

# An International Delphi Consensus on Meniscus Radial Tears: From Diagnosis to Management and Rehabilitation

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The Meniscus Radial Tear Expert Group

**Purpose:** To establish consensus statements on risk factors, diagnosis, nonoperative management, surgical indications and techniques, rehabilitation strategies, and clinical and functional outcomes of meniscus radial tears (MRT).

**Methods:** A working group of fellowship-trained sports medicine surgeons developed original statements based on a review of the current literature on MRT. A panel of 45 international orthopaedic surgeons was surveyed. Agreement with each statement was assessed using a 5-point Likert scale, and statements were retained, revised, or excluded according to predefined thresholds ( $\geq 80\%$  agreement and  $< 20\%$  disagreement). Expert-suggested revisions and additional statements generated during the first 2 rounds were further reviewed and voted on in the final round 3.

**Results:** The expert panel achieved consensus on repair for isolated acute traumatic MRTs and those associated with acute cruciate ligament injuries, whereas repair in chronic degenerative tears should be based on meniscal tissue quality and degree of osteoarthritis. Although partial meniscectomy may provide short-term relief, its long-term detrimental effects should not be underestimated. Increased age alone was not considered a risk factor for MRT repair. Successful healing requires addressing peripheral extension and gapping, with anatomic restoration prioritized over surgical technique or suture choice. Given limited evidence on early weightbearing and unrestricted motion, a conservative postoperative protocol is advised. No repair technique has proven superior with choice guided by surgeon preference.

**Conclusions:** Expert consensus supports repair of acute traumatic and acute cruciate ligament-associated MRTs, whereas indications for chronic degenerative tears depend on tissue quality and joint status. Increased age alone was not considered a contraindication to MRT repair. Anatomic restoration is essential for a successful outcome, irrespective of surgical technique. An initial nonweight-bearing rehabilitation protocol is recommended.

**Level of Evidence:** Level V, expert opinion, modified Delphi consensus.

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Meniscal radial tears (MRTs) are particularly challenging injuries that disrupt the circumferential collagen fibers of the meniscus and increase meniscal excursion (ME), thereby predisposing to long-term joint degeneration.<sup>1,2</sup> Although several clinical and biomechanical studies have sought to shed light on risk factors, imaging diagnosis, and both surgical and non-surgical

management, many questions remain unanswered for knee surgeons treating MRTs in daily practice.<sup>1,3-7</sup> Key areas of debate include the choice between repair and partial meniscectomy, the selection of repair technique (all-inside, inside-out, or outside-in), and the influence of tear location on healing potential, particularly medial versus lateral and central versus peripheral tears. Uncertainties

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also exist regarding patient-related risk factors, such as female sex, medial-sided tears, and advanced age. Additional areas of debate include the indications for biological augmentation and the role of concomitant procedures, such as corrective osteotomies or cartilage restoration. The lack of consensus on key aspects of MRT care is further complicated by evolving surgical techniques and heterogeneous rehabilitation protocols. To address these gaps, a modified Delphi process was undertaken to establish an international expert consensus on critical aspects of MRT management.

The primary purpose of this study was to establish consensus statements on risk factors, diagnosis, nonoperative management, surgical indications and techniques, rehabilitation strategies, and clinical and functional outcomes of MRTs.

## METHODS

### Study Design

This is a modified Delphi consensus study designed in accordance with the CREDES (Conducting and REporting of DELphi Studies) and the Guidance on Conducting and Reporting Delphi Studies frameworks.<sup>8,9</sup>

### Literature Review and Statement Generation

A comprehensive literature review was conducted using databases including MEDLINE, Embase, Scopus, and Google Scholar. Search terms included: “meniscus radial tear,” “meniscal radial tear,” “diagnosis meniscus radial tear,” “treatment meniscus radial tear,” “surgical technique for meniscus radial tear,” “meniscus radial tear meniscectomy,” “physical therapy,” “physiotherapy,” and “outcomes meniscus radial repair.”

Guided by the most relevant gaps identified in the published literature, a working group of 2 orthopaedic surgeons and researchers (L.D., J.C.) conducted the literature review and formulated a series of open-ended draft statements. These addressed 7 key categories: (1) cause and risk factors; (2) imaging diagnosis; (3) nonoperative management; (4) surgical indications; (5) surgical treatment; (6) rehabilitation and recovery; and (7) outcomes after MRT repair. The draft statements were subsequently reviewed, refined, and finalized before being distributed to the expert panel for the Delphi rounds.

## Expert Panel Selection

Specific eligibility criteria were applied when selecting panel members. These included a minimum of 5 years of independent clinical practice post-training, specialization in sports medicine with a focus on meniscal injuries, and active surgical practice at a high-volume center treating knee pathologies.<sup>10</sup> In addition, candidates were required to fulfill at least one of the following criteria: (1) authorship of peer-reviewed publications or participation in clinical trials, multicenter studies, or preclinical research related to MRT; (2) membership in international orthopaedic/sports medicine committees, editorial board service, or regular invited presentations on meniscal pathology; and (3) previous experience participating in Delphi panels, guideline development, or consensus statements. The aforementioned criteria facilitated broad international participation.

