Received: 21 February 2024 | Accepted: 2 April 2024

DOI: 10.1002/ksa.12183



# Meniscal extrusion consensus statement: A collaborative survey within the Meniscus International Network (MenIN) Study Group

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**Funding information**
None

## Abstract

**Purpose:** The purpose of the present study was to perform a survey administered to members of the Meniscus International Network (MenIN) Study Group, seeking to delineate the most contentious aspects of meniscal extrusion classification and provide a foundation for new, more comprehensive definitions and treatments for these pathologies.

**Methods:** MenIN Study Group is a group of international experts treating and performing research on meniscus pathology and treatment. All MenIN Study Group members were asked to complete a survey aimed at establishing criteria for the optimal classification system for meniscal extrusion. Data obtained from the completed questionnaires were transferred into a spreadsheet and then analysed. All responses are presented as counts, percentages or means.

**Results:** Forty-seven (85.5%) MenIN Study Group members completed the survey and were included in this analysis. Key aspects recommended for inclusion in a comprehensive classification system for meniscal extrusion included laterality (93.6%), anatomical location (76.6%), patient age (76.6%), body mass index (BMI) (68.1%) and aetiology (68.1%). For classifying meniscal extrusion, 53.2% considered the distance in millimetres from the tibial plateau's outer margin as the most reliable measurement technique on imaging. Preferences for imaging modalities varied, with 44.7% favouring weight-bearing magnetic resonance imaging (MRI) and 36.2% opting for weight-bearing ultrasound due to its greater availability. Respondents advocated for a classification system addressing stability or progression of meniscal extrusion (66%), reducibility (53.2%), potential progression of knee osteoarthritis (OA) (83%), influencing treatment approaches (83%), a gradation system (83%), consideration of dynamic factors (66%), association with clinical outcomes and prognosis (76.6%) and investigation around centralization procedures (57.4%).

**Conclusions:** In conclusion, the findings of this survey shed light on the global perspectives regarding meniscal extrusion classification. It was generally felt that a new classification of extrusion measured on MRI scans at the mid-tibial plateau should be developed, which considers factors such as laterality, anatomical location, age, BMI and aetiology. Additionally, the

**Abbreviations:** BMI, body mass index; MenIN, Meniscus International Network; MRI, magnetic resonance imaging; OA, osteoarthritis; US, ultrasound.

results support the integration of dynamic factors and clinical outcomes in MRI-based classifications to inform treatment approaches.

**Level of Evidence:** Level IV.

**KEYWORDS**
classification, extrusion, international, meniscus, survey

## INTRODUCTION

A multitude of traumatic or degenerative lesions affecting meniscal, capsular or osseous structures may result in pathological displacement of the meniscus beyond the tibial border, also called meniscal extrusion. The displacement of the meniscus induces biomechanical alterations in the knee joint, which have the potential to instigate progressive cartilage damage, ultimately leading to osteoarthritis (OA) [14]. Meniscal root lesions are frequently cited as a primary causative factor for meniscal extrusion [10, 11], with surgical repair becoming a standard of care amongst specialized knee surgeons. However, the pathomechanism of meniscal extrusion is complex, with some authors reporting degenerative changes and other pathology affecting the meniscus stability leading to meniscal extrusion ultimately leading to meniscal root tear [12, 18, 19]. Nonetheless, various authors underscore the role of diverse factors, advocating concurrent stabilization techniques, such as meniscal centralization using anchors at the tibial rim, meniscotibial ligament repair, deep medial collateral ligament repair or circumferential suture augmentation of the meniscus [29].

Meniscal extrusion has garnered substantial attention amongst knee surgeons, with recent years witnessing the emergence of numerous studies and classification systems designed to improve understanding of the pathology and clinical implications [3, 14, 20, 29]. These frameworks aim to augment our understanding of the aetiology, biomechanical repercussions and clinical implications of meniscal extrusion. Notably, these classifications exhibit divergence in their methodologies, encompassing measurements in millimetres to percentages of extrusion, and a consensus on this matter remains elusive [28]. The absence of unanimity in measurement techniques underscores the technical challenges inherent in comprehending and standardizing the assessment of meniscal extrusion. Ongoing research endeavours and collaborative efforts amongst experts are imperative to ultimately establish a unified comprehension within this critical domain of knee biomechanics.

