair.

The development of PTOA following ACL tears has been well documented and is likely partially related to a combination of altered contact mechanics and time-zero chondral injuries. In 2011, Shelbourne et al.[35] reported "mild lateral joint-space narrowing" in patients who underwent ACL reconstruction without repair of a lateral meniscal root tear when compared with controls without a root tear. It is unclear whether the injury severity led to this difference or whether it was due to the lateral meniscal root tear left in situ without repair. Emphasizing the importance of meniscal integrity, in a clinical study with 5- to 15-year follow-up, Shelbourne and Gray[36] reported that partial or total meniscectomy led to inferior results in patients undergoing ACL reconstruction.

## Shumborski et al.'s Study

Shumborski et al.[1] are to be congratulated for conducting a large study of 492 patients with minimum follow-up of 15 years. As is common with large studies with long follow-up, results are typically limited to PROs, and objective measurements including physical examination, functional testing, radiographs, and MRI are not feasible to obtain.

As reported in the methods, all surgeries were performed between 1993 and 1994. The lateral meniscus was intact in 440 patients and "with stable tear" in 52 patients. Per the authors, "Stability was evaluated with a probe, and the meniscus was determined to be stable if the surgeon was unable to move the torn piece into the intercondylar notch or joint." The arthroscopic photos demonstrate the 2 tear patterns which included 28 patients with a root avulsion (Fig 1) and 24 patients with a "parrot-beak" tear of the lateral meniscus adjacent to the root (Fig 2). Classification of these tears as "stable" may cause confusion for readers as Figure 1 demonstrates elevation of the posterior horn with a probe in a patient with a root tear suggesting a complete and unstable tear and Figure 2 demonstrates an unstable appearing "beak tear" adjacent to the meniscal root.

Our understanding of meniscus tears has evolved over the last 3 decades since these patients were treated, and a greater emphasis has been placed on maintaining function of meniscal tissue rather than whether a tear can be displaced "into the intercondylar notch or joint" leading to "mechanical symptoms of locking or catching" as discussed in their limitations section. In the context of knee laxity secondary to an ACL tear, structural integrity is a more important factor for these vertically oriented radial meniscal tears wherein complete fiber disruption implies loss of structural stability and therefore function. Description of the amount of elevation of the meniscus off the tibial plateau, percentage of disrupted root tissue, and whether the meniscofemoral ligaments are torn or intact may be of greater importance when assessing potential influence of the tear on meniscal function. In addition to probing, an "aspiration test" may be performed to assess lateral meniscal stability in the setting of a tear.[37,38]

Graft failure and development of PTOA are 2 significant concerns for ACL reconstruction surgeons and patients alike, and PROs may not be sensitive for the detection of these 2 clinical events. For example, in a recent study where the addition of a lateral extra-articular tenodesis to ACL reconstruction reduced graft failure rates by 60%, no differences in patient reported outcomes were observed between treatment groups.[31] As previously discussed, the LMPR has an important role biomechanically in aiding control of anterolateral translation, acting as a co-stabilizer with the ACL. Loss of function of this structure could potentially lead to increased risk of graft failure. Studies investigating the clinical impact of such tears should therefore investigate ACL graft rupture as a primary end point. Unfortunately, as stated by the authors, this study was underpowered to detect such changes.

Of note, patients in this study who had an unrepaired "stable" tear did have significant increases in their pain severity score and frequency of pain compared with those without this tear pattern. This was not deemed clinically relevant by the authors. At the individual level, however, this might look different.

## Shelbourne Editorial Commentary

Dr. Shelbourne has vast clinical experience and has contributed greatly to the modern treatment of ACL tears. In the editorial commentary written in response

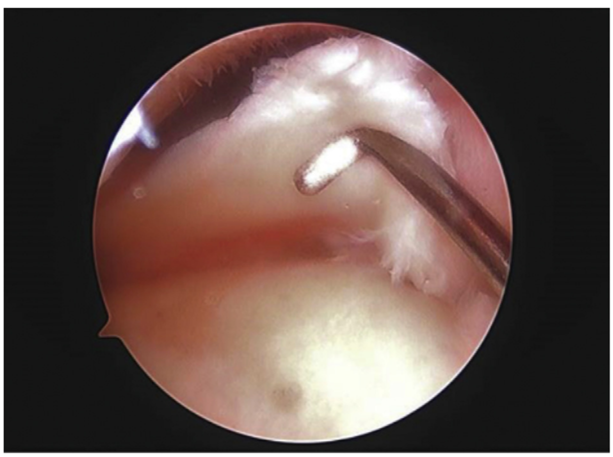

**Fig 1.** An arthroscopic view of a lateral meniscus posterior root tear elevated with a probe is shown. Reprinted from Shumborski et al.[1]