A total of 45 experts participated in 3 rounds of surveys conducted between June 2025 and September 2025. Among the participants, 17 (37.8%) were from North America, 16 (35.6%) were from Europe, 6 (13.3%) were from Asia, 3 (6.7%) were from South America, 2 (4.4%) were from the Middle East, and 1 (2.2%) was from Oceania.

## Delphi Rounds

A 3-round modified Delphi process was conducted. The survey, administered in English via Google Forms, was distributed to participants by email. A follow-up message included an overview of the study and a link to the questionnaire. Experts rated their level of agreement with each statement using a 5-point Likert scale: (1) “Strongly agree,” (2) “Agree,” (3) “Neither agree nor disagree,” (4) “Disagree,” and (5) “Strongly disagree.” Participants were instructed to respond to each item as specifically and comprehensively as possible, drawing on both their clinical experience and the available literature.

All 3 Delphi rounds were conducted online. Panel members were anonymous and instructed to provide detailed comments and suggestions on any statements they considered revisable. In Round 1, 45 open-ended questions and statements were distributed to panel members via email. Statements achieving  $\geq 80\%$  agreement and  $< 20\%$  disagreement were retained for Round 2, with consensus considered established. Statements not meeting these thresholds were either discarded or revised based on qualitative feedback. Participants were also invited to propose new statements or modifications through free-text responses.

After Round 1, responses were summarized, and the working group identified areas of consensus and

controversy. Revised or newly generated statements were developed accordingly for Round 2. In this round, participants rescored the revised and new statements and provided additional comments where necessary. Statements again meeting  $\geq 80\%$  agreement and  $< 20\%$  disagreement thresholds were retained for Round 3, whereas others were revised or removed based on feedback.

In Round 3, 2 types of assessments were conducted: (1) newly developed or modified statements were evaluated using a 5-point Likert scale to determine the degree of agreement; and (2) statements that had already reached consensus in earlier rounds were reassessed to confirm stability of expert opinion. This dual approach allowed refinement of new content while validating the consistency of prior consensus, thereby strengthening the robustness of the final recommendations.

The overall Delphi process is outlined in Figure S1.

## Statistical Analysis

Consensus statements were distributed to participants using Google Forms (Mountain View, CA), and responses were exported into predefined Microsoft Excel spreadsheets (Redmond, WA). Descriptive analyses were performed, with frequencies and percentages used to summarize Likert scale responses, as well as overall agreement and disagreement rates. Stacked bar charts were generated using R software (version 4.3.3; R Foundation for Statistical Computing, Vienna, 2024)<sup>11</sup> to visually depict the distribution of responses and the levels of agreement and disagreement across the expert panel.

## RESULTS

All 45 panel members participated in each of the 3 Delphi rounds, yielding a complete (100%) response rate.

The number of responses, statements, proportion of statements reaching consensus, and any modifications or newly proposed items are summarized in Table 1.

In Round 1, a total of 45 statements were evaluated. Consensus was achieved for 15 statements (33.3%), whereas 4 (8.9%) statements were removed as a result of high disagreement ( $\geq 20\%$ ) (Table S1 and Figure S2), and the remaining 26 statements were modified and refined based on expert feedback for Round 2. Additionally, 2 new statements were generated after Round 1, resulting in a total of 28 statements assessed in Round 2 (Table S2). Of these, consensus was achieved for 17 statements (60.7%). The remaining 11 statements were further revised according to experts' suggestions and advanced to Round 3. In Round 3, 11 modified and 3 new statements were re-evaluated. Alongside these, 32 statements that had already reached consensus in Rounds 1 and 2 were reassessed to confirm the stability of expert opinion.<sup>12,13</sup> Overall, by the end of the 3-round Delphi process, a total of 42 statements (91.3%) achieved consensus (Table 1).

## Cause, Risk Factors, Imaging Diagnosis, and Nonoperative Management

In Round 3, 6 statements pertaining to the Risk Factors and Cause section were evaluated. The mean level of agreement among experts was 96.6% (range, 93.3%-100%), with a mean disagreement of 3.3% (range, 0%-6.7%). The highest agreement was observed for the association of lateral meniscus oblique radial tears with acute cruciate ligament (ACL) injuries. Additionally, strong consensus was noted for the degenerative nature of medial meniscus radial tears and the deleterious biomechanical impact of MRTs on joint homeostasis (Table 2).

