International Delphi Consensus on Medial Meniscal Root Tears Shows High Agreement on Diagnosis, Treatment, and Rehabilitation but Lack of Agreement on Treatment of Asymptomatic Tears

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Purpose: To develop an expert consensus statement on the diagnosis, management, and rehabilitation of medial meniscal root tears (MMRTs) using a modified Delphi technique. **Methods:** A working group developed statements on MMRT diagnosis, nonoperative management, surgical indications, surgical management, alignment, and rehabilitation using modified Delphi techniques. Fifty-six experts were surveyed over 3 rounds to reach consensus, with agreement measured on a 5-point Likert scale. Statements were included, revised, or excluded on the basis of predefined thresholds ($\geq$75% agreement, $<$20% disagreement). Experts suggested revisions or new statements in the first 2 rounds, and final consensus statements were included. **Results:** All 56 experts completed 3 survey rounds. Experts agreed that root tears may occur with no known history of trauma, typically in older patients, and that it should be diagnosed with an magnetic resonance imaging. In symptomatic patients with MMRTs without advanced osteoarthritis should be repaired using an anatomic transtibial pull-out technique (performing a pie-crusting technique can be helpful for visualization). Nonoperative management is advised for patients with advanced osteoarthritis. High tibial osteotomy may be considered for significant varus malalignment during MMRT repair. The only statement without consensus was the management of asymptomatic MMRTs with mild medial compartment cartilage wear, indicating ongoing debate. **Conclusions:** Overall, 98% of statements reached consensus. There is agreement that magnetic resonance imaging is the gold standard for diagnosis. Symptomatic MMRTs without advanced osteoarthritis should be repaired early using an anatomic transtibial pull-out technique. End-stage knee osteoarthritis warrants nonoperative management of MMRTs, and a structured postoperative protocol with limited weightbearing and range of motion is essential after repair. No agreement was reached on managing asymptomatic MMRTs in patients without significant medial compartment degeneration. Meniscal centralization sutures may help in cases of substantial extrusion, but their routine use is debated. **Level of Evidence:** Level V, consensus of expert opinion.

Medial meniscus root tears (MMRTs) are a common, yet often underdiagnosed, cause of knee pathology, particularly in older patients, where they present as degenerative lesions.[1,2] If left untreated, MMRTs often lead to rapid progression of knee osteoarthritis (OA) as a result of compromised hoop stress distribution.[1,2] Historically overlooked, these injuries have been reported to account for up to 27% of all meniscal tears and are recognized as a significant contributor to progression of knee OA.[3-6] Although

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surgical repair typically is recommended for younger, active individuals, the decision to proceed with surgery in asymptomatic or older patients depends on factors such as meniscal quality, alignment, and the severity of underlying OA.[7] Despite advancements in diagnostic imaging, surgical techniques, and rehabilitation strategies, outcomes after MMRT repair remain influenced by multiple factors, including severity of OA preoperatively, the presence of subchondral insufficiency fractures, and the degree of meniscal extrusion (ME).[8-16]

Although there is general agreement on the indications for a MMRT repair, significant variability exists in clinical decision-making because of the complexity of these injuries and the lack of standardized treatment guidelines.[10-12] Although it is well established that MMPRTs should be repaired in symptomatic patients without advanced OA when MRI confirms a clear tear,[13-21] there is currently no evidence guiding the management of asymptomatic patients with MMPRT. Several unresolved questions remain regarding the role of concomitant valgus-producing osteotomy, upper age limits for surgery, optimal management of ME, and contraindications related to OA severity.[10] These gaps may contribute to inconsistencies in diagnostic, treatment, and rehabilitation protocols, underscoring the need for a standardized approach.[10,15]

The purpose of the current study was to develop an expert consensus statement on the diagnosis, management, and rehabilitation of MMRTs using a modified Delphi technique. The authors hypothesized that by establishing standardized recommendations, this consensus would aid in refining clinical decision-making while identifying critical areas where further research is needed to improve patient care.

Methods

Study Design

A comprehensive literature review was conducted using MEDLINE, Embase, Scopus, and Google Scholar with the following search terms: "meniscus root tear," "medial meniscus posterior root tear," "diagnosis medial meniscus root tear," "treatment medial meniscus root tear," "medial meniscus posterior root repair," "physical therapy," and "physiotherapy." Articles were manually cross-referenced to ensure all relevant studies were included. A full-text review was performed for all eligible articles. On the basis of published literature, a working group of 5 individuals (J.C., J.R.G., L.T., A.J.K., and R.F.L.) facilitated the development of open-ended statements guided by the most important clinical research questions that remain to be addressed.[16,17] Figure 1 outlines the process used to develop the expert consensus. A comprehensive list of statements was generated across 6 categories: diagnosis, nonoperative management, surgical indications, surgical management, alignment, and rehabilitation and recovery. These categories were designed to encompass a broad range of concepts essential for the effective understanding and management of MMRTs. The expert panel was surveyed for 3 rounds to establish consensus on the inclusion or exclusion of each statement.

Identification of Statements for Inclusion in the First-Round Survey

Potential statements for inclusion in the first-round survey were developed by the working group on the basis of recently published studies, including scoping reviews, systematic reviews, and meta-analyses on various aspects of MMRTs. Online surveys were created to enable respondents to evaluate whether these statements should be included in an expert consensus document on MMRTs. Respondents rated their agreement using a 5-point Likert scale with options being "strongly agree," "agree," "neither agree nor disagree," "disagree," or "strongly disagree."

All members of the International Meniscus Root Expert Group were invited to evaluate the statements. A self-administered questionnaire in English was developed using Google Forms, an open-access online survey tool. The survey was distributed via email to 56 recognized experts in meniscus surgery. A follow-up email was sent shortly thereafter, which included a brief explanation of the survey's purpose and a direct link to access the appropriate version of the questionnaire.

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Received April 8, 2025; accepted June 9, 2025.

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0749-8063/25635/$36.00
https://doi.org/10.1016/j.arthro.2025.06.028

In addition to rating their agreement, experts were encouraged to propose additional items or suggest modifications through a free-text comment section during the first 2 rounds. To ensure face validity, clarity, and acceptability, the survey was initially piloted by 5 experts, resulting in minor revisions based on their feedback.

Establishing Consensus Using Delphi Methods

The modified Delphi method was employed to achieve group consensus on the inclusion of statements in an expert consensus document addressing the diagnosis and management of MMRTs. Although there is no universally accepted definition of an expert, the following criteria were considered when selecting panel members: a minimum of 5 years of clinical practice posttraining; specialization in sports medicine with a focus on meniscal injuries; and active surgical practice at high-volume centers managing knee pathologies. In addition, candidates were required to meet at least 1 of the following criteria: (1) authorship of peer-reviewed publications on MMPR injuries, or participation in clinical trials, multicenter studies, or preclinical research; (2) active membership in international committees, service on the editorial boards of leading sports medicine journals, or frequent invitations to speak on meniscal root pathology at international conferences; or (3) previous experience with Delphi panels, guideline development, or consensus statement initiatives. The aforementioned criteria facilitated broad international participation, thus enhancing the validity and reliability of the consensus process.