The Meniscus International Network (MenIN) Study Group constitutes an international research consortium comprising fully trained orthopaedic and sport trauma surgeons, with a dedicated focus on meniscal pathologies in the knee. The primary objective of the MenIN Study Group is to aggregate data and experiences from diverse national settings, facilitating the formulation of high-level recommendations for the broader sport trauma community. The purpose of the present study was to present the findings of a survey administered to members of the MenIN Study Group, seeking to delineate the most contentious aspects of meniscal extrusion classification and provide a foundation for new, more comprehensive definitions and treatments for these pathologies. It was hypothesized that there would be an agreement for most concepts pertaining to meniscal extrusion between experts in the field.

## MATERIALS AND METHODS

All MenIN Study Group members were asked to complete a survey aimed at establishing criteria for the optimal classification system for meniscal extrusion. The survey was a self-administered questionnaire in English that was built using Google Forms, a free open-source software survey tool that is available on the internet. The survey was sent via email to 55 experts in meniscus surgery (i.e., highly skilled and experienced professionals with specialized knowledge and proficiency in performing surgical procedures related to the meniscus) on 8 December 2023. An email follow-up survey was sent shortly afterwards. Within the email, the invitees were provided with a brief explanation of the purpose of the survey and were asked to click on a link that would lead them to the appropriate version of the survey. The survey required approximately 5–10 min to complete. The survey needed to be brief to maximize the response rate. The survey was closed on 20 January 2014. Data obtained from the completed questionnaires were transferred in a spreadsheet and then analysed using Microsoft Excel (Microsoft Office 365 for Windows). All responses are presented as counts, percentages or means [21].

## RESULTS

### Study participants

Forty-seven out of 55 members of the MenIN Study Group (85.5%) completed the survey from 20 countries across five continents (Figure 1). Participants were affiliated with


**FIGURE 1** Distribution of survey participants for meniscus extrusion worldwide.

44 different institutions, including 33 (75%) public hospitals and 11 (25%) private hospitals. Amongst public institutions, 19 (58%) were university hospitals. The most represented country was Italy, contributing 11 (23%) participants from nine institutions.

## Anatomy and patient demographics for meniscal extrusion

Forty-two participants (89.4%) agreed on the importance of considering laterality (distinguishing between medial and lateral meniscal extrusion), and 35 participants (76.1%) advocated for including anatomic location (anterior, middle and posterior). Key aspects recommended for inclusion in a comprehensive classification system for meniscal extrusion included laterality (44 participants, 93.6%), anatomical location (36 participants, 76.6%), age (36 participants, 76.6%), body mass index (BMI; 32 participants) (68.1%) and aetiology (32 participants, 68.1%) (Figure 2).

## Diagnosis and imaging

Notably, 45 respondents (95.7%) currently use magnetic resonance imaging (MRI) to quantify meniscal extrusion. Additionally, 13 participants (27.7%) also utilize ultrasound (US) in conjunction with MRI (Figure 3).

For classifying meniscal extrusion, 25 participants (53.2%) considered the distance in millimetres from the tibial plateau's outer margin as the most reliable measurement technique on imaging. Preferences for imaging modalities varied, with 21 participants (44.7%) favouring weight-bearing MRI and 17 participants (36.2%) opting for weight-bearing US due to its greater availability. On coronal MRI scans, determining the level of meniscal extrusion was considered most