In the Imaging Diagnosis subsection, the 5 statements yielded a mean agreement of 92.9% (range, 82.2%-97.8%)

**TABLE 1** Summary of Delphi Survey Rounds

| Round        | Statements Assessed, n | New and Modified Statements, n                                    | Reached Consensus, n (%) | Not Reaching Consensus/ Statements Excluded |
|--------------|------------------------|-------------------------------------------------------------------|--------------------------|---------------------------------------------|
| 1            | 45                     | -                                                                 | 15 (33.3%)               | 4 (8.9%)                                    |
| 2            | 28                     | 26 revised, 2 new                                                 | 17 (60.7%)               | -                                           |
| 3            | 46                     | 11 revised, 3 new, 32 previous statements that achieved consensus | 42 (91.3%)               | 4 (8.7%)                                    |
| <b>Total</b> | 46                     |                                                                   | <b>42 (91.3%)</b>        | -                                           |

Note: The bold numbers indicate the number of statements that achieved consensus in each round and overall. n, number.

**TABLE 2** Levels of Agreement and Disagreement on Cause, Risk Factors, Imaging Diagnosis, and Nonoperative Management of Meniscus Radial Tears After Round 3 of the Expert Panel Survey

| Cause and Risk Factors                                                                                                                                                                                                                                                                                                     | % Agreement | % Disagreement |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|
| Lateral meniscus oblique radial tears (LMORTs) are more frequently traumatic and are most commonly associated with ACL injuries.                                                                                                                                                                                           | 100.0       | 0.0            |
| Medial meniscus radial tears are typically degenerative in nature and often underdiagnosed                                                                                                                                                                                                                                 | 97.8        | 2.2            |
| Meniscus radial tears are associated with a higher grade of cartilage damage and greater severity of meniscal extrusion (ME) than other types of tears                                                                                                                                                                     | 93.3        | 6.7            |
| A complete radial tear significantly impairs load distribution, leading to markedly increased peak contact pressures not only at the posterior horn but also at the mid-body of the meniscus                                                                                                                               | 97.8        | 2.2            |
| Untreated radial tears of the lateral meniscus mid-body can progress to segmental defects, biomechanically equivalent to a complete meniscectomy, leading to rapid cartilage degeneration                                                                                                                                  | 93.3        | 6.7            |
| Increased patient age, when associated with high-grade cartilage damage (Kellgren-Lawrence grade III or IV or Outerbridge grade III or IV), is an independent negative prognostic factor for successful repair of meniscal radial tears                                                                                    | 97.8        | 2.2            |
| Diagnosis - Imaging                                                                                                                                                                                                                                                                                                        | % Agreement | % Disagreement |
| Meniscal extrusion may be considered pathological after a lateral meniscus radial tear, even when coronal or sagittal displacement on MRI is $\leq 3$ mm                                                                                                                                                                   | 82.2        | 17.8           |
| The marching cleft sign on MRI is a valuable indicator of an oblique radial tear at the junction of the meniscal body and horn                                                                                                                                                                                             | 97.8        | 2.2            |
| The ghost sign, also known as the empty meniscus sign, is a useful MRI finding for diagnosing not only meniscal root tears but also complete radial tears                                                                                                                                                                  | 95.6        | 4.4            |
| A standing posteroanterior radiographs performed in flexion (Rosenberg view) are essential for evaluating joint space narrowing in patients with radial meniscus tears, particularly in chronic cases                                                                                                                      | 95.6        | 4.4            |
| The optimal threshold for meniscal extrusion may vary according to factors such as age, body mass index, and the presence of advanced degenerative changes                                                                                                                                                                 | 93.3        | 6.7            |
| Nonoperative Management                                                                                                                                                                                                                                                                                                    | % Agreement | % Disagreement |
| Conservative treatment is a reasonable approach in patients over 50 years of age with asymptomatic meniscus radial tear (incidental finding) and Kellgren-Lawrence grade III or IV, or diffuse cartilage wear ( $>50\%$ Outerbridge grade 3 or 4 in the medial compartment), and in those who are poor surgical candidates | 95.6        | 4.4            |
| In cases where nonoperative management of a meniscal radial tear is attempted, persistent symptoms beyond 3 months may indicate the need for surgical intervention, provided there are no contraindications such as high-grade osteoarthritis (Kellgren-Lawrence grade III or IV)                                          | 91.1        | 8.9            |
| <i>Note:</i> Statements with $\geq 95\%$ agreement are highlighted in green, indicating the highest level of expert consensus.<br>ACL, acute cruciate ligament; MRI, magnetic resonance imaging.                                                                                                                           |             |                |

and a mean disagreement of 2.2% (range, 2.2%-17.8%) (Table 2).

Regarding nonoperative treatment of MRTs, conservative management may be considered in patients over 50 years of age with asymptomatic radial tears detected incidentally, particularly in the presence of advanced pre-existing osteoarthritis (OA; Kellgren-Lawrence grade

III or IV, or diffuse cartilage wear Outerbridge grade 3 or 4) (Table 2).