Among the participants, 21 (37.5%) were from Europe, 19 (33.9%) from North America, 6 (10.7%) from Asia, 5 (8.9%) from South America, 2 (3.6%) from the Middle East, 2 (3.6%) from Oceania, and 1 (1.8%) from Africa. The findings from the literature review were summarized by the working group for each question and provided to the expert panel in the first round, along with a request for comments and additional input. Experts participated in 3 rounds of surveys conducted between August 2024 and January 2025 (Table 1).

In round 1, a total of 78 open-ended questions and statements were distributed via email to the panel members. They were instructed to answer each item as specifically and thoroughly as reasonably possible, on the basis of their clinical experience and the current literature.

In round 1, statements were categorized as "essential" and retained for round 2 if more than 75% of respondents agreed and fewer than 20% disagreed. Statements that did not meet these criteria were either discarded or modified on the basis of feedback from participants.

The responses were summarized, and the working group identified areas of consensus and controversy. On the basis of expert feedback and suggestions, revised or new open-ended statements were developed to further explore key topics in round 2.

In round 2, participants were asked to re-score the revised and new statements and provide free-text comments. Responses were analyzed, and statements were retained for round 3 if they met the predefined thresholds of more than 75% agreement and less than 20% disagreement. Statements failing to meet these criteria were again revised or removed, as per expert feedback. Statements retained or edited after round 2 were reconsidered in round 3. The cycle of scoring, analysis, and revision was repeated, with participants asked to rescore statements during the third-round survey. For the final consensus, a priori-defined criteria were applied: statements were included in the final consensus document if over 75% of respondents agreed and fewer than 20% disagreed in round 3.

Statistical Analysis

All consensus data analyses were conducted using Microsoft Excel (Redwood, WA). Consensus statements were formulated and distributed via Google Forms (Mountain View, CA), with response data subsequently exported into predefined spreadsheets. These spreadsheets facilitated the compilation of response counts for each Likert scale option per question, alongside calculations of agreement and disagreement percentages. At each phase, response distributions were quantified as frequencies with corresponding percentages, enabling the assessment of statements for retention, modification, or lack of consensus.

Results

All 3 survey rounds were completed by 56 international experts on MMRTs, yielding a 100% response rate. The number of responses, total items per survey, proportion of statements reaching consensus, and any modifications or newly proposed items are summarized in Table 1.

Throughout the modified Delphi process, the initial set of 78 items was refined to 74 statements, with consensus within each of the 5 categories increasing progressively across survey rounds. Among the 78 statements evaluated in round 1, 74 (94.9%) reached consensus by the end of round 3. Four statements (5.1%) were excluded—3 statements after the first round and 1 statement after the second—because of a lack of consensus. The excluded statements were (1) ultrasonography, when available, has a role in diagnosing MMRTs by providing indirect signs of a root

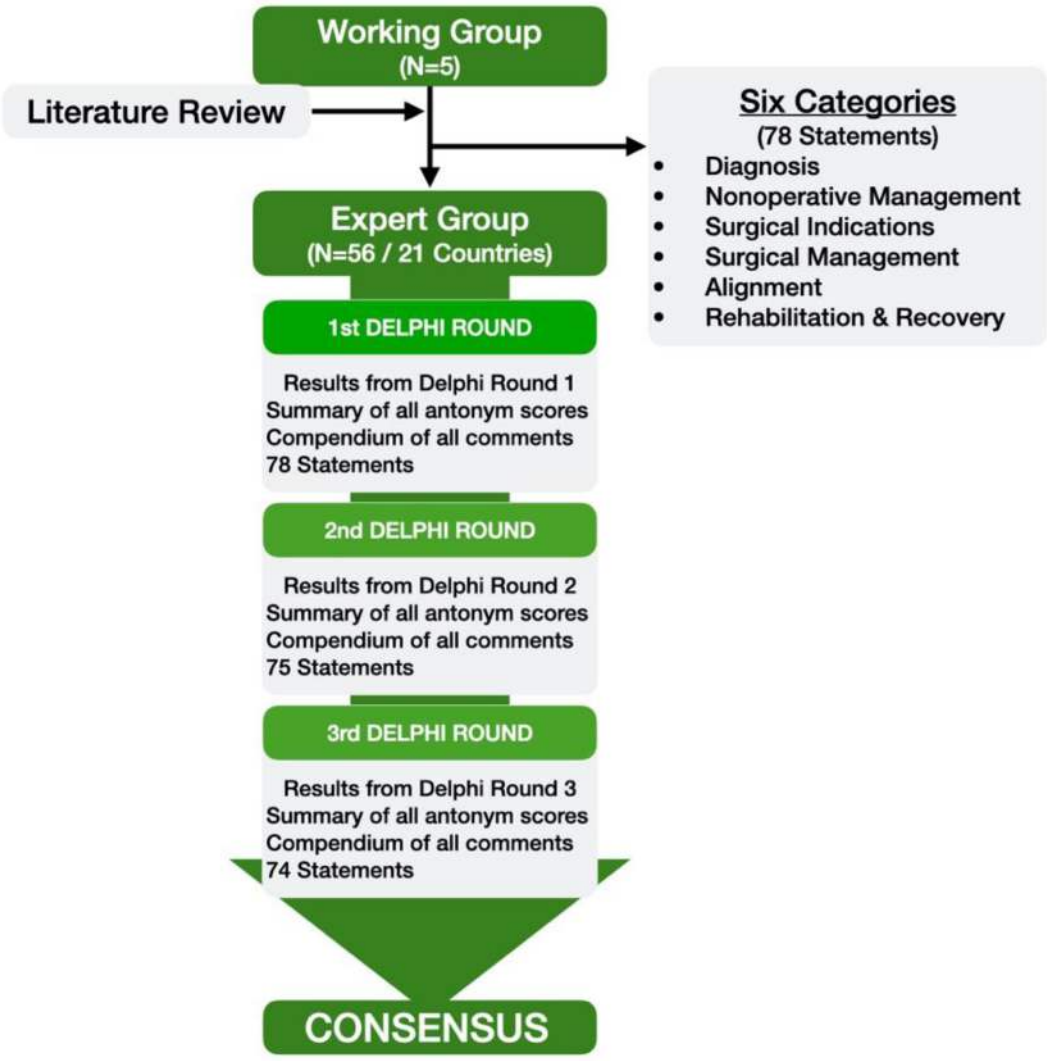

Fig 1. Flow of consensus process for modified Delphi consensus on medial meniscal root tears.

tear; (2) an MRI arthrogram should be obtained to evaluate the potential for a failed MMRT repair; (3) fluid around the posterior meniscal root is a reliable and useful MRI sign for diagnosing MMRTs.