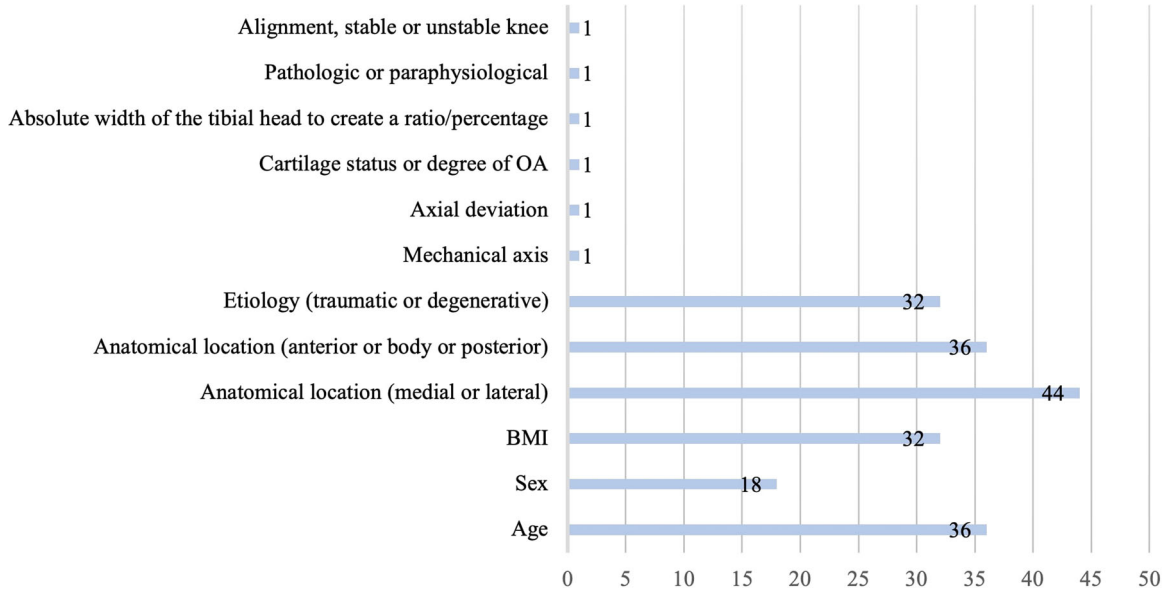


**FIGURE 2** Patient-specific aspects that participants believe should be included in a comprehensive classification system for meniscal extrusion. BMI, body mass index; OA, osteoarthritis.

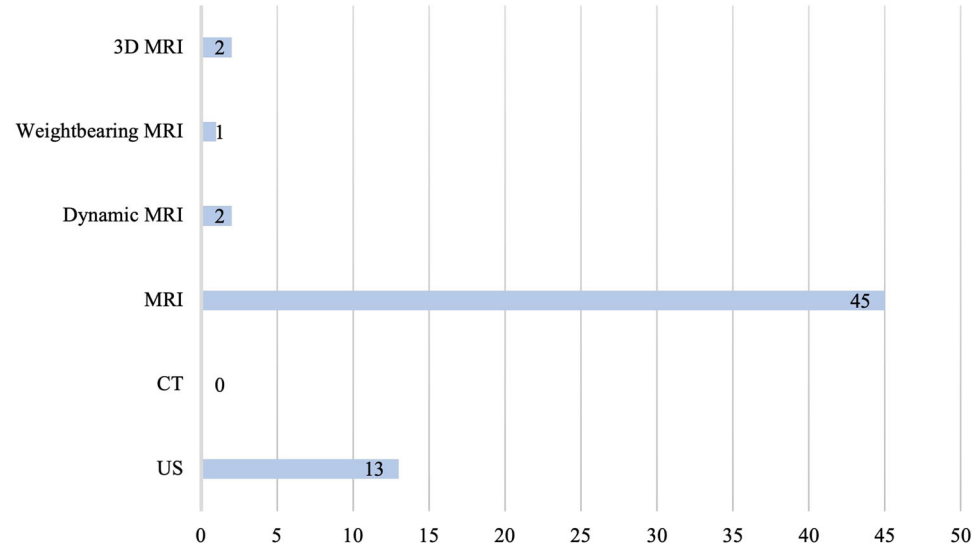


**FIGURE 3** Imaging techniques currently used by participants to quantify or measure the extent of meniscal extrusion. 3D, three-dimensional; CT, computed tomography; MRI, magnetic resonance imaging; US, ultrasound.

appropriate using the coronal view in the middle of the anteroposterior sagittal scan by 22 participants (46.8%) of respondents. While 82.9% identified knee flexion as an issue in classification, 30 participants (63.8%) still recommended a reliable classification based on exams in extension. For MRI, 35 participants (74.5%) suggested 1.5 Tesla, and 11 participants (23.4%) recommended 3.0 Tesla for sufficient accuracy. Challenges associated with imaging techniques included differences in MRI quality (28 participants, 59.6%) and operator-dependency for US (14 participants, 29.8%).

## Biomechanics

Biomechanical concepts leading to symptoms included reduced force distribution causing cartilage overload (25 participants, 53.2%) and changes in knee biomechanics leading to soft tissue overload and pain (10 participants, 21.3%). Respondents advocated for a classification system addressing stability or progression of meniscal extrusion (31 participants, 66%), reducibility (25 participants, 53.2%), potential progression of knee OA (83%), influencing treatment

approaches (39 participants, 83%), a gradation system (39 participants, 83%), consideration of dynamic factors (31 participants, 66%), association with clinical outcomes and prognosis (36 participants, 76.6%) and investigation around centralization procedures (27 participants, 57.4%).

