



QUALITY IN SPORT

eISSN 2450-3118 · Open Access · Peer-reviewed

apcz.umk.pl/QS Nicolaus Copernicus University in Toruń



KOŹMA, Gracjan, BORKOWSKA, Marta, SOLTAN, Alicja, PAWLICKI, Jakub, WITASZCZYK, Małgorzata, WIKTORZAK, Natalia, LIPSKA, Julia, PRZĄDKA, Jagoda, KOCHAN-OLSZEWSKA, Dominika, RUDNICKI, Longin, LASKUS, Justyna, KLIMAS, Paweł, GAWIOR, Bartosz and STASIAK, Olga. Return to Sport After Isolated Meniscal Repair: From Time-Based Protocols to Criteria-Based Clearance. A Narrative Review. *Quality in Sport*. 2026;71:74865. <https://doi.org/10.12775/QS.2026.71.74865>

ARTICLE TIMELINE

Received: 01.08.2026. Revised: 18.08.2026. Accepted: 07.09.2026. Published: 13.09.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).

Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych). © The Authors 2026.

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Return to Sport After Isolated Meniscal Repair: From Time-Based Protocols to Criteria-Based Clearance. A Narrative Review

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Abstract

Background: Meniscal repair preserves meniscal tissue and may reduce the adverse long-term consequences associated with partial meniscectomy. However, rehabilitation protocols and return-to-sport criteria remain inconsistent, and time since surgery is still often the main factor guiding progression.

Aim: To present current evidence on rehabilitation and return to sport after isolated meniscal repair, focusing on return rates and timing, functional criteria, tear- and repair-related factors and return to the preinjury level of sport.

Methods: A narrative review was conducted using PubMed/MEDLINE and Google Scholar and supplemented by screening reference lists. Thirty publications were included, with priority given to studies of isolated meniscal repair in athletes and physically active patients.

Results: Return-to-play rates ranged from 71.2% to 100%, with time to RTP ranging from 3.3 to 10 months. Return to the same or a higher level of activity was reported in only three studies and ranged from 53.9% to 92.6%. Current evidence supports combining a minimum period needed for biological healing with assessment of pain, effusion, range of motion, muscle strength, neuromuscular control and load tolerance. Stable vertical longitudinal tears may allow faster progression, whereas radial, root, complex and horizontal tears usually require a more restrictive rehabilitation approach. Functional testing may identify persistent deficits, but validated cut-off values specific to isolated meniscal repair are lacking. Return to sport does not necessarily mean return to the preinjury level of sport or full sports performance.

Conclusions: Return to sport should be gradual and individualised, based on healing time and clinical, functional and sport-specific criteria. No universal, validated return-to-sport algorithm is currently available. Prospective studies are needed to standardise endpoint definitions and validate progression criteria.

Keywords: isolated meniscal repair; return to sport; return to play; rehabilitation; functional assessment; criteria-based rehabilitation; meniscal preservation

1. Introduction

The menisci play an important role in the knee joint by increasing the contact area between the femur and the tibia and helping to transmit loads. Their ability to convert axial loads into circumferential (hoop) stresses is especially important. This hoop stress mechanism allows the menisci to distribute forces within the joint, reduce focal overload of the articular cartilage and

contribute to shock absorption and knee stability. Meniscal injury or loss of meniscal tissue may disturb this mechanism, leading to cartilage overload and reduced knee function (1).

A better understanding of meniscal function has changed the treatment of meniscal tears. Today, greater attention is given to meniscus-preserving treatment when it is technically feasible and biologically appropriate (2). Partial meniscectomy may allow an earlier return to activity, but it also leads to loss of meniscal tissue and may be associated with less favourable long-term outcomes. Studies comparing meniscal repair with partial meniscectomy suggest that meniscal preservation may reduce the risk of osteoarthritis progression and the need for knee arthroplasty (3,4). A similar numerical pattern was reported by Skinner et al. In an analysis of a large insurance database, a diagnosis of knee osteoarthritis within 5 years after surgery was recorded in 13.5% of patients after isolated partial meniscectomy and in 10.7% after isolated meniscal repair. These findings should be interpreted with caution because the study was based on procedure and diagnosis codes and did not include clinical or radiographic data (5).

In athletes and physically active patients, one of the main goals of treatment is not only to relieve symptoms but also to allow a safe return to training, competition and the preinjury level of activity. Return to sport should take into account the tear pattern, the repair technique used, patient expectations and the demands of the specific sport (6).

Despite the growing number of publications, rehabilitation protocols and return-to-sport criteria after isolated meniscal repair have not been clearly standardised. Studies differ in the definition of return to sport, the timing of weight-bearing, range-of-motion restrictions and the criteria used for return-to-sport clearance. It is increasingly recognised that time since surgery should not be the only criterion for decision-making. A more appropriate approach combines healing time with the assessment of symptoms, range of motion, muscle strength, neuromuscular control and load tolerance (7,8).