Clinical and Imaging Diagnosis

In the diagnosis section, 20 statements were evaluated: 12 related to clinical diagnosis, including medical history and physical examination, and 8 focused on imaging findings. The mean level of agreement among experts for clinical diagnosis statements was 91% (range, 88%-97%), with a mean disagreement of 9% (range, 3%-12%). The greatest level of agreement was observed regarding the etiology of MMRTs in the absence of previous trauma, particularly in older patients, supporting the notion that increased age is a risk factor for degenerative MMPRTs.

In the imaging diagnosis subsection, the 8 statements yielded a mean agreement of 91.9% (range, 85%-97%) and a mean disagreement of 8.1% (range, 3%-15%). The greatest agreement was noted for the evaluation of joint space narrowing on standard standing posteroanterior radiographs in patients with MMRTs, and for the recommendation of further MRI assessment when an MMPRT is suspected. Notably, 97% of the expert panel agreed that the "ghost sign" is a reliable and useful MRI finding for diagnosing MMRTs. However, some disagreement remained regarding the diagnostic reliability of ME on MRI (Table 2).

Nonoperative Management

In the nonoperative management subsection, 10 statements were evaluated. The mean level of agreement among experts was 88.7% (range, 83%-94%), with a mean disagreement of 11.3% (range, 6%-17%). The greatest agreement was observed for the recommendation of nonoperative management in patients

Table 1. Summary of Results at Completion of Each Survey Round in the Modified Delphi Process to Establish an Expert Consensus on Root Tear Management

Delphi Round	Responses	Total Items Included in Survey	Items Reaching Consensus	Modifications, Additions, or Deletions
1	56 (100%)	78	65	15
2	56 (100%)	75	72	3
3	56 (100%)	74	73	–

older than 50 years of age with MMRTs and end-stage knee OA (Kellgren-Lawrence grade 4). In addition, asymptomatic MMRTs in patients with pre-existing high-grade OA (Kellgren-Lawrence grade 3 or 4) or diffuse cartilage damage—defined as >50% of the medial compartment with Outerbridge grade 3 or 4 changes— also were considered appropriate indications for nonoperative treatment.

Some disagreement persisted regarding the prognostic value of bone marrow edema and the presence of subchondral cysts in patients with preserved joint space, particularly in terms of their association with poor outcomes following nonoperative management. Furthermore, 14% of panelists disagreed with the recommendation to limit deep knee flexion as part of the nonoperative treatment protocol (Table 3).

Surgical Indication and Management

The surgical indications subsection included a total of 14 statements. The mean level of agreement among

Table 2. Levels of Agreement and Disagreement on Clinical and Imaging Diagnosis of MMPRTs After Round 3 of the Expert Panel Survey

Diagnosis	% Disagreement	% Agreement
History and examination		
When MMRTs occur secondary to trauma, it is typically in younger patients and may occur in combination with ligament injuries.	11	89
MMRTs may occur with no known history of trauma, or only a minimal trauma, typically in older patients.	3	97*
Increased age is a risk factor for degenerative MMRTs.	3	97*
Elevated BMI is a risk factor for MMRTs.	10	90
Female sex is a risk factor for MMRTs.	11	89
Medial compartment knee osteoarthritis is a risk factor for degenerative MMRTs.	10	90
Varus alignment is a risk factor for MMRTs.	9	91
A history of acute posterior knee pain or experiencing a "pop," often during deep knee flexion activity, is suggestive of a MMRT.	7	93
Proximal tunnel placement during posterior cruciate ligament reconstruction could lead to iatrogenic MMRTs.	12	88
Mechanical symptoms, such as catching and locking, are not pathognomonic for a MMRT.	10	90
Pain with deep knee flexion or squatting is occasionally present on clinical examination in patients with a MMRT.	10	90
Traditional provocative examination tests, such as the McMurray maneuver, are less useful for the identification of MMRTs rather than meniscal tears with an unstable flap tear.	12	88
Imaging		
A standing posteroanterior (PA) radiograph performed in 45° flexion (Rosenberg) is the best radiograph to evaluate joint space narrowing in patients with MMRTs.	5	95*
Long leg alignment films should be performed to measure alignment in patients with a suspected MMRT.	8	92
Magnetic resonance imaging (MRI) should always be performed in the assessment of suspected MMRTs in patients who demonstrate sufficient medial joint space on weight-bearing radiographs.	3	97*
Medial meniscus extrusion is a reliable and useful sign on MRI for the diagnosis of MMRTs.	14	86
A ghost sign is a reliable and useful sign on MRI for the diagnosis of MMRTs.	3	97*
A truncation sign (typically on coronal MRI) is a reliable and useful sign on MRI for the diagnosis or MMRTs.	7	93
Bone marrow edema in the posteromedial tibial plateau at the medial meniscal root attachment can be a secondary sign for the diagnosis of MMRTs on MRI.	10	90
The LaPrade classification of meniscus root tears, which is based on tear morphology visualized on arthroscopy, should regularly be employed for the classification of MMRTs.	15	85

MMRT, medial meniscus root tear.
*Statements with ≥95% agreement indicate the greatest level of expert consensus.

Table 3. Levels of Agreement and Disagreement on Nonoperative Management of MMPRTs After Round 3 of the Expert Panel Survey

Nonoperative Management	% Disagreement	% Agreement
An asymptomatic MMRT (incidental finding) and Kellgren-Lawrence grade 3 or 4, or diffuse cartilage wear (>50% Outerbridge grade 3 or 4 in the medial compartment) in patients over 50 years of age is an indication for nonsurgical treatment of a MMRT.	7	93
End-stage knee osteoarthritis (Kellgren-Lawrence grade 4) is an indication for nonoperative management of MMRTs.	6	94
Bone marrow edema and the presence of subchondral cysts with an intact joint space are associated with poor treatment outcomes of nonoperative management of MMRTs.	17	83
The extent of meniscus extrusion has treatment and prognostic significance	12	88
Activity modification, restricted weightbearing, physical therapy, and injections are useful interventions for the nonsurgical management of MMRTs.	10	90
Medial compartment unloader braces can help manage symptoms of MMRTs in patients with varus malalignment.	15	85
Deep knee flexion should be limited as part of the nonoperative management of MMRTs.	14	86
Intra-articular injections, such as corticosteroids or orthobiologics, may be effective for the symptomatic management of MMRTs when surgery is not indicated.	13	87
In cases where nonoperative management of MMRTs is trialed, persistence of symptoms after 3 months indicates the need for surgical treatment, in the absence of contraindications (i.e., high-grade osteoarthritis).	10	90
Nonoperative treatment of MMRTs is associated with the progression of knee osteoarthritis.	9	91

MMRT, medial meniscus root tear.

experts was 87.8% (range, 74%-98%), with a mean disagreement of 12.2% (range, 2%-26%). The greatest level of agreement was observed regarding the recommendation to contraindicate surgical management of MMPRTs in patients with end-stage OA (Kellgren-Lawrence grade 4), as well as the importance of shared decision-making with patients. This included discussions on postoperative rehabilitation restrictions, such as a 6-week period of limited weight-bearing with the use of crutches or a walker.