## Concomitant pathologies

Conditions accompanying meniscal extrusion that should be considered in evaluation included OA (42 participants, 89.4%), radial tears (32 participants, 68.1%), root tears (40 participants, 85.1%), ramp lesions (12 participants, 25.5%) and meniscotibial ligament lesions (22 participants, 46.8%) (Figure 4).

## Validation study

Prospective validation was deemed the best approach, with 28 participants (59.6%) favouring a validation study on new data collected after developing the classification system to demonstrate its reliability, validity and clinical relevance.

# DISCUSSION

The current study, conducted by the MenIN Study Group, aimed to elucidate contentious aspects of meniscal extrusion classification and lay the groundwork for improving uniformity of assessing meniscal extrusion. The survey, completed by an expert consensus group from diverse global settings, highlighted several key findings. There was a consensus amongst participants regarding the importance of considering factors such as laterality, anatomical location, age, BMI and aetiology in meniscal extrusion classification. The majority of respondents (>95%) favoured MRI as the primary modality for quantifying meniscal extrusion, with a nearly a third of respondents also utilizing US in conjunction with MRI. Preferences for measurement techniques and imaging modalities varied, reflecting the need for standardized protocols for classifying meniscal extrusion.

Based on the responses of surgeons in this study, various elements, such as patients' characteristics (e.g., age and BMI), specific tear attributes (laterality and anatomical location) and aetiology, should be considered when devising a comprehensive classification system. Specifically, weight loss and a low BMI have previously been reported to positively affect meniscal extrusion and meniscal healing following posterior medial meniscus root repair, highlighting the importance of BMI for both classification and prognosis [13]. Considering the implications of a meniscal extrusion classification system, respondents in the current study advocated for a classification addressing OA progression, treatment approaches, a grading system, clinical outcomes/prognosis, stability or progression of meniscal extrusion, dynamic factors, centralization procedures and reducibility [23]. Various classification systems have been proposed to categorize meniscal extrusion, and these existing systems aim to provide clinicians with standardized frameworks for assessing the severity, stability and prognostic implications of meniscal extrusion [1, 3]. One commonly cited classification system is the Stoller classification, which categorizes meniscal extrusion into three

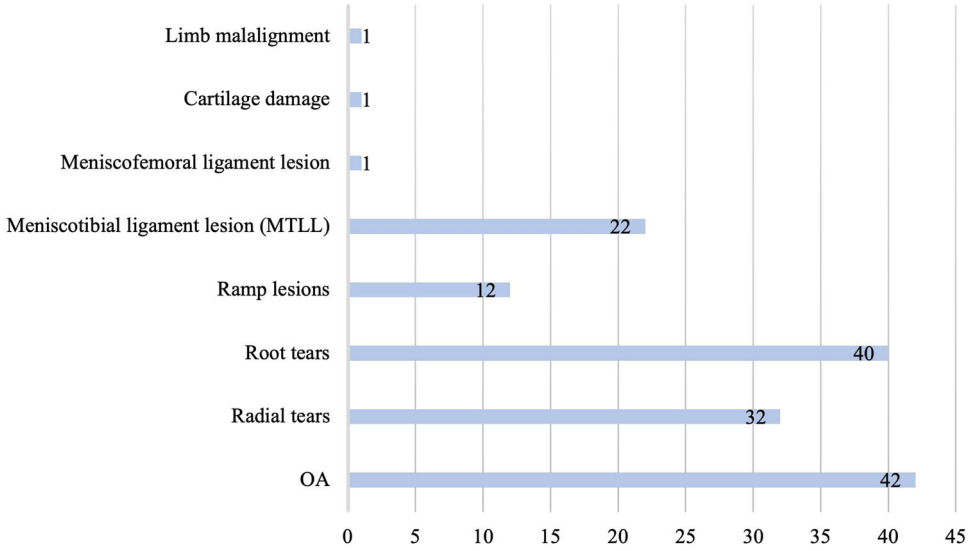


**FIGURE 4** Specific conditions or coexisting pathologies that frequently accompany meniscal extrusion that the classification system should consider for a more comprehensive evaluation. OA, osteoarthritis.

grades based on the extent of extrusion relative to the tibial plateau [27]. Another classification system was proposed by Englund et al. [7], which focused on the dynamic nature of meniscal extrusion, considering factors such as stability, reducibility and progression over time. This system categorizes meniscal extrusion into stable or unstable based on the presence or absence of extrusion with weight-bearing. Additionally, Englund et al. [7] emphasized the importance of assessing reducibility, defined as the ability to reduce extrusion with knee flexion, as a predictor of treatment response and prognosis. By considering these other necessary factors such as stability, reducibility and dynamic behaviour, the results of the current expert consensus may be used to refine such classification systems and provide clinicians with a more comprehensive and standardized assessment of meniscal extrusion to improve patient care.