Eight statements were assessed for Surgical Indications, yielding a mean agreement of 94.7% (range, 86.7%-100%) and a mean disagreement of 5.3% (range, 0%-13.3%). The highest agreement was observed for isolated acute traumatic MRTs or those associated with

ACL injuries, which is preferred to be repaired. In contrast, the indication for repair in chronic degenerative meniscal tears depends on the quality of the meniscal tissue and the extent of associated degenerative changes within the joint (Table 3).

Among 11 statements achieving consensus on surgical treatment, the mean agreement was 94.9% (range, 84.4%-100%) with a mean disagreement of 5.03% (range, 0%-15.6%). All 46 experts agreed that although partial meniscectomy often provides short-term symptomatic relief, its detrimental long-term effects should not be underestimated. High agreement was achieved on statements evaluating the utility of different techniques and suture combinations. However, the expert panel emphasized that addressing the peripheral extension of the tear and the presence of gapping are critical factors for ensuring successful repair healing (Table 3).

## Rehabilitation and Clinical Outcomes After Meniscal Radial Tear Repair

Among 6 statements that achieved consensus on rehabilitation and recovery, the mean agreement was 91.9% (range, 86.7%-95.6%) and the mean disagreement was 8.9% (range, 4.4%-13.3%) (Table 4).

Regarding clinical outcomes after MRT repair, there is no conclusive evidence supporting the superiority of 1 technique over another. Both all-inside and inside-out repair techniques show improvements in PROMs. The choice of repair method should therefore be guided by the surgeon's preference and experience, provided that meniscal anatomy and function are adequately restored (Table 4).

The stacked bar chart illustrates the final distribution of agreement and disagreement for each statement from the Delphi Round 3 survey (Figure 1).

Consensus was not achieved regarding potential risk factors for MRT repair, including female sex, medial-sided tears, and increased age. Similarly, no consensus was reached on the role of partial meniscectomy for degenerative medial MRTs in patients with advanced degenerative changes (Kellgren-Lawrence grade III or IV) and varus alignment ( $>5^\circ$ ), with 34.1% of experts disagreeing with this approach. No consensus was achieved on the role of orthobiologics in MRT repair, and on the use of fibrin clot augmentation to enhance healing. All statements that were removed during the Delphi survey as a result of high disagreement ( $\geq 20\%$ ) are detailed in Table S3.

## DISCUSSION

The main findings of this modified Delphi consensus study on MRTs are as follows: (1) isolated acute traumatic

MRTs and those associated with ACL injuries should be repaired; (2) increased age was not considered a risk factor for failure MRT repair; (3) repair in chronic degenerative tears should be based on meniscal tissue quality and the degree of joint degeneration; (4) partial meniscectomy may provide short-term symptomatic relief; however, its long-term detrimental effects should not be underestimated; (5) successful healing requires addressing peripheral extension and gapping, with anatomic restoration prioritized over surgical technique or suture choice; (6) no single repair technique has proven superior; both all-inside and inside-out approaches improve clinical outcomes, with the choice guided by surgeon experience and the restoration of meniscal anatomy; and (7) given the limited evidence on early weightbearing and unrestricted motion, a conservative postoperative rehabilitation protocol is recommended.

Management of MRTs has evolved significantly in recent years, driven by improved understanding of both the biomechanical consequences of radial stress and the biological potential for meniscal healing.<sup>1</sup> The detrimental effects of complete radial tears on the load-distributing function of the lateral meniscus are well established, not only for posterior root tears but also for lesions at the posterior horn and mid-body.<sup>14</sup> Similarly, biomechanical studies of medial MRTs have shown that even large partial tears create high-stress concentrations and disrupt circumferential load transmission.<sup>15</sup> Clinically, these biomechanical impairments have been associated with a significantly increased risk of knee OA progression.<sup>1,16,17</sup>

Taken together, these data highlight the importance of meniscal preservation whenever possible. In line with this evidence, the expert panel unanimously agreed that acute traumatic MRTs should be repaired whenever basic criteria of tissue quality are met, whereas repair in chronic degenerative tears should be individualized based on tissue quality and the extent of concomitant joint degeneration.

Lateral meniscus oblique radial tears have gained increasing attention in recent years.<sup>18,19</sup> The expert panel agreed that this subtype represents one of the most common patterns of lateral meniscal tears in patients with concomitant ACL injury. Lateral meniscus oblique radial tears are typically traumatic, and recent evidence supports high success rates when repaired in conjunction with ACL reconstruction.<sup>5</sup> Biomechanical studies have reinforced this clinical rationale highlighting the importance of repairing such lesions in the setting of ACL injury.<sup>20,21</sup>

ME is recognized as a key risk factor after MRTs, being independently associated with higher-grade cartilage damage and progression to degenerative joint changes.<sup>1</sup> Although ME is more commonly observed after medial root and radial tears, lateral meniscus injuries can also induce extrusion, particularly when the