One of the primary areas of disagreement involved the surgical indication for asymptomatic MMPRTs in patients with mild cartilage wear in the medial compartment (Outerbridge grades 0−2). In addition, 16% of the panelists disagreed with the recommendation to contraindicate MMPRT repair in the presence of subchondral bone collapse (Table 4).

The surgical management subsection comprised a total of 9 statements. The mean level of agreement among experts was 91.6% (range, 83%-98%), with a mean disagreement of 8.4% (range, 2%-17%). The greatest agreement was observed for the recommendation that the optimal location for MMRT repair is the anatomic footprint of the root attachment. There was also strong agreement regarding the utility of a concomitant superficial medial collateral ligament (MCL) percutaneous release using a spinal needle to facilitate surgical access (Table 4).

Lower Limb Alignment

The lower limb alignment subsection comprised a total of 4 statements. The mean level of agreement among experts was 88.8% (range, 83%-94%), with a mean disagreement of 11.3% (range, 6%-17%). The greatest agreement was observed for the recommendation that concomitant osteotomy is indicated in active patients younger than 50 years presenting with MMPRT and significant varus knee malalignment (>5°). Furthermore, when indicated, a single-stage MMPR repair combined with realignment osteotomy was preferred over a staged approach.

One of the primary areas of disagreement concerned the use of concomitant realignment osteotomy during MMRT repair in older active patients (>50 years) engaged in impact activities, who present with significant varus alignment (>5°) and low-grade OA (Table 5).

Postoperative Rehabilitation and Recovery

The postoperative rehabilitation and recovery subsection comprised a total of 17 statements. The mean level of agreement among experts was 91.2% (range, 82%-99%), with a mean disagreement of 8.8% (range, 1%-18%). The greatest agreement was observed for the recommendation to restrict weight bearing for 4 to 6 weeks after MMRT repair.

One primary area of disagreement concerned the use of a medial compartment unloader brace during the initial weight-bearing period. This was considered potentially beneficial, particularly in patients with varus malalignment who did not undergo a valgus producing realignment osteotomy, or in those who received concomitant centralization or augmentation procedures (Table 6).

The overall and relative agreement proportions for individual statements following round 3 are illustrated in Figure 2.

Table 4. Levels of Agreement and Disagreement on Surgical Indications and Management After Round 3 of the Expert Panel Survey

Subsection	% Disagreement	% Agreement
Surgical indications		
An asymptomatic MMRT (incidental finding) in patients with mild medial compartment cartilage wear (Outerbridge grades 0, 1, 2) should be repaired.	26*	74*
A symptomatic MMRT should be repaired in patients with mild cartilage wear (Outerbridge grades 0, 1, 2).	5	95†
Early repair of MMRTs is recommended within three months of symptom onset when possible	6	94
Early (within 6 weeks of symptom onset) repair of MMRTs is recommended, when possible.	12	88
Older patient age (>65 years) is not a contraindication for repair of MMRTs and should be evaluated on an individual patient basis (activity level, adequate joint space on radiographs, low grade Kellgren-Lawrence).	10	90
Chronic MMRTs are eligible for repair in the setting of adequate meniscal tissue quality and adequate remaining joint space.	10	90
Subchondral bone collapse is a contraindication to MMRT repair.	16	84
Subchondral insufficiency fractures of the knee (SIFK) (previously known as spontaneous osteonecrosis of the knee [SONK]), without bony deformity, with an intact joint space IS NOT a contraindication to a MMRT repair.	14	86
Kellgren-Lawrence grade 3 knee osteoarthritis is not an absolute contraindication for MMRT repair, but other factors, including age, alignment and involvement of other compartments, need to be considered.	19	81
End-stage knee osteoarthritis (Kellgren-Lawrence grade 4) is a contraindication to surgical repair of MMRTs.	2	98†
In the setting of a symptomatic MMRT, a partial medial meniscectomy is rarely indicated.	11	89
The presence of SIFK (previously known as SONK) negatively influences surgical outcomes of MMRT repair.	20	80
Revision repair of a previous MMRT repair is an option in patients with remaining meniscus tissue with limited degeneration and mild medial compartment cartilage wear (Outerbridge grades 0, 1, 2).	18	82
When considering a repair of MMRTs, shared decision-making with the patient must include a discussion of the rehabilitation restrictions following surgery, including a period of 6 weeks of limited weight-bearing with the use of crutches or a walker.	2	98†
Surgical management		
An anatomic transtibial pull-out repair is the preferred technique for repair of MMRTs.	5	95†
The optimal location for the repair of MMRTs is the anatomic footprint of the root attachment for tears that occur directly at or close to this site.	2	98†
A medialized repair of MMRTs may be considered in radial tears that do not occur directly at the root attachment, to avoid overtensioning of the repair.	14	86
Repair of MMRTs leads to superior midterm clinical outcomes when compared to a medial meniscectomy and nonoperative treatment.	6	94
Although biomechanical studies have supported certain suture and tunnel configurations, different suture repair configurations have not been reported to result in differing clinical outcomes.	12	88
The use of a centralization (peripheral stabilization) suture may be beneficial in cases of substantial extrusion of the meniscus.	17	83
Although orthobiologics, such as platelet-rich plasma or bone marrow aspirate concentrate, have been explored for enhancing outcomes in MMRT repair, there is currently insufficient evidence to support their routine use, and further research is needed.	6	94
A concomitant superficial medial collateral ligament (MCL) percutaneous release with a spinal needle (i.e., pie crusting or trephination) is useful during repair of a MMRT and does not affect outcomes or MCL stability.	4	96†
During the repair of a MMRT, a cartilage restoration procedure for low to mid-grade cartilage lesions is not required.	10	90

MMRT, medial meniscus root tear.
*Represents items not reaching consensus.
†Statements with ≥95% agreement indicate the highest level of expert consensus.