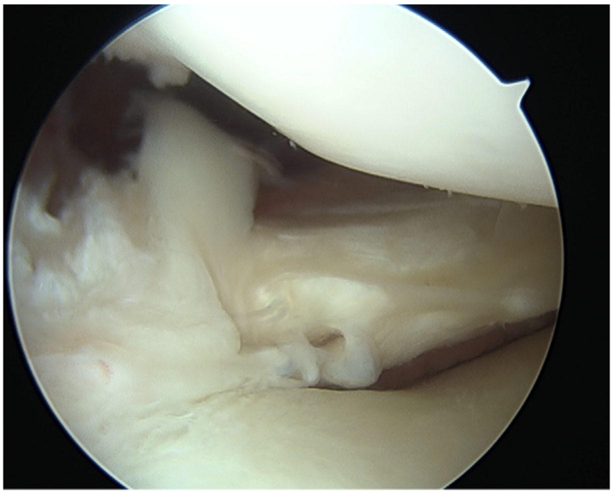

**Fig 2.** An arthroscopic view of a lateral meniscus posterior horn tear is shown. This tear pattern appears consistent with a partial or complete radial oblique subtype described by Krych et al.[10] Reprinted from Shumborski et al.[1]

to the Shumborski study, Dr. Shelbourne offers support for the critical role of rehabilitation for the success of ACL reconstruction and advises surgeons to minimize disruption of weight-bearing and activities.[2] We agree that early range of motion and physical activity is important to ACL reconstruction recovery, but believe that individualization of rehabilitation is necessary for certain meniscal injury patterns.

The Shumborski study was focused on 2 specific tear types, whereas the Shelbourne editorial commentary was more broadly focused on treatment of a variety of meniscal tears patterns in the setting of ACL reconstruction. We believe that some of the discussion points in the Shelbourne editorial commentary may benefit from clarification, specifically concerning weight-bearing, trephination, and meniscal tear types. It was stated that "weight-bearing is critical for meniscal healing, in that it pushes the meniscus against the capsule, whereas non—weight-bearing may cause distraction of the joint, and the meniscus would be pulled into the joint." We agree that weight-bearing as tolerated following repair of vertical peripheral meniscal tears in the setting of ACL reconstruction is advisable; however, biomechanical principles as well as several studies have demonstrated deleterious effects of compressive load through a repaired radial or root meniscal tear.[39]

The concept of trephination for stable meniscal tears was discussed as a potential treatment approach and it was stated that "trephination is easy to perform and essentially mimics the needle stick as applied with sutures, except that you can create many more needle sticks and effectively create blood channels from the periphery into the meniscus." While trephination could have a limited role in select tears, it has been demonstrated that even vertical longitudinal tears propagate upon cyclic loading[40] and therefore preservation of the lateral meniscus in the setting of vertical longitudinal tears is recommended as it has been shown that resection leads to deleterious changes in knee stability and contact mechanics.[41] However, trephination does not have a role for the posterior lateral meniscal root and oblique radial tears described by Shumborski et al.[1] as the issue is loss of meniscal function due to disrupted attachments rather than lack of healing due to poor tissue vascularization.

The importance of classifying meniscal tear types is underscored by the endorsement for "trephination and abrasion with peripheral or posterior LMTs and with peripheral vertical MMTs." Peripheral vertical tears are uniquely different tear types due to intrinsic healing ability due to vascularization as well as the nature of load transmission through the meniscus. We believe that the tear patterns evaluated by Shumborski et al. are biomechanically and clinically different entities than peripheral vertical tears and should not be directly compared.