**TABLE 3** Levels of Agreement and Disagreement on Surgical Indications and Treatment of Meniscal Radial Tears After Round 3 of the Expert Panel Survey

| <b>Surgical Indications</b>                                                                                                                                                                                                                                                                                                                                                            | <b>% Agreement</b> | <b>% Disagreement</b> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------------|
| In patients with medial meniscus radial tears without advanced degenerative changes (K-L grade III-IV), lower-limb malalignment greater than 5° should be addressed either concurrently or in a staged procedure                                                                                                                                                                       | 88.9               | 11.1                  |
| Complete meniscal radial tears associated with ACL injuries should be repaired, regardless of whether they occur on the medial or lateral side                                                                                                                                                                                                                                         | 100.0              | 0.0                   |
| Acute traumatic tears should always preferably be repaired as long as basic criteria related to tear location and tissue quality are met                                                                                                                                                                                                                                               | 100.0              | 0.0                   |
| Patients with obesity (BMI > 35), uncorrected lower-limb malalignment, or advanced cartilage damage at presentation may have limited benefit from radial tear repair                                                                                                                                                                                                                   | 91.1               | 8.9                   |
| The indication for repair in chronic degenerative meniscal tears depends on the quality of the meniscal tissue and the extent of accompanying degenerative changes within the joint                                                                                                                                                                                                    | 100.0              | 0.0                   |
| Arthroscopic repair is indicated in symptomatic patients sustaining acute, traumatic tears, as well as in the setting of chronic, degenerative tearing in which adequate meniscal tissue remains and advanced degenerative changes are absent                                                                                                                                          | 95.6               | 4.4                   |
| Focal cartilage damage should be addressed either concurrently or in a staged procedure in patients with medial meniscus radial tears without advanced degenerative changes (K-L grade III-IV)                                                                                                                                                                                         | 86.7               | 13.3                  |
| Relative contraindications to radial meniscal repair include patients with joint space narrowing (<3 mm) as well as the presence of Kellgren-Lawrence grade ≥III chondral degeneration, especially along both the femoral and tibial cartilage                                                                                                                                         | 95.6               | 4.4                   |
| <b>Surgical Treatment</b>                                                                                                                                                                                                                                                                                                                                                              | <b>% Agreement</b> | <b>% Disagreement</b> |
| Although partial meniscectomy often provides short-term symptomatic relief, substantial evidence highlights its detrimental long-term effects                                                                                                                                                                                                                                          | 100.0              | 0.0                   |
| Radial tears of the mid-body and posterior horn may be repaired with different techniques, as long as anatomic restoration of the meniscus is ensured                                                                                                                                                                                                                                  | 100.0              | 0.0                   |
| Advantages of inside-out repair include considerably lower cost and the ability to deploy multiple sutures with minimal damage to the meniscus, whereas limitations include the need for a posterior incision, increasing the risk of neurovascular injury, postoperative pain, increased surgical time, need for an experienced assistant and needlestick injury to the surgical team | 97.8               | 2.2                   |
| The use of all-inside implants has gained popularity as a result of advancements in implant design and surgical technique, making repairs less technically demanding. However, the main disadvantages include higher implant costs and limited access to the anterior portion of the meniscus                                                                                          | 97.8               | 2.2                   |
| Addressing the peripheral extension of the tear as well as the presence of gapping are imperative factors to ensure successful healing of the repair                                                                                                                                                                                                                                   | 97.8               | 2.2                   |
| For partial radial tears extending into the red-white zone (Chahla Type II), repair is performed using either horizontal or vertical mattress suture configurations                                                                                                                                                                                                                    | 88.9               | 11.1                  |
| For complete radial tears, incorporating a rip-stop suture helps minimize the risk of suture cut-out and may enhance the healing potential of the repair compared with nonreinforced suture constructs                                                                                                                                                                                 | 95.6               | 4.4                   |
| For partial radial tears extending into the red-white zone (Chahla Type II), repair is typically performed using an outside-in, all-inside, or inside-out technique, depending on the tear location                                                                                                                                                                                    | 95.6               | 4.4                   |

TABLE 3 (Continued)

| Surgical Indications                                                                                                                                                                                                                                                                                                     | % Agreement | % Disagreement |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|
| For radial tears of the lateral meniscus, side-to-side repair using all-inside or inside-out meniscus-based techniques—without transtibial augmentation—is often the optimal choice, given the inherently greater mobility of the native lateral meniscus                                                                | 95.6        | 4.4            |
| For complete radial tears on the medial side (Chahla Types III, IV, and V), repair is typically performed using a hashtag suture configuration. If meniscal extrusion is present, suture fixation through a transtibial tunnel can be used to help reduce it                                                             | 84.4        | 15.6           |
| In patients without advanced degenerative changes (K-L grade III or IV) and with well-aligned knees ( $\leq 5^\circ$ varus), complete or degenerative radial tears of the posterior horn of the medial meniscus can be treated using a transtibial fixation technique, as they are functionally equivalent to root tears | 91.1        | 8.9            |
| <i>Note:</i> Statements with $\geq 95\%$ agreement are highlighted in green, indicating the highest level of expert consensus.<br>ACL, acute cruciate ligament; BMI, body mass index; K-L, Kellgren-Lawrence.                                                                                                            |             |                |