The emphasis on MRI for assessing meniscal extrusion in the current study aligns with previous studies highlighting its accuracy and detail in anatomical evaluation [17, 24]. However, the incorporation of US alongside MRI may represent a novel approach, potentially offering complementary information in cases where MRI is limited or unavailable. In a systematic review and meta-analysis of 45 studies assessing meniscal extrusion measurements, Farivar et al. [9] reported that 89% used MRI and only 2% used a combination of MRI and US. Although low reported use clinically, US has been validated in previous studies as a reliable modality to quantitatively assess meniscal extrusion. In a prospective study comparing meniscal extrusion on MRI versus US, authors reported substantial agreement between imaging modalities (intraclass correlation coefficients >0.70) with US having excellent sensitivity (96%) and good specificity (82%) [25]. The consensus on factors to be included in a comprehensive classification system echoes suggestions from prior research, emphasizing the importance of a multifaceted approach to accurately characterize meniscal pathology. Recent studies have demonstrated the effectiveness of MRI in assessing meniscal extrusion. Crema et al. [5] highlighted the utility of high-resolution MRI techniques in detecting meniscal pathology, including extrusion, with a high level of sensitivity and specificity. However, prior studies have shown that substantial variation exists in measurement techniques for meniscal extrusion, especially with the use of different imaging modalities and sequences [9]. The results of this survey confirm the variability in preferences for imaging modalities and measurement techniques and therefore future studies should aim to classify meniscal extrusion using more uniform methodology to allow comparisons and pooling between studies [15].

For classifying meniscal extrusion, most considered the distance in millimetres from the tibial plateau's outer margin as the most reliable measurement technique on imaging, the coronal view was considered most appropriate, and a 1.5 Tesla MRI magnet was considered sufficiently accurate for assessing meniscal extrusion. Farivar et al. [9] reported that the three most commonly used landmarks to acquire coronal images for meniscal extrusion measurements were the medial collateral ligament (38%), the midpoint of the anterior–posterior length of the medial meniscus (23%) and the middle of the medial femoral condyle (19%). Authors noted that the pooled mean extrusion values according to the measurement location were 3.5 ± 0.7, 3.9 ± 0.8 and 4.5 ± 2.1 mm, respectively, with no significant differences noted between the modality types (i.e., MRI, CT, US). Rao et al. [26] reported that measuring the distance from the tibial plateau's outer margin yielded consistent and reproducible results, and by comparing MRI images to arthroscopic findings, the authors demonstrated the validity of this measurement technique in accurately assessing meniscal extrusion, thus corroborating the findings of the current study. Through a systematic evaluation of MRI scans from a large cohort of patients, Bloecker et al. [2] concluded that the coronal view provided the most detailed and reliable assessment of meniscal extrusion. This aligns with the preference observed in the current study, further supporting the utility of the coronal view in accurately characterizing meniscal extrusion.

Regarding the choice of MRI magnet strength, several studies have explored the impact of different field strengths on the assessment of meniscal extrusion. Englund et al. [8] compared the diagnostic performance of 1.5 and 3.0 Tesla MRI magnets in detecting meniscal pathology and found that both field strengths provided sufficient accuracy for assessing meniscal extrusion. A systematic review by Zhang et al. [30] evaluated the diagnostic performance of MRI in assessing meniscal extrusion and identified 1.5 Tesla MRI as the most commonly used magnet strength in clinical practice, supporting its widespread use in clinical settings. These findings corroborate the preference for MRI to diagnose meniscal extrusion observed in the current study and reinforce its standing as a primary imaging modality for evaluating meniscal extrusion.

The current study, in line with previous research, highlights knee OA, meniscal root tears and meniscal radial tears as the most prevalent concomitant pathologies that should be considered when assessing meniscal extrusion. Numerous studies have investigated the association between meniscal extrusion and concomitant pathologies, shedding light on the importance of considering additional knee abnormalities in the evaluation of meniscal extrusion [4, 6], Englund et al. [7] conducted a longitudinal cohort study to examine the relationship between meniscal extrusion and knee OA. The authors found a strong association