Discussion

The main findings of the current modified Delphi consensus study on medial meniscus root tears are as follows: (1) a high overall level of consensus was achieved across all statements related to the evaluation, diagnosis, nonoperative management, surgical management, alignment, rehabilitation, and recovery; (2) statements concerning surgical management, rehabilitation, and recovery achieved a high relative consensus among experts; (3) the indication of operative repair of asymptomatic MMRTs with mild medial compartment cartilage wear was the only statement

Table 5. Levels of Agreement and Disagreement on Lower Limb Alignment in Patients With MMPRT After Round 3 of the Expert Panel Survey

Alignment	% Disagreement	% Agreement
Concurrent realignment surgery (in the setting of an MMRT) should be considered if the weight-bearing axis is medial to the medial tibial eminence on HKA films (or >5° of varus alignment).	13	87
There is a role for a concomitant realignment osteotomy during repair of a MMRT in young active patients (<50 years) participating in impact activities with significant varus malalignment of the knee (>5°).	9	91
There is a role for a concomitant realignment osteotomy during repair of a MMRT in older active patients (>50 years) participating in impact activities with significant varus alignment of the knee (>5°) and low-grade osteoarthritis.	17	83
If an osteotomy is indicated, it is preferable to perform a single-stage medial meniscus root repair with a concomitant realignment osteotomy as opposed to staged surgeries.	6	94

HKA, hip-knee-ankle; MMRT, medial meniscus root tear.

that did not reach consensus (74% agreement); (4) high agreement (>95%) was reached for several statements within each category including: MMRTs can occur with no history of trauma, typically in older patients. MRI is the primary diagnostic tool for MMRT, and Kellgren-Lawrence grade 4 is an absolute contraindication for MMRT repair. An anatomic transtibial pull-out repair is the preferred surgical approach and the MCL pie-crusting technique can aid visualization. A structured postoperative rehabilitation protocol with restricted weight-bearing for 6 weeks and limited range of motion to 90° (for 4 weeks) is essential. Finally, persistent pain and/or a sensation of locking or catching should raise concern for a failed repair and should be evaluated with an MRI.

MMRTs often occur in middle-aged patients with degenerative knee OA, typically after minimal trauma.[18,19] However, experts reached consensus that

Table 6. Levels of Agreement and Disagreement on Postoperative Rehabilitation and Recovery in Patients with MMPR Repair After Round 3 of the Expert Panel Survey

Rehabilitation and Recovery	% Disagreement	% Agreement
Weight bearing should be restricted postoperatively after repair of MMRTs.	1	99*
Postoperative weight-bearing after MMRT repair should be restricted to non-weight-bearing or toe-touch weight-bearing during the initial recovery period.	5	95*
Weight bearing should be restricted for 4-6 weeks postoperatively after repair of MMRTs.	4	96*
Postoperative weight-bearing after MMRT repair should be restricted to non−weight-bearing or toe-touch weight-bearing for 4-6 weeks during the initial recovery period.	11	89
A sequential staged rehabilitation program (range of motion, muscular endurance, strength, and finally power) is important for a successful outcome after repair of MMRTs.	5	95*
Passive deep knee flexion should be restricted postoperatively after repair of MMRTs.	4	96*
Passive deep knee flexion should be restricted to 90° postoperatively after MMRT repair.	8	92
Passive deep knee flexion should be restricted for 4-6 weeks postoperatively after MMRT repair.	8	92
Passive deep knee flexion should be restricted to 90° for 4-6 weeks postoperatively after MMRT repair, with gradual progression thereafter on the basis of patient recovery and tolerance.	12	88
Normal gait and weight-bearing can be resumed progressively, starting at 6 weeks after repair of MMRTs.	9	91
Following the repair of MMRTs, a medial compartment unloader brace may be indicated in patients with varus malalignment who did not undergo a valgus producing realignment osteotomy.	18	82
Following repair of MMRTs, a knee brace, such as an unloader brace, may be considered during the initial prior of weight-bearing, particularly in patients undergoing centralization or other additional procedures.	18	82
Return to sports is allowed 6 months after repair of MMRTs if the patient's symptoms are resolved and their quadriceps limb symmetry index is ≥85%.	9	91
Psychological factors such as kinesiophobia and fear avoidance should be considered and addressed during the rehabilitation process after repair of MMRTs.	10	90
Radiographs of the knee (anteroposterior and flexed posteroanterior views) should be obtained at 6 months postoperatively and as needed if symptoms persist to evaluate the tibiofemoral joint spaces.	13	87
An MRI to assess for MMRT repair healing can be obtained after a year postoperatively if symptoms persist.	10	90
Persistent pain and/or a sensation of locking or catching should raise concern for a failed MMRT and should be evaluated with an MRI.	5	95*

MMRT, medial meniscus root tear.
*Statements with ≥95% agreement indicate the greatest level of expert consensus.