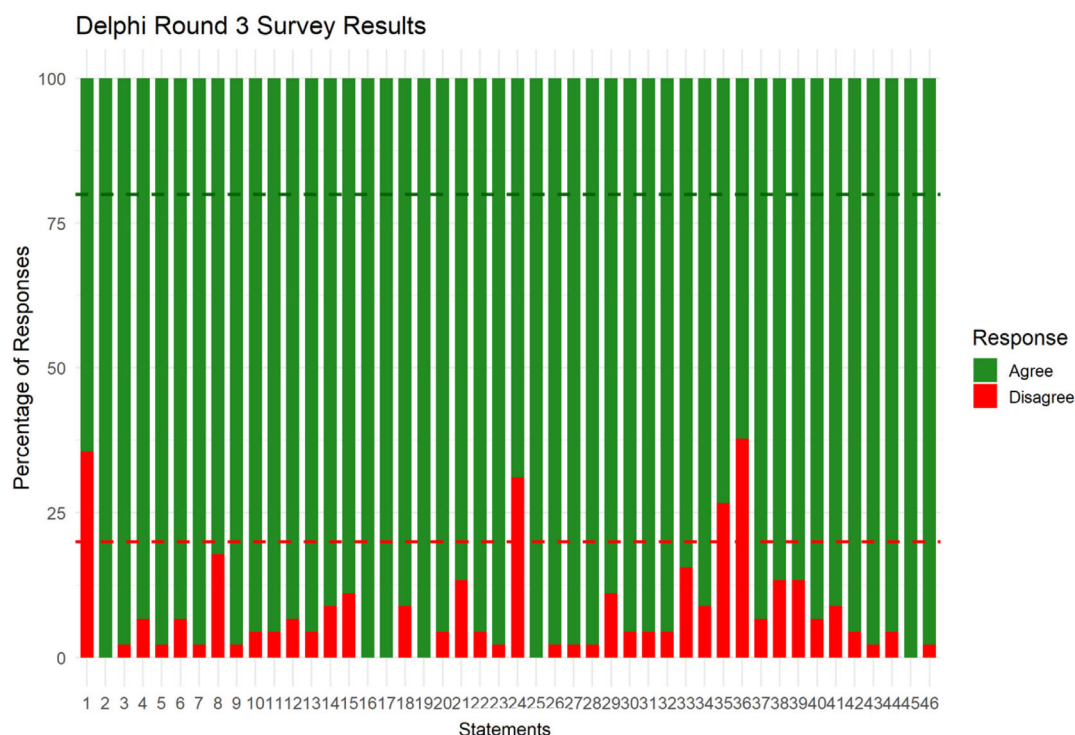
TABLE 4 Levels of Agreement and Disagreement on Rehabilitation, Recovery, and Outcomes After Meniscal Radial Tear Repair After Round 3 of the Expert Panel Survey

| Rehabilitation and Recovery                                                                                                                                                                                                       | % Agreement | % Disagreement |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|
| Given the limited evidence supporting early weightbearing and unrestricted range of motion, postoperative rehabilitation protocols for radial meniscus tear repairs should adopt a more conservative approach                     | 93.3        | 6.7            |
| Nonweight bearing for the first 4-6 weeks after radial meniscus tear repair is essential to protect the repair while allowing a gradual progression to weight bearing                                                             | 86.7        | 13.3           |
| Knee flexion is typically limited to $90^\circ$ during the first 4 weeks                                                                                                                                                          | 86.7        | 13.3           |
| Knee motion can be gradually progressed after 4-6 weeks                                                                                                                                                                           | 93.3        | 6.7            |
| A running progression program may be considered after approximately 16 weeks, based on the achievement of standard functional criteria                                                                                            | 91.1        | 8.9            |
| Caution is required against return to high load, repetitive impact activities. Patient education is critically important to set appropriate and realistic expectations                                                            | 95.6        | 4.4            |
| Outcomes After Meniscus Radial Tear Repair                                                                                                                                                                                        | % Agreement | % Disagreement |
| Overall, there is no conclusive clinical evidence supporting superiority of all-inside repair over inside-out or outside-in techniques. The choice of repair method is typically based on the surgeon's preference and experience | 97.8        | 2.2            |
| In appropriately indicated cases, the repair of radial tears has shown promising outcomes, with healing rates ranging from 60% to 86%                                                                                             | 95.6        | 4.4            |
| Repair of radial tears allows for effective return to function and activity through improvements in subjective outcome scores.                                                                                                    | 100.0       | 0.0            |
| Both all-inside and inside-out repair techniques have shown improvements in patient-reported outcomes.                                                                                                                            | 97.8        | 2.2            |
| <i>Note:</i> Statements with $\geq 95\%$ agreement are highlighted in green, indicating the highest level of expert consensus.                                                                                                    |             |                |

meniscomfemoral ligament is disrupted.<sup>22</sup> ME is traditionally classified as significant when coronal displacement is  $\geq 3$  mm; however, controversy remains regarding the application of this threshold to the lateral meniscus after MRTs.<sup>23</sup> Experts agreed that, because of anatomical and biomechanical differences between the medial and the lateral meniscus, extrusion should be considered

pathological on the lateral side even when it does not exceed the 3-mm threshold typically applied medially. This interpretation is supported by available clinical and biomechanical studies.<sup>24-26</sup>