between meniscal extrusion and the development and progression of knee OA, with extrusion being a significant predictor of cartilage loss and joint space narrowing. Similarly, meniscal root tears have emerged as a significant concern in the context of meniscal extrusion. Marzo et al. [22] demonstrated that meniscal root tears were strongly associated with increased extrusion and were predictive of poor clinical outcomes, highlighting the importance of assessing root integrity when evaluating meniscal extrusion. In a retrospective study by Katz et al. [16], which investigated the prevalence and characteristics of meniscal radial tears, the authors reported that radial tears were often associated with increased extrusion and were indicative of advanced meniscal degeneration. Overall, the findings from these studies underscore the importance of considering additional knee pathologies when evaluating meniscal extrusions. Knee OA, meniscal root tears and meniscal radial tears have been consistently identified as prevalent concomitant pathologies associated with meniscal extrusion, emphasizing the need for comprehensive assessment and management strategies in patients with meniscal pathology.

Limitations of the current study include the reliance on survey data, which may be subject to respondent bias and interpretation variability. Additionally, the study's focus on expert opinions within the MenIN Study Group may limit the generalizability of findings to broader medical communities. Future research could involve prospective validation studies to confirm the reliability and clinical relevance of proposed classification systems. Using the current study results and consensus, new meniscal extrusion classification systems may be designed to reflect the dynamic factors influencing meniscal extrusion to better align clinicians and scientists and thus further improve diagnostic accuracy and patient outcomes.

## CONCLUSIONS

In conclusion, the findings of this survey shed light on the global perspectives regarding meniscal extrusion classification. It was generally felt that a new classification of extrusion measured on MRI scans at the mid-tibial plateau should be developed which considers factors such as laterality, anatomical location, age, BMI and aetiology.

### AUTHOR CONTRIBUTIONS

*Substantial conception/design of work*: Filippo Familiari, Jorge Chahla, Riccardo Compagnoni, Nicholas N. DePhillipo, Gilbert Moatshe and Robert F. LaPrade. *Data collection*: Filippo Familiari and Riccardo Compagnoni. *Data analysis*: Filippo Familiari, Riccardo Compagnoni and Nicholas N. DePhillipo. *Interpretation of data*: Filippo Familiari, Jorge Chahla, Gilbert Moatshe and Robert F. LaPrade. *Drafting the work*: Filippo Familiari, Riccardo Compagnoni and Nicholas N. DePhillipo. *Critically revising the work*: Jorge Chahla, Gilbert Moatshe and Robert F. LaPrade. *Manuscript preparation*: Filippo Familiari, Riccardo Compagnoni and Nicholas N. DePhillipo. *Approving final version for publication*: All authors. *Agreement for accountability of all aspects of work*: All authors. All authors have read and approved the final submitted manuscript.

### ACKNOWLEDGEMENTS

The authors have no funding to report.

### MENISCUS INTERNATIONAL NETWORK (MenIN) STUDY GROUP

Paolo Adravanti, Corrado Bait, Philippe Beaufils, Roland Becker, Giuseppe Calafiore, Jourdan Cancienne, Kai-Ming Chan, Brian J. Cole, Vincenzo Condello, Pieter D'Hooghe, Travis J. Dekker, Lars Engebretsen, João Espregueira-Mendes, Scott C. Faucett, Takayuki Furumatsu, Andrew G. Geeslin, Safa Gursoy, Camilo Partezani Helito, Gazi Huri, Jin Goo Kim, Hideyuki Koga, Sebastian Kopf, Christopher M. Larson, Sang Hak Lee, Rodrigo Maestu, Vincenzo Madonna, Giulio Maria Marcheggiani Muccioli, Pier Paolo Mariani, Jacques Menetrey, Joan Carles Monllau, Iain R. Murray, Roberto Negrín, David A. Parker, Simone Perelli, Jonas Pogorzelski, Nicolas Pujol, Kristian Samuelsson, Romain Seil, Roberto Simonetta, Robert Śmigielski, Elvire Servien, Bertrand Sonnery-Cottet, Tim Spalding, Ciara Stevenson, Sachin Tapasvi, René Verdonk, Peter Verdonk, Gustavo Vinagre, Stefano Zaffagnini.

### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

### DATA AVAILABILITY STATEMENT

The raw data and materials supporting the findings of this study are available upon request from the corresponding author.

### ETHICS STATEMENT

Not applicable.

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**How to cite this article:** Familiari, F., Chahla, J., Compagnoni, R., DePhillipo, N. N., Moatshe, G., LaPrade, R. F. et al. Meniscal extrusion consensus statement: a collaborative survey within the Meniscus International Network (MenIN) Study Group. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2024;1–9. https://doi.org/10.1002/ksa.12183