## Our Philosophy and Treatment Approach

While most patients return to an active lifestyle after ACL reconstruction and do not require revision surgery, there are many patients who are unable to return to their same level of activity and there are certain injury subtypes that may contribute to suboptimal outcomes. Young patients are known to have a high graft failure rate, and this is likely to be multifactorial. In addition, the clinical consequences of progression to PTOA in the youngest athletes are significant, without definitive treatments for this group of patients once joint degeneration is established. The biomechanical and early clinical evidence strongly supports repair of these meniscal tears, and without clinical evidence that documents a clear harm associated with repair, we prefer to err on the side of repair in these patients.

## Future Directions

Expansion of the lateral meniscal root and oblique radial tear classifications to include tear stability with qualitative and quantitative descriptions of findings at the time of diagnostic arthroscopy may improve communication regarding these tears. Specific objective clinical data that would help to guide treatment for this tear pattern include long-term evaluation with weight-bearing radiographs, evaluation of meniscal repair healing and articular cartilage health on MRI, and objective measures of knee stability.

## Limitations

We recognize the patients in the studies by Shumborski et al.[1] and Shelbourne et al.[35] had surgery before the development of root tear classifications and the important biomechanical studies on these tear types performed in the last decade. Further, it is well understood that clinical evidence often lags behind biomechanical evidence. Given the relatively short history of recognition of lateral meniscal root tears and development of mechanically effective repair techniques, it is recognized that limited long-term clinical evidence will be available.

## Conclusions

Repair of posterior lateral meniscal root and oblique radial tears at the time of ACL reconstruction is recommended to improve knee stability and decrease the risk of PTOA. The recommendations from the articles by Shumborski et al.[1] and Shelbourne[2] may lead clinicians to neglect treatment of these important meniscal tears. Meniscal tear stability must be evaluated based on structural integrity and preservation of anatomic attachments rather than propensity for development of intra-articular catching due to tear displacement. We believe that the meniscal repair techniques are straightforward for sports medicine surgeons trained in ACL reconstruction, and that perceived difficulty of repairing these tears may influence the decision to leave the tears in situ without repair. Given the influence of meniscal status on development of PTOA and the influence on quality of life in young active patients, we strongly recommend performing meniscal preservation. Further, revision ACL reconstruction is complex and requires specialized techniques, and repair of chronic lateral meniscal root tears not treated at the index surgery may not be possible.

Robert F. LaPrade, M.D., Ph.D.
*Twin Cities Orthopaedics, Edina, Minnesota, USA*

Andrew G. Geeslin, M.D.
*Larner College of Medicine, University of Vermont, Burlington, Vermont, USA*

Jorge Chahla, M.D., Ph.D.
*Rush University, Chicago, Illinois, USA*

Moises Cohen, M.D., Ph.D.
*Federal University of São Paulo, São Paulo, Brazil*

Lars Engebretsen, M.D., PhD.
*Orthopedic Clinic, University of Oslo, Oslo, Norway*

Scott C. Faucett, M.D., M.S.
*CAO Research Foundation, Washington, DC, U.S.A.*

Alan M. Getgood, M.D., F.R.C.S.
*Fowler Kennedy Sports Medicine Clinic, London, Ontario, Canada*

Eivind Inderhaug, M.D., Ph.D.
*Helse Bergen University Hospital, Bergen, Norway*

Darren L. Johnson, M.D.
*University of Kentucky, Lexington, Kentucky, USA*

Sebastian Kopf, Dr. med
*Medical School Theodor Fontane, Brandenburg, Germany*

Aaron J. Krych, M.D.
*Mayo Clinic, Rochester, Minnesota, USA*

Christopher M. Larson, M.D.
*Twin Cities Orthopedics, Edina, Minnesota, USA*

Martin Lind, M.D., Ph.D.
*Aarhus University Hospital, Arhus, Denmark*

Gilbert Moatshe, M.D., Ph.D.
*University of Oslo, Oslo, Norway*

Iain R. Murray, F.R.C.S., Ph.D.
*Edinburgh Orthopaedics, The University of Edinburgh, Edinburgh, UK*

Volker Musahl, M.D.
*UPMC Freddie Fu Sports Medicine Center Pittsburgh, Pennsylvania, USA*

Roberto Negrin, M.D.
*Clínica las Condes, Santiago, Chile*

Jonathan C. Riboh, M.D.
*Orthocarolina and Atrium Health Musculoskeletal Institute, Charlotte, North Carolina, USA*