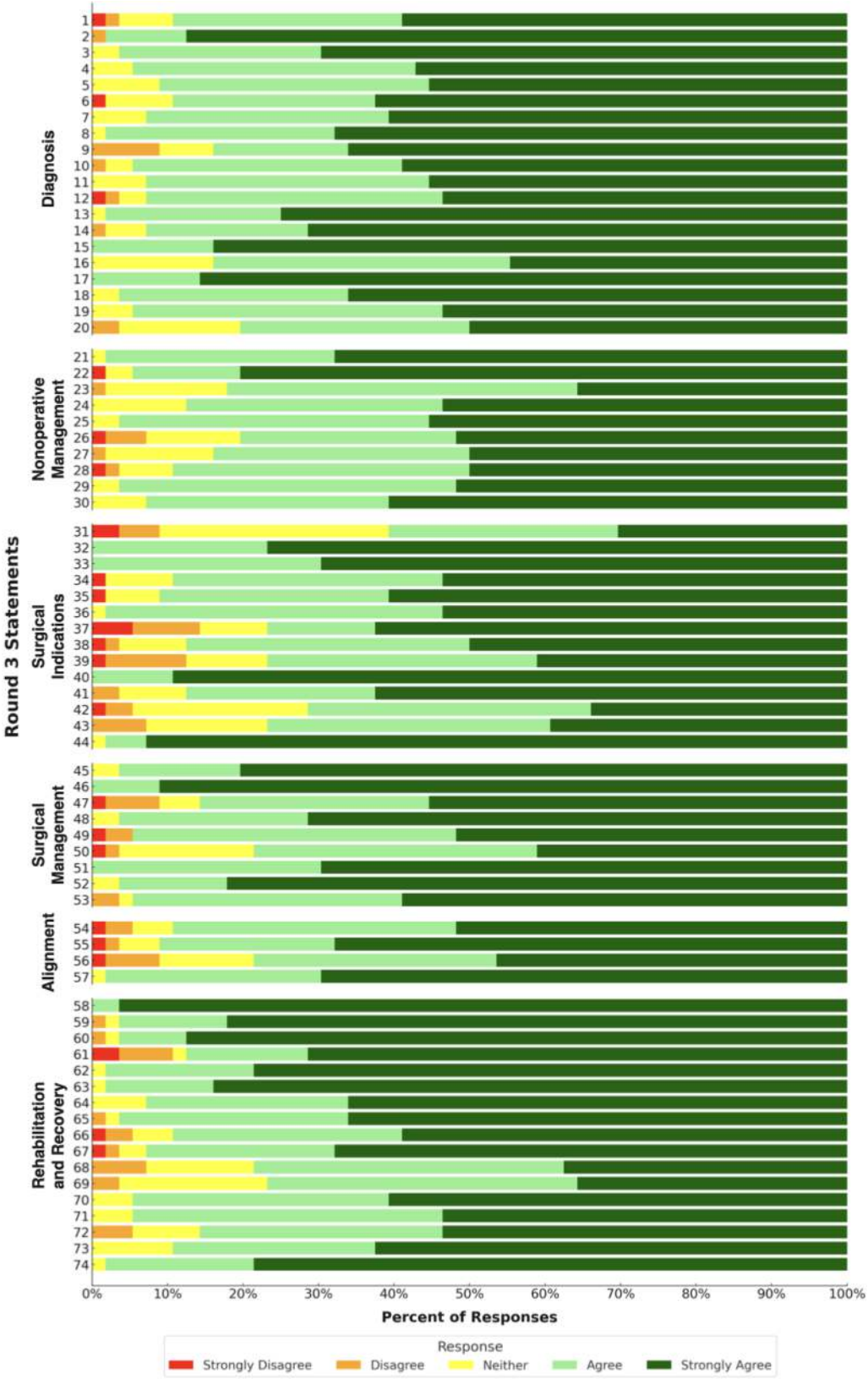

Fig 2. Stacked bar chart representing the distribution of agreement levels in the third-round modified Delphi survey for consensus on medial meniscal root tears.

MMRTs also can result from trauma, particularly in younger patients, and often are associated with ligament injuries.[20] The present study identified established risk factors for MMRTs, including older age, elevated BMI, female sex, medial compartment knee OA, and varus alignment.[8,21] Iatrogenic MMPRT may occur during transtibial drilling for a posterior cruciate ligament reconstruction.[22-25]

MMRTs, which may account for up to one-fifth of all meniscal tears, often go undiagnosed or untreated, contributing to substantial morbidity and an increased risk of arthritis progression and eventual arthroplasty.[3-5] Therefore, maintaining a high index of suspicion and obtaining a thorough clinical history are essential, because classic meniscal symptoms, such as catching or locking, may be absent.[26] Experts in this modified Delphi consensus agreed that patients with MMRTs may present with a history of acute posterior knee pain or a sensation of a "pop," often occurring during deep knee flexion activities. Consensus also was reached on the fact that although posterior knee pain with deep knee flexion or squatting is occasionally present on examination, traditional provocative tests such as the McMurray maneuver are less useful for identifying MMRTs compared to meniscal tears with an unstable flap tear, and mechanical symptoms such as catching and locking are not pathognomonic for a MMRT. These findings align with the literature, noting the clinical challenges of diagnosing MMRTs, due to the absence of typical meniscal tear symptoms.[26]

Imaging plays a critical role in the evaluation and diagnosis of MMRTs.[27-29] Experts agreed that radiographic assessment is essential, with the standing posteroanterior radiograph in 45° flexion (Rosenberg view) being the most effective modality for assessing joint space narrowing. In addition, the experts agreed that long-leg alignment films should be obtained to evaluate limb alignment, because varus malalignment may influence treatment decisions. The experts and the literature support that MRI is the gold standard for the noninvasive diagnosis of MMRTs and should always be performed in patients with sufficient medial joint space on weight-bearing radiographs.[13] Responders agreed that bone marrow edema in the posteromedial tibial plateau at the medial meniscal root attachment can be a secondary sign for the diagnosis of MMRTs on MRI. In addition, experts agreed that medial ME on MRI is a reliable diagnostic marker for a MMRT, and the literature has reported that extrusion greater than 3 mm correlates with underlying cartilage degeneration.[30,31] Finally, experts agreed that the LaPrade classification, which categorizes MMRTs based on arthroscopic tear morphology, is useful for the classification of MMRTs.[32]

Nonoperative management of MMRTs is generally reserved for patients in whom surgery is contraindicated or unlikely to provide significant benefit, such as those with advanced OA or low functional demand.[11] Consensus was reached that patients older than 50 years of age with Kellgren-Lawrence grade 3 or 4 OA or diffuse cartilage wear (>50% Outerbridge grade 3 or 4 in the medial compartment) warrant nonsurgical treatment. Furthermore, end-stage knee OA (Kellgren-Lawrence grade 4) was established as a definitive indication for nonoperative management.

As a conservative treatment strategy, experts agreed that medial unloader braces may be beneficial in patients with varus malalignment by offloading the medial compartment.[11,33] Intra-articular injections, including corticosteroids and orthobiologics, may provide temporary symptom relief when surgery is not indicated, although their long-term efficacy remains uncertain.[10,34] In addition, patient-specific factors must be considered, as experts agreed that ipsilateral compartment bone marrow edema and the presence of subchondral cysts, even with an intact joint space, are associated with poorer outcomes following nonoperative treatment. Although conservative management may alleviate symptoms, it does not prevent disease progression. Robust evidence demonstrates that unrepaired MMRTs contribute to progressive cartilage loss, ME, and ongoing joint degeneration, with the extent of ME having both prognostic and therapeutic implications.[27,34-38] In cases in which nonoperative treatment is pursued initially, experts agreed that persistent symptoms beyond three months warrant reconsideration of MMRT repair, provided no contraindications, such as high-grade OA, are present.

Given the crucial role of the meniscus root in knee biomechanics, surgical repair is generally recommended for MMRTs in patients without advanced arthritis to restore hoop stress and prevent the high contact pressures that contribute to cartilage breakdown.[2,5,10,11,28,29,35,39] Experts reached a consensus that symptomatic MMRTs in patients with mild cartilage wear (Outerbridge grades 0-2) should be repaired and that surgical intervention should occur as soon as possible, ideally within three months of symptom onset and preferably within 6 weeks for optimal outcomes.

No consensus was reached regarding whether an incidentally discovered, asymptomatic MMRT in patients with minimal to mild medial compartment cartilage wear (Outerbridge grades 0-2) warrants surgical repair (74% expert agreement for repair). Therefore, the management of incidentally discovered, asymptomatic MMRTs in patients with minimal to mild medial compartment cartilage wear (Outerbridge grades 0-2) remains a subject of debate. Although surgical repair is recommended for symptomatic tears in patients without advanced arthritis to prevent

cartilage degeneration, nonoperative management, including activity modification and physical therapy, may be appropriate for asymptomatic cases.[2,5,10,11,28,29,33-35,39] However, there is concern that not repairing MMRTs may lead to progressive ME, increased contact pressures, and an accelerated risk of OA development over time.[10,11,35,40] Given the limited evidence for these specific cases, treatment decisions should be individualized based on patient factors such as age, activity level, and pre-existing degenerative changes. Further research is needed to clarify the natural history of untreated asymptomatic MMRTs and establish evidence-based guidelines.

Experts agreed that in the setting of a symptomatic MMRT, a partial medial meniscectomy is rarely indicated, because existing literature demonstrates that a MMRT repair results in superior postoperative outcomes compared to a partial meniscectomy.[2,41-43] Indications for MMRT repair include symptomatic MMRTs in relatively young or active patients with mild cartilage wear (Outerbridge grades 0-2)and those with acute traumatic tears. In addition, chronic degenerative tears may be eligible for repair if meniscal tissue quality and joint space are adequate. Increased age alone is not a contraindication, as patients older than 65 years should be evaluated on the basis of activity level and joint degeneration.