The aim of this review is to present current evidence on return to sport after isolated meniscal repair, focusing on postoperative rehabilitation, return timing, functional criteria and tear- and repair-related factors. It also examines the shift from decisions based only on time to an approach that combines healing time, functional assessment and sport-specific demands.

2. Methods

This was a narrative review. The literature was searched in PubMed/MEDLINE and Google Scholar. The following keywords and their combinations were used: “isolated meniscal repair”, “meniscal repair”, “meniscus repair”, “return to sport”, “return to play”, “return to activity”,

“return to running”, “rehabilitation protocol”, “criteria-based return to sport”, “functional testing”, “meniscal repair failure”, “reoperation”, “meniscal preservation” and “osteoarthritis”. The terms were combined using the operators AND and OR. The search was supplemented by screening the reference lists of publications considered relevant to the topic.

The review included clinical studies, observational studies, narrative reviews, systematic reviews, meta-analyses, scoping reviews and consensus statements on meniscal repair, postoperative rehabilitation and return to sport. Priority was given to studies of isolated meniscal repair in athletes and physically active patients. Publications addressing concomitant anterior cruciate ligament (ACL) reconstruction, partial meniscectomy, knee osteoarthritis or other related topics were used only as supporting sources when they provided relevant information on meniscal biomechanics, rehabilitation, the risk of repair failure, return to activity or the long-term consequences of treatment. A total of 30 publications were included. Because this was a narrative review, no formal risk-of-bias assessment or quantitative synthesis of the results was performed.

3. Current Evidence on Rehabilitation and Return to Sport After Isolated Meniscal Repair

3.1. Terminology and Endpoints of Return to Activity and Sport

In the literature on meniscal repair, terms related to return to activity after surgery are not equivalent and describe different levels of activity. The broadest term is return to activity, which may include daily activities or recreational physical exercise. Other terms, such as return to running (RTR), return to sport (RTS), return to play (RTP), return to performance and return to the preinjury level, may refer to progressively more demanding outcomes, although RTS and RTP are not used consistently across studies (9).

This distinction is important when interpreting study results. Return to sport alone does not automatically mean return to the preinjury level or full recovery of sports performance. Some publications report only whether the patient returned to any sports activity, while others refer to return to play or return to the preinjury level (10,11). Therefore, the reported data should be interpreted with caution, especially when studies do not clearly define the activity level reached. In this review, return to sport is considered part of a broader process that includes return to activity, running, training, competition and, for some patients, return to the preinjury level of sport.

3.2. Return-to-Sport Rates and Timing

Available studies suggest that most patients return to sport after isolated meniscal repair. However, the reported time to return depends on the endpoint that was assessed. In the review by Schwach et al., the mean time to return to running was 12.9 weeks, while the mean time to return to sport was 20 weeks (9). However, these data refer to differently defined stages of return to activity and should not be directly compared with return to play. In studies assessing return to play in athletes, Blanchard et al. reported an overall RTP rate of 83.1%, with a mean time to RTP of 8.7 months (11). Fried et al. reported return-to-play rates ranging from 71.2% to 100%, with time to RTP ranging from 3.3 to 10 months (10).

It is especially important to distinguish return to play from recovery of the preinjury activity level. In the study by Vrgoč et al., which included 52 athletes after isolated meniscal repair, 85% returned to their preinjury level of sport, with a mean time to RTS of 6.5 months. Repair failure, defined as a retear requiring reoperation, occurred in 8 of 52 patients (15%). Despite the high return rate, the mean Tegner score for the whole cohort decreased from 7.1 before surgery to 6.2 at the final follow-up (12). Rodríguez-Roiz et al., with a mean follow-up of 7 years, reported that 41 of 43 amateur athletes (95.3%) resumed sports activity after isolated meniscal repair, while the mean Tegner score remained close to the preinjury level (5.46 vs 5.11) (13). However, results from individual cohorts should be interpreted in a broader context. Fried et al. found that return to the same or a higher level of activity was reported less often, with rates ranging from 53.9% to 92.6%. Blanchard et al. also noted that many studies did not clearly state whether athletes returned to their preinjury level of sport (10,11). High RTS rates should therefore not be interpreted as full recovery of preinjury sports performance.

3.3. Postoperative Rehabilitation Milestones and Progression

Rehabilitation after meniscal repair should be treated as a staged process rather than a fixed protocol based only on time since surgery. Available evidence shows considerable variation and a lack of standardisation across rehabilitation protocols, especially in weight-bearing, range-of-motion restrictions and the timing of activity progression (7). The EU-US Meniscus Rehabilitation 2024 Consensus states that rehabilitation after meniscal repair should be based on both healing time and clinical and functional criteria (8). This means that progression to the next stage should not depend only on the number of weeks since surgery, but also on the assessment of effusion, pain, range of motion, quadriceps control and tolerance of increasing loads (8,14).