Romain Seil, M.D., Ph.D.
*Sports Clinic, Centre Hospitalier de Luxembourg — Clinique d'Eich, Luxembourg, Luxenbourg Institute of Research in Orthopaedics, Sports Medicine and Science, Luxembourg, Human Motion, Orthopaedics, Sports Medicine and Digital Methods, Luxembourg Institute of Health, Luxembourg*

Tim Spalding, F.R.C.S. Orth
*Cleveland Clinic London, London, UK*

**Note:** The authors report the following potential conflicts of interest or sources of funding: R.F.L. is a consultant for Arthrex, Ossur, and Smith & Nephew; receives royalties from Arthrex, Ossur, Smith & Nephew, and Elsevier; and is on the editorial boards of *American Journal of Sports Medicine*, *Journal of Experimental Orthopaedics*, and *Knee Surgery, Sports Traumatology, Arthroscopy*. A.G.G. is on the editorial boards of Arthroscopy and editor of Infographics; a consultant Smith & Nephew; and paid presenter or speaker for

Ossur. J.C. reports other from AOSSM, Arthrex, AANA, Conmed, International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS), Ossur, and Smith & Nephew, outside the submitted work. A.M.G. reports grants and personal fees from Smith & Nephew; grants from Ossur; other from Precision OS and Spring Loaded, outside the submitted work. D.L.J. reports consultancy and royalties from Smith & Nephew. A.J.K. reports personal fees from Smith & Nephew, outside the submitted work. C.M.L. reports personal fees from Smith & Nephew and Responsive Arthroscopy, outside the submitted work. G.M. reports grants and personal fees from Smith & Nephew; other from *Journal of Bone and Joint Surgery*, *Arthroscopy*, and ISAKOS, outside the submitted work. I.R.M. reports personal fees from Stryker and Arthrex, outside the submitted work. Full ICMJE author disclosure forms are available for this letter online, as supplementary material.