Regarding Kellgren-Lawrence grading in surgical decision-making, experts reached consensus that Kellgren-Lawrence grade 3 is not an absolute contraindication for MMRT repair; however, a younger patient age, limb alignment, and involvement of other compartments should be considered. Experts also agreed that end-stage knee OA (Kellgren-Lawrence grade 4) is an absolute contraindication for MMRT repair.[44-46] In addition, experts reached a consensus that revision repair is a viable option in patients with preserved meniscus tissue exhibiting limited degeneration and cartilage wear (Outerbridge grades 0-2).

For patients with MMRTs and subchondral insufficiency fractures of the knee (SIFK), previously known as spontaneous osteonecrosis of the knee (i.e., SONK), experts agreed that the extent of bone damage is a critical factor in surgical decision-making. When SIFK is present without bony deformity and joint space remains intact, it is not considered a contraindication for MMRT repair. However, an MMRT repair is contraindicated in cases of subchondral bone collapse. Although the literature suggests that SIFK may accelerates knee OA progression,[47-49] MMRT repair could help halt low-grade SIFK and improve clinical outcomes.[50] In the present study, experts acknowledged that although SIFK may influence MMRT repair outcomes, definitive supporting literature remains limited. When operative treatment is pursued, the primary goal is to achieve an anatomic meniscus root repair, restoring hoop tension by reattaching the torn root to its native footprint on the tibia. Experts reached an overwhelming consensus (94%) that MMRT repair yields superior midterm clinical outcomes compared with medial meniscectomy or nonoperative management, consistent with existing literature.[2,29,35,37,51]

Experts reached consensus that an anatomic transtibial pull-out repair is the preferred technique, particularly for tears at or near the posterior root attachment. Strong evidence supports this approach, with 98% of experts agreeing that the optimal repair site is the anatomic footprint.[10,40,52-55] In cases of radial tears that extend beyond this site, experts agreed that a medialized repair may be considered to prevent over-tensioning. Biomechanical studies have demonstrated that anatomic MMRT repair effectively restores contact mechanics, reduces ME, and lowers compartment pressures.[52,56,57] Although various suture and tunnel configurations exist, experts agreed that no significant differences in clinical outcomes have been demonstrated among them.[58-61]

Adjunctive procedures in MMRT repairs also were evaluated. Experts reached consensus on the usefulness of a concomitant superficial MCL percutaneous release (i.e., pie crusting or trephination) to improve surgical exposure, with minimal impact on MCL stability or outcomes, as supported by recent literature.[62] Consensus was reached on the use of a centralization (peripheral stabilization) suture for cases with significant ME; this technique improves contact mechanics and reduces extrusion more effectively than root repair alone, with early clinical studies reporting improved outcomes at 2 years.[10,63-66] Although consensus supports its utility, long-term evidence is needed to justify routine use as a result of concerns about its technical complexity, risk of overconstraint, and unclear indications.[67,68] Some advocate universal use, whereas others reserve centralization for extrusion exceeding 3 to 5 mm, highlighting the need for further research.[65,67,68] Furthermore, experts agreed that cartilage restoration procedure for low- to mid-grade cartilage lesions is not required at the time of MMRT repair. Finally, although orthobiologics such as platelet-rich plasma and bone marrow aspirate concentrate have been explored as potential adjuncts to enhance healing of meniscal tears, experts agreed that current evidence is insufficient to support their routine use, highlighting the need for further research.[69-71] Limb alignment is a key factor in MMRT surgical management, particularly in patients with varus malalignment. Experts reached consensus that concurrent realignment surgery should be considered when the weight-bearing axis falls medial to the medial tibial eminence on hip-knee-ankle films or

when varus alignment exceeds 5°. High tibial osteotomy has been explored as an adjunct to MMRT repair in such cases, with studies reporting favorable clinical outcomes when performed concomitantly.[72-79] Experts further agreed that a concomitant realignment osteotomy has a role in both young, active patients younger than 50 years who participate in impact activities and older, active patients older than 50 years with low-grade OA. Studies suggest that a MMRT repair combined with high tibial osteotomy improves knee function, reduces pain, and may slow osteoarthritic progression more effectively than isolated MMRT repair.[72,73,75] Experts agreed that when realignment surgery is indicated, a single-stage MMRT repair with a concurrent osteotomy is preferable over a staged approach.

Postoperative rehabilitation is a critical component of optimizing outcomes after a MMRT repair. Experts agreed that a structured, progressive rehabilitation program—beginning with range of motion exercises and advancing through muscular endurance, strength, and power—is essential for recovery.[10,11,15] Consensus was reached that weight-bearing should be restricted during the initial postoperative period, with non−weight-bearing or toe-touch weight-bearing recommended for the first 4 to 6 weeks. This aligns with existing literature, which broadly supports delaying full weight-bearing until at least 6 weeks postoperatively, although some protocols allow for an earlier gradual partial weight-bearing progression.[10,11,15,76,77] Experts agreed that by 6 weeks, normal gait and progressive weight-bearing can typically begin, with a gradual return to full activity based on individual recovery. Consensus was reached that passive deep knee flexion should be limited to 90° for the first 4 to 6 weeks postoperatively, with gradual progression thereafter as tolerated. Most protocols aim for 90° flexion by 4 weeks and surpassing 120° without loading by 6 weeks.[10,11,15,76]

Radiographic follow-up is recommended to monitor healing and joint health. Experts reached consensus that knee radiographs (anteroposterior and flexed posteroanterior views) should be performed at 6 months postoperatively and as needed thereafter to assess joint spaces. In addition, MRI may be used after one year if symptoms persist like pain, catching, or locking persist suggesting failed repair.

Future research is needed to validate these findings with clinical outcomes data and refine treatment strategies.

Limitations

The findings of this study should be interpreted within the context of its limitations. Although the modified Delphi method ensures a structured consensus process, statements were based on expert opinion and literature review rather than direct clinical data. Differences in resource availability, health care systems, and geographic variations may limit the generalizability of some recommendations. Although efforts were made to minimize bias by including experts from diverse backgrounds, certain populations or perspectives may have been unintentionally underrepresented. In addition, although a high threshold for consensus was set, individual biases may still have influenced responses.