The main goals of the early rehabilitation phase are to protect the repair site, reduce effusion and pain, restore knee extension and regain quadriceps activation (14). The usual criteria for progression to the next, more advanced phase are full or nearly full passive range of motion, no effusion and good neuromuscular control of the quadriceps. In the next phase, the focus shifts to restoring a normal gait pattern, gradually increasing loads and improving dynamic control of the limb. Progression to increased loading and dynamic control training should begin only when the patient has a full active range of motion and muscle strength of at least 80% of that of the contralateral limb (8).

The type of tear and the stability of the repair should also be considered when planning postoperative restrictions. Stable vertical longitudinal tears that preserve the hoop stress mechanism usually allow faster weight-bearing progression. In contrast, radial, root, complex and horizontal tears require a more conservative approach (8,14,15). The EU-US Meniscus Rehabilitation 2024 Consensus states that full weight-bearing may be considered after repair of stable vertical tears. For complete oblique and radial tears, no weight-bearing is recommended and range of motion should be limited to 0–90° for 4–6 weeks. For horizontal tears in young athletes, partial or no weight-bearing and a 0–90° range-of-motion limit are advised for 4 weeks. After root repair, weight-bearing should be avoided for 6 weeks, with range of motion limited to 0–90° during the first 4 weeks. Restrictions after complex tears should be adjusted to the specific tear pattern and repair stability (8). Similarly, Calanna et al. recommend partial weight-bearing during the first 4 weeks for stable tears with a preserved hoop stress mechanism and no weight-bearing during the first 6 weeks after repair of radial and root tears (15). Mameri et al. provided a biomechanical explanation for this approach, noting that radial tears are exposed to distraction forces and increased strain during axial loading, which increases the risk of repair failure (16).

Activities that place high loads on the repair site should also be limited. Deep squats, jumping and rotational knee movements should usually be avoided for at least 4 months after meniscal repair and then introduced gradually. The minimum rehabilitation period after repair of stable vertical tears is usually at least 4 months, whereas complex, radial, root and horizontal tears may require 6–9 months of rehabilitation (8).

3.4. Functional Assessment and Criteria-Based Clearance

The decision to clear a patient for sport after isolated meniscal repair should not be based only on the time since surgery. Fried et al. showed that time was the most commonly used return-to-play criterion in most studies, while objective functional criteria were reported much less

often (10). However, this approach is too limited because time alone does not indicate whether strength, neuromuscular control and load tolerance have been restored or whether the patient is ready for the specific demands of the sport. For this reason, current recommendations state that return to sport after treatment of meniscal tears should be based on both healing time and clinical and functional criteria (17).

Assessment before return to activity should include both clinical findings and functional tests. Basic criteria include no or minimal joint effusion, full range of motion, no significant knee pain and recovery of quadriceps and hamstring strength (14,17). Single-leg tasks are also important because a full return to sport requires adequate unilateral strength and the ability to stabilise the limb, decelerate, change direction and absorb loads (9,17). In clinical practice, strength may be measured using isokinetic or hand-held dynamometry. Balance and lower-limb control tests, the limb symmetry index (LSI) and hop tests may also be used (14,17).

The value of functional testing after isolated meniscal repair is supported by the findings of Gronbeck and Tompkins. The authors assessed patients between 80 and 150 days after surgery. Although most patients had good functional performance at around 4 months after surgery, some still did not reach the 90% LSI threshold. The percentage of patients who did not reach 90% LSI was 30% for the single-leg hop, 29% for the single-leg crossover triple hop, 36% for the single-leg triple hop for distance and 20% for the single-leg timed hop. The largest deficits were found in the retro step-up test, in which 45% of patients did not reach the 90% LSI threshold (18). However, the 90% LSI threshold has not been validated specifically for return to sport after isolated meniscal repair. These findings show that even when many patients appear to function well after several months of rehabilitation, time since surgery alone cannot reliably determine whether they are ready to return to sport.

The EU-US Meniscus Rehabilitation 2024 Consensus also states that patient motivation and readiness to return should be assessed together with clinical and functional criteria. Patient-reported outcome measures (PROMs), such as the IKDC, KOOS, Tegner Activity Scale, Marx Activity Rating Scale and VAS may be helpful. However, they should support rather than replace objective functional assessment (17). If the patient does not achieve the next rehabilitation milestones or continues to have effusion, pain, mechanical symptoms or functional instability, return to sport should be delayed. Further rehabilitation or orthopaedic reassessment may then be needed (17,18).