*https://doi.org/10.1016/j.arthro.2022.09.015*

## References


1. Shumborski SJ, Salmon LJ, Monk CI, Pinczewski LA. Stable lateral meniscal posterior root tears left in situ at time of anterior cruciate ligament reconstruction are of minimal long-term clinical detriment. *Arthroscopy* 2021;37:3500-3506.
2. Shelbourne KD. Editorial Commentary: Meniscus tears seen at the time of anterior cruciate ligament reconstruction are overtreated. *Arthroscopy* 2021;37:3507-3509.
3. Johannsen AM, Civitarese DM, Padalecki JR, Goldsmith MT, Wijdicks CA, LaPrade RF. Qualitative and quantitative anatomic analysis of the posterior root attachments of the medial and lateral menisci. *Am J Sports Med* 2012;40:2342-2347.
4. Aman ZS, DePhillipo NN, Storaci HW, et al. Quantitative and qualitative assessment of posterolateral meniscal anatomy: Defining the popliteal hiatus, popliteomeniscal fascicles, and the lateral meniscotibial ligament. *Am J Sports Med* 2019;47:1797-1803.
5. Masferrer-Pino A, Saenz-Navarro I, Rojas G, et al. The menisco-tibio-popliteus-fibular complex: Anatomic description of the structures that could avoid lateral meniscal extrusion. *Arthroscopy* 2020;36:1917-1925.
6. West RV, Kim JG, Armfield D, Harner CD. Lateral meniscal root tears associated with anterior cruciate ligament injury: Classification and management (SS-70). *Arthroscopy* 2004;20:E32-E33.
7. LaPrade CM, Jansson KS, Dornan G, Smith SD, Wijdicks CA, LaPrade RF. Altered tibiofemoral contact mechanics due to lateral meniscus posterior horn root avulsions and radial tears can be restored with in situ pull-out suture repairs. *J Bone Joint Surg Am* 2014;96:471-479.
8. Forkel P, Herbort M, Sprenker F, Metzlaff S, Raschke M, Petersen W. The biomechanical effect of a lateral meniscus posterior root tear with and without damage to the meniscofemoral ligament: Efficacy of different repair techniques. *Arthroscopy* 2014;30:833-840.
9. Forkel P, Reuter S, Sprenker F, et al. Different patterns of lateral meniscus root tears in ACL injuries: Application of a differentiated classification system. *Knee Surg Sports Traumatol Arthrosc* 2015;23:112-118.
10. Krych AJ, LaPrade MD, Cook CS, et al. Lateral meniscal oblique radial tears are common with ACL injury: A classification system based on arthroscopic tear patterns in 600 consecutive patients. *Orthop J Sports Med* 2020;8:2325967120921737.
11. Musahl V, Citak M, O'Loughlin PF, Choi D, Bedi A, Pearle AD. The effect of medial versus lateral meniscectomy on the stability of the anterior cruciate ligament-deficient knee. *Am J Sports Med* 2010;38:1591-1597.
12. Forkel P, von Deimling C, Lacheta L, et al. Repair of the lateral posterior meniscal root improves stability in an ACL-deficient knee. *Knee Surg Sports Traumatol Arthrosc* 2018;26:2302-2309.
13. Geeslin AG, Civitarese D, Turnbull TL, Dornan GJ, Fuso FA, LaPrade RF. Influence of lateral meniscal posterior root avulsions and the meniscofemoral ligaments on tibiofemoral contact mechanics. *Knee Surg Sports Traumatol Arthrosc* 2016;24:1469-1477.
14. Smith PA, Bezold WA, Cook CR, et al. Kinematic analysis of lateral meniscal oblique radial tears in the anterior cruciate ligament-deficient knee. *Am J Sports Med* 2021;49:3898-3905.
15. Lording T, Corbo G, Bryant D, Burkhart TA, Getgood A. Rotational laxity control by the anterolateral ligament and the lateral meniscus is dependent on knee flexion angle: A cadaveric biomechanical study. *Clin Orthop Relat Res* 2017;475:2401-2408.
16. Shybut TB, Vega CE, Haddad J, et al. Effect of lateral meniscal root tear on the stability of the anterior cruciate ligament-deficient knee. *Am J Sports Med* 2015;43:905-911.
17. Tang X, Marshall B, Wang JH, et al. Lateral meniscal posterior root repair with anterior cruciate ligament reconstruction better restores knee stability. *Am J Sports Med* 2019;47:59-65.
18. Forkel P, Herbort M, Schulze M, et al. Biomechanical consequences of a posterior root tear of the lateral meniscus: Stabilizing effect of the meniscofemoral ligament. *Arch Orthop Trauma Surg* 2013;133:621-626.
19. Perez-Blanca A, Espejo-Baena A, Amat Trujillo D, et al. Comparative biomechanical study on contact alterations after lateral meniscus posterior root avulsion, transosseous reinsertion, and total meniscectomy. *Arthroscopy* 2016;32:624-633.
20. Minami T, Muneta T, Sekiya I, et al. Lateral meniscus posterior root tear contributes to anterolateral rotational instability and meniscus extrusion in anterior cruciate ligament-injured patients. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1174-1181.
21. Musahl V, Rahnemai-Azar AA, Costello J, et al. The influence of meniscal and anterolateral capsular injury on