Although greater magnitudes of extrusion have been reported in medial root tears, knee OA, and varus alignment, uncertainty still persists as to whether an absolute



**FIGURE 1** Distribution of agreement and disagreement for each statement in the Delphi Round 3 survey. Responses are displayed as percentages in stacked bar charts (green = agree, red = disagree). Dashed lines indicate the predefined consensus thresholds ( $\geq 80\%$  agreement and  $< 20\%$  disagreement).

cutoff value should be used.<sup>1,27</sup> Some studies suggest that extrusion may be more appropriately expressed as a proportion relative to meniscal or tibial plateau size to account for patient-specific variation.<sup>28</sup> The expert panel agreed that the optimal threshold for defining pathological ME after MRTs may vary depending on factors such as age, body mass index, and the presence of advanced degenerative changes.

Among the statements that achieved consensus on surgical indications for MRT repair was the recommendation to address lower-limb malalignment, either concomitantly or in a staged manner. In recent years, lower-limb alignment has been extensively studied in the context of medial meniscus repair, particularly regarding preoperative varus alignment.<sup>29-31</sup> Although most of the available evidence concerns medial root repairs, where varus malalignment is a recognized risk factor for ME,<sup>27</sup> MRTs share similar deleterious biomechanical consequences, including total disruption of hoop stresses.<sup>1</sup> Thus, residual ME is a major concern. Although clinical data on combined meniscus repair and osteotomy remain limited, shifting load-bearing back toward physiologic distribution is expected to improve medial compartment symptomatology and protect the repair site, potentially reducing the risk of residual ME.<sup>1,29,31</sup> Accordingly, the expert panel recommended correcting malalignment either simultaneously with MRT repair or in a staged procedure when appropriate.

The expert panel reached consensus that an age greater than 50 years and K-L grade III may be considered as reference points when evaluating indications for meniscal radial repair, particularly in asymptomatic patients. Although there are no strict universal cut-offs in high-level clinical guidelines, both existing evidence and expert experience support the use of these parameters for prognostic stratification and shared clinical decision-making rather than as absolute exclusion criteria.

Several considerations warrant emphasis. First, surgeons should prioritize biological age and overall joint health over chronological age alone. Second, the indication applies specifically to clinically asymptomatic, incidentally identified tears, for which the expected benefit of repair may be limited. Importantly, the proposed age threshold should not be interpreted as an absolute mandate; instead, repair decisions should be guided by a comprehensive assessment that includes patient symptoms, activity level, tissue quality, alignment, and cartilage status.<sup>32,33</sup> Age per se should therefore not be considered an absolute contraindication to meniscal repair.

Furthermore, K-L grade III reflects established cartilage degeneration and an altered joint environment, in which the biological and mechanical conditions for meniscal healing are less favorable.<sup>32</sup> In this setting, the success of meniscal repair becomes less predictable, and the risk of ongoing

joint degeneration remains higher, even in the presence of technically successful repair. These factors justify a more cautious approach and support consideration of conservative management in appropriately selected patients.

Partial MRTs typically involve the avascular white-white zone of the meniscus and were historically considered irreparable, most often treated with meniscectomy.<sup>1</sup> Although partial meniscectomy may provide short-term symptomatic relief and improved PROMs,<sup>34,35</sup> its long-term detrimental impact is well documented.<sup>1,16,17</sup> All 45 experts unanimously agreed that, despite possible short-term improvement, partial meniscectomy for MRTs should be avoided because of its long-term adverse consequences. This is particularly discouraged in patients with preserved cartilage or in the setting of concomitant injuries, such as ACL tears.

Both the all-inside and the inside-out techniques have distinct advantages and limitations. Over the past several years, numerous studies have sought to determine the superiority of 1 technique over the other, but results remain inconclusive.<sup>3,4</sup> Historically, the inside-out approach has been the most commonly reported for MRT repair, yet advances in device design and surgical techniques have driven increasing adoption of all-inside repair.<sup>3,4</sup>

The expert panel reached high agreement on several advantages of the inside-out method, including substantially lower cost and the ability to place multiple sutures with minimal iatrogenic damage to the meniscus. Nonetheless, this technique is associated with longer operative time, the requirement for an experienced surgical assistant, and a small but relevant risk of neurovascular injury.<sup>1,3</sup> By contrast, modern all-inside devices have made meniscal repair technically less demanding. However, disadvantages include higher implant costs and limited access to the anterior horn of the meniscus.<sup>1</sup>