Conclusions

Overall, 98% of statements reached consensus. There is agreement that MRI is the gold standard for diagnosis. Symptomatic MMRTs without advanced OA should be repaired early using an anatomic transtibial pull-out technique. End-stage knee osteoarthritis warrants nonoperative management of MMRTs, and a structured postoperative protocol with limited weight-bearing and range of motion is essential after repair. No agreement was reached on managing asymptomatic MMRTs in patients without significant medial compartment degeneration. Meniscal centralization sutures may help in cases of substantial extrusion, but their routine use is debated.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: B.B. received payment for lectures/faculty involvement from Smith & Nephew and Ortomedic and is in the board/editorial boards of European Society of Sports Traumatology, Knee Surgery and Arthroscopy, *Journal of ISAKOS*, *Knee Surgery, Sports Traumatology, Arthroscopy*, *American Journal of Sports Medicine*, and *Video Journal of Sports Medicine*. J.C. reports board or committee member, American Orthopaedic Society for Sports Medicine, Arthroscopy Association of North America, and International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine; paid consultant for Arthrex, CONMED Linvatec, Ossur, and RTI Surgical; hospitality payments from

Breg, DePuy Synthes Sales, Joint Restoration Foundation, Medical Device Business Services, Pacira Pharmaceuticals Incorporated, and SI-Bone; educational support from Midwest; paid consultant; paid presenter or speaker Associates for Smith & Nephew; and paid consultant, hospitality payments from Vericel Corporation. C.M.L. reports other financial or material support from Arthrex; paid presenter or speaker for DJ Orthopaedics; paid consultant and IP royalties from Ossur; and IP royalties, other financial or material support from, and paid consultant for Smith & Nephew. A.G.G. has received consulting fees from Smith & Nephew, speaking fees from Ossur and

Arthrex, and support for education from Stryker Corporation and Medwest Associates. A.G. reports editorial or governing board of the *American Journal of Sports Medicine* and *Knee Surgery, Sports Traumatology, Arthroscopy*; IP royalties from Graymont; board or committee member of the International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine; stock or stock options from LinkX Robotics; Ostesys Robotics; Precision OS; Smart HTO; Spring Loaded Technologies, and Surgical Health Innovations Corp; paid consultant, paid presenter or speaker, and research support from Smith & Nephew and research support from Ossur. D. L.J. reports board or committee member, American Orthopaedic Society for Sports Medicine and Southern Orthopaedic Association; research support from DJ Orthopaedics and Smith & Nephew Endoscopy; publishing royalties, financial or material support from Elsevier; editorial or governing board of *Journal pf Surgical Orthopaedic Advances*, *Orthopedics*, *Orthopedics Today*, *Sports Medicine and Arthroscopy Review*, and SLACK Incorporated; IP royalties from Smith & Nephew; and paid consultant for Smith & Nephew Endoscopy. A.K. reports editorial or governing board of the *American Journal of Sports Medicine* and Springer; IP royalties from and paid consultant for Arthrex; and board or committee member of the Arthroscopy Association of North America and the International Cartilage Repair Society. R.F.L. reports consulting or advisory with Ossur Americas, Smith & Nephew, Linvatec Europe, and Responsive Arthroscopy and funding grants from Ossur Americas, Smith & Nephew, Arthroscopy Association of North America, and American Orthopaedic Society for Sports Medicine. M. L. reports educational services for Smith & Nephew. T. L. reports paid presenter or speaker for Arthrex; board or committee member of the International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine; paid consultant and paid presenter or speaker for Medacta; and paid consultant, paid presenter or speaker, and research support from Smith & Nephew. D.P. reports board or committee member of the ACL Study Group, Asia Pacific Knee Arthroscopy and Sports Medicine Society, and Asia Pacific Knee Society, and International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine; editorial or governing board of the *American Journal of Sports Medicine*, *Orthopaedic Journal of Sports Medicine*, *Journal of ISAKOS*, and *SMARTT Journal*; stock or stock options; unpaid consultant for Ganymed Robotics; stock or stock options from Personalised Surgery; paid consultant; paid presenter or speaker for Smith & Nephew; and research support from Zimmer. W.P. reports paid presenter or speaker for Arthrex and Geistlich; board or committee member of Deutsche Kniegesellschaft and GOTS; IP royalties from Karl Storz; editorial or governing board of *Kniejournal*; and paid consultant for OPED, Valley, Germany. R.S. reports paid presenter or speaker for Arthrex and Smith & Nephew and editorial or governing board of *Knee Surgery, Sports Traumatology, Arthroscopy*. B.S-C. reports stock or stock options with AREAS and IP royalties from and paid consultant for Arthrex. T.S. reports IP royalties from and paid presenter or speaker for CONMED Linvatec; paid consultant and paid presenter or speaker for Episurf; board or committee member of the ICRS Cartilage Foundation; paid presenter or speaker for Joint Operations UK; editorial or governing board of *Knee Surgery, Sports Traumatology, Arthroscopy*; paid consultant for and stock or stock options from Orthonika; and paid presenter or speaker for Smith & Nephew. M.J.S. reports paid consultant for and receives royalties from Arthrex and has received research support from Stryker. S.T. reports consulting or advisory with Smith & Nephew and Newclip Technics. M.T. reports board membership with International Society of Arthroscopy Knee Surgery and Orthopaedic Sports Medicine and consulting or advisory with Arthrex. N. N.V. reports hospitality payments from Abbott Laboratories, Axonics, Boston Scientific, Foundation Fusion Solutions LLC, IBSA Pharma, Nalu Medical, Nevro Corp, Orthofix Medical, Pacira Pharmaceuticals Incorporated, Relievant Medsystems, Salix Pharmaceuticals, Vericel Corporation, and Vertos Medial; board or committee member of the American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, and Arthroscopy Association of North America; IP royalties; research support from Arthrex and Smith & Nephew; research support from Breg and Ossur; IP royalties from Graymont Professional Products IP LLC; paid consultant for Medacta USA; educational support from Medwest Associates; editorial or governing board of SLACK Incorporated; travel and lodging from Spinal Simplicity LLC:; and IP royalties, paid consultant, and research support from Stryker. A. Y. reports paid consultant for AlloSource and JRF Ortho; research support from Arthrex and Organogenesis; stock or stock options from Icarus Medical; unpaid consultant and stock or stock options from Patient IQ and Sparta Biomedical; and paid consultant and paid presenter or speaker for Stryker. V.M. reports board or committee member of the ACL Study Group, American Orthopaedic Society for Sports Medicine, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine, and *Journal of ISAKOS*; other financial or material support from Arthrex; editorial or governing board of *Knee Surgery, Sports Traumatology, Arthroscopy*: paid consultant for Newclip; stock or stock options from Ostesys; other financial or material support from and paid consultant for Smith & Nephew; and publishing royalties, financial or material

support from Springer. All other authors (F.A., L.D., J. R.G., C.G., A.J.B., D.L.B., C.H.B., K.S.C., M.C., L.E., F. F., S.C.F., M.J.F., T.F., T.H., E.I., J.G.K., Y.K., E.K., S.K., C.M.L., D.W.L., C.A.L., I.I.L.T., R.M., G.M., J.K.M., R. N.V., Y.O., J.C.R., E.S., C.S., S-H.K., M.J.T., L.V.T., W. A.v.d.W., R.P.B.v.B.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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