knee laxity in patients with anterior cruciate ligament injuries. *Am J Sports Med* 2016;44:3126-3131.
22. Zheng T, Song GY, Feng H, et al. Lateral meniscus posterior root lesion influences anterior tibial subluxation of the lateral compartment in extension after anterior cruciate ligament injury. *Am J Sports Med* 2020;48:838-846.
23. Feucht MJ, Bigdon S, Mehl J, et al. Risk factors for posterior lateral meniscus root tears in anterior cruciate ligament injuries. *Knee Surg Sports Traumatol Arthrosc* 2015;23:140-145.
24. Magosch A, Mouton C, Nuhrenborger C, Seil R. Medial meniscus ramp and lateral meniscus posterior root lesions are present in more than a third of primary and revision ACL reconstructions. *Knee Surg Sports Traumatol Arthrosc* 2021;29:3059-3067.
25. DePhillipo NN, Dekker TJ, Aman ZS, Bernholt D, Grantham WJ, LaPrade RF. Incidence and healing rates of meniscal tears in patients undergoing repair during the first stage of 2-stage revision anterior cruciate ligament reconstruction. *Am J Sports Med* 2019;47:3389-3395.
26. Sanders TL, Maradit Kremers H, Bryan AJ, et al. Incidence of anterior cruciate ligament tears and reconstruction: A 21-year population-based study. *Am J Sports Med* 2016;44:1502-1507.
27. Cinque ME, Dornan GJ, Chahla J, Moatshe G, LaPrade RF. High rates of osteoarthritis develop after anterior cruciate ligament surgery: An analysis of 4108 patients. *Am J Sports Med* 2018;46:2011-2019.
28. Costa-Paz M, Garcia-Mansilla I, Marciano S, Ayerza MA, Muscolo DL. Knee-related quality of life, functional results and osteoarthritis at a minimum of 20 years' follow-up after anterior cruciate ligament reconstruction. *Knee* 2019;26:666-672.
29. Lindanger L, Strand T, Molster AO, et al. Predictors of osteoarthritis development at a median 25 years after anterior cruciate ligament reconstruction using a patellar tendon autograft. *Am J Sports Med* 2022;50:1195-1204.
30. Oiestad BE, Engebretsen L, Storheim K, Risberg MA. Knee osteoarthritis after anterior cruciate ligament injury: A systematic review. *Am J Sports Med* 2009;37:1434-1443.
31. Getgood AMJ, Bryant DM, Litchfield R, et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285-297.
32. Horvath A, Meredith SJ, Nishida K, Hoshino Y, Musahl V. Objectifying the pivot shift test. *Sports Med Arthrosc Rev* 2020;28:36-40.
33. Shekhar A, Tapasvi S, Williams A. Outcomes of combined lateral meniscus posterior root repair and anterior cruciate ligament reconstruction. *Orthop J Sports Med* 2022;10:23259671221083318.
34. Zhuo H, Pan L, Xu Y, Li J. Functional, magnetic resonance imaging, and second-look arthroscopic outcomes after pullout repair for avulsion tears of the posterior lateral meniscus root. *Am J Sports Med* 2021;49:450-458.
35. Shelbourne KD, Roberson TA, Gray T. Long-term evaluation of posterior lateral meniscus root tears left in situ at the time of anterior cruciate ligament reconstruction. *Am J Sports Med* 2011;39:1439-1443.
36. Shelbourne KD, Gray T. Results of anterior cruciate ligament reconstruction based on meniscus and articular cartilage status at the time of surgery. Five- to fifteen-year evaluations. *Am J Sports Med* 2000;28:446-452.
37. Jacquet C, Magosch A, Mouton C, Seil R. The aspiration test: An arthroscopic sign of lateral meniscus posterior horn instability. *J Exp Orthop* 2021;8:17.
38. Jacquet C, Mouton C, Magosch A, et al. The aspiration test reveals an instability of the posterior horn of the lateral meniscus in almost one-third of ACL-injured patients. *Knee Surg Sports Traumatol Arthrosc* 2022;30:2329-2335.
39. Robinson JR, Frank EG, Hunter AJ, Jermin PJ, Gill HS. The strength of transosseous medial meniscal root repair using a simple suture technique is dependent on suture material and position. *Am J Sports Med* 2018;46:924-932.
40. Novaretti JV, Herbst E, Chan CK, Debski RE, Musahl V. Small lateral meniscus tears propagate over time in ACL intact and deficient knees. *Knee Surg Sports Traumatol Arthrosc* 2021;29:3068-3076.
41. Novaretti JV, Lian J, Patel NK, et al. Partial lateral meniscectomy affects knee stability even in anterior cruciate ligament-intact knees. *J Bone Joint Surg Am* 2020;102:567-573.

## "Nothing Ruins a Good Operation … Like Clinical Follow-Up": Author Reply to "Posterior Lateral Meniscal Root and Oblique Radial Tears: The Biomechanical Evidence Supports Repair of These Tears, Although Long-Term Clinical Studies Are Necessary"

We are honored that Dr. Robert LaPrade and this eminent group of surgeons took such an interest in this study. They present an extensive review of the biomechanical and laboratory evidence to support repair of lateral meniscus posterior horn root tears. We do not dispute these findings, and we agree with their conclusions that repair has a strong biomechanical basis to expect improvement of clinical outcomes and avoid premature osteoarthritis. There is currently an absence of clinical evidence to confirm these expectations. Our study, with its limitations, presents the only long-term natural history of untreated lateral meniscal posterior horn lesions in the context of anterior cruciate ligament