Recent cadaveric studies have had potential biomechanical advantages of all-inside repairs.<sup>7</sup> Vertical suture constructs created with all-inside devices show reduced displacement, higher load to failure, and greater stiffness than horizontal inside-out constructs.<sup>6</sup> Other comparative studies similarly report lower displacement and higher load to failure for medial meniscus repairs using all-inside constructs, as well as greater stiffness for both medial and lateral meniscus repairs.<sup>6,7,36,37</sup>

One of the most clinically relevant agreements reached by the expert panel was that successful outcomes after MRT repair depend primarily on anatomic reduction and preservation of meniscal tissue to ensure knee stability and delay the progression of early OA, rather than on the choice of repair technique. Surgeons must carefully distinguish between biomechanical studies that show construct superiority under static, time-zero conditions and outcomes observed in clinical practice. Interestingly, although

some studies report biomechanical superiority of all-inside constructs, failures in this technique most often occur through suture breakage, whereas inside-out repairs more commonly fail because of suture pullout through the tissue.<sup>6</sup> Thus, high construct stiffness alone is insufficient to establish clinical superiority. Given the dynamic and mobile nature of the meniscus, over-constraining the repair site with meniscus-based all-inside devices may compromise tissue healing and increase the risk of suture failure by failing to replicate native meniscal biomechanics. Ultimately, the panel emphasized that either technique can be used, provided that anatomic restoration of the meniscus is achieved. This message is particularly relevant for surgeons practicing in resource-limited settings, where access to costly all-inside devices may be restricted.

For more complex radial tears (Chahla Types III, IV, and V),<sup>2</sup> the expert panel agreed that incorporating a rip-stop suture construct helps minimize the risk of suture displacement and may enhance healing potential than nonreinforced constructs. In cases of complete medial-sided tears with associated ME, transtibial suture augmentation can be used to help reduce extrusion.<sup>2,38-40</sup> Although mid- and long-term clinical data are lacking, biomechanical studies suggest that transtibial pullout augmentation decreases gapping at the tear site and improves both load to failure and displacement characteristics.<sup>2,38,39</sup> However, this approach is not recommended for lateral meniscus tears, given the greater native mobility of the lateral meniscus. In such cases, side-to-side repair using either all-inside or inside-out meniscus-based techniques was the preferred option of the expert panel.

In terms of clinical outcomes, the expert panel agreed that both all-inside and inside-out repair techniques result in improvements in PROMs, and there is no conclusive clinical evidence showing superiority of the all-inside approach over inside-out or outside-in techniques. The choice of repair method should therefore be guided by the surgeon's experience and familiarity with the technique. The panel also reached consensus that, in appropriately selected cases, MRT repair yields promising results, with healing rates up to 80%-90%.<sup>1,4</sup> Whether these favorable short- and mid-term results translate into long-term protection against degenerative joint disease remains uncertain and requires further investigation.

It is also noteworthy to address the statements that were discarded by the panel because of high disagreement. Previous reports suggested that increased age, female sex, and medial meniscus repair may be associated with higher failure rates after MRT repair.<sup>41</sup> However, the expert panel did not reach consensus on these factors, emphasizing that outcomes cannot be interpreted in isolation from other important variables such as pre-existing joint

degeneration, meniscal tissue quality, and lower-limb alignment. Consequently, based on this consensus, these demographic or tear-related factors alone should not be considered contraindications for MRT repair, provided that the established indications and contraindications are respected and meniscal preservation is prioritized.

Regarding orthobiologics, despite ongoing interest in their role in meniscus repair, no consensus was achieved on the use of fibrin clot augmentation for MRTs. Future research should focus on areas where disagreement exists, as identified by the expert panel, to generate supportive evidence and advance the field of meniscus preservation.

## Limitations

Several limitations inherent to the modified Delphi methodology and Level V evidence should be acknowledged. First, the findings represent expert opinion rather than high-level clinical evidence and are therefore subject to inherent biases, including recall bias and interpretation bias. Second, panel composition and selection may introduce selection bias, limiting the generalizability of the results to broader or more diverse clinical populations. Third, consensus thresholds are inherently arbitrary and may influence which statements achieve or fail to achieve consensus. Fourth, the modified Delphi process lacks control or comparison groups and may oversimplify complex clinical decision-making by reducing nuanced expert perspectives to Likert scale responses. Finally, the rapidly evolving nature of evidence and surgical techniques in meniscus treatment may limit the long-term applicability of this consensus.

## CONCLUSIONS

Expert consensus supports repair of acute traumatic and ACL-associated MRTs, whereas indications for chronic degenerative tears depend on tissue quality and joint status. Increased age alone was not considered a contraindication to MRT repair. Anatomic restoration is essential for a successful outcome, irrespective of surgical technique. An initial nonweight-bearing rehabilitation protocol is recommended.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section.