3.5. Tear-, Repair- and Patient-Specific Factors Affecting Return to Sport

Return to sport after isolated meniscal repair is influenced by tear pattern, repair stability and patient characteristics. A key issue related to tear type is whether the hoop stress mechanism is preserved or disrupted. Stable vertical longitudinal tears, in which the circumferential fibres remain intact, usually tolerate earlier weight-bearing and have a more favourable prognosis. In contrast, radial, root and complex tears may disrupt the continuity of the circumferential fibres and often require more restrictive rehabilitation protocols (14,15). Clinical data also support the importance of tear pattern. In a retrospective cohort of 53 athletes, Lassioued et al. reported that vertical longitudinal tears were associated with higher postoperative IKDC and Tegner scores than other tear types, especially complex tears (19).

The effect of medial or lateral tear location on treatment outcomes and return to sport remains unclear. In the study by Nakayama et al., return-to-sport rates were similar after medial and lateral meniscal repair, and there were no significant differences in clinical outcomes or re-tear rates (20). Similarly, Erickson et al. and Lassioued et al. found no significant differences in postoperative outcomes between medial and lateral tears (19,21). In clinical practice, tear morphology, vascular-zone location and repair stability may therefore be more important for prognosis than whether the tear involves the medial or lateral meniscus.

However, tear location may play an important role when choosing the surgical treatment. In their review of elite athletes, D'Ambrosi et al. recommended repairing lateral meniscal tears because of their good healing potential and the increased risk of chondrolysis and reoperation after partial meniscectomy. For medial meniscal tears, the authors suggested that the primary treatment goal should guide decision-making. If the priority is the fastest possible return to sport, a highly selective partial meniscectomy may be considered. In other situations, they favoured repair because it preserves meniscal tissue and may reduce the risk of accelerated osteoarthritis development (22).

The effect of repair technique on treatment outcome also remains unclear and may depend on tear location and type. In the review by Golz et al., all-inside repair of vertical longitudinal and bucket-handle tears was associated with functional outcomes, healing rates and complication rates similar to those of inside-out repair, but with a shorter operative time (23). In the meta-analysis by Miller et al., which included only athletes, the failure rate was higher after all-inside repair than after inside-out repair (23.1% vs 12.2%). This difference was especially clear for medial meniscal repairs, with failure rates of 58.1% after all-inside repair and 14.7% after inside-out repair. For lateral meniscal repairs, the failure rates of the two techniques were similar. However, every all-inside repair included in the analysis used the Fast-Fix device,

which limits the generalisability of these findings to other, especially newer, all-inside systems. Based on these findings, the authors recommended considering the inside-out technique first in athletes with medial meniscal tears (24). Migliorini et al. reported somewhat different findings. In a larger and more heterogeneous population, they found no differences between the techniques in overall failure and reoperation rates. However, all-inside repair was associated with more reinjuries (26% vs 11%) but also with a higher rate of return to the preinjury level (75% vs 58%) (25). The differences between these two publications do not support one technique as universally better for all patients. They may partly result from differences in the study populations, tear types and locations and the definitions of failure and reinjury.

Patient-related factors and the time from injury to surgery may also affect treatment outcomes and the expected return to activity. In the study by Lassioued et al., surgery within 3 months of injury and age below 20 years were associated with higher postoperative Tegner scores, while non-smoking was associated with a higher IKDC score. Higher preoperative functional status was also associated with better postoperative outcomes (19). However, the effect of age on prognosis remains unclear and should not be assessed without considering other patient characteristics and tear features. Jaibaji et al. showed that in carefully selected patients aged 40 years or older, failure rates and functional outcomes after meniscal repair may be similar to those seen in younger patients (26). In the study by Domzalski et al., smoking was associated with less favourable outcomes after outside-in meniscal repair. Smokers had lower KOOS scores than non-smokers (67.4 vs 80.2) and returned later to daily activities (5.4 vs 4.2 months) and sports activity (9.4 vs 7.6 months) (27). Smoking status should therefore be considered when prognosis and the expected time to return to activity are discussed with the patient.

3.6. Sport-Specific Outcomes and Return to Performance

In athletes, RTS should not be viewed only as the point when sports activity is resumed. It is also important to determine whether the patient regains load tolerance, training intensity and a level of function similar to that before the injury. Hanna et al. stressed that the decision to return to play should depend on the type of pathology, the athlete's competitive level, their expectations and the specific demands of the sport (6). Similarly, the EU-US Meniscus Rehabilitation 2024 Consensus states that the final stage of rehabilitation in athletes should include preparation for the demands of the specific sport (17). Training volume should be increased gradually because, in a competitive athlete, returning to a single training session does not mean that the athlete is ready for a match or competition.

Dzidzishvili et al. also reported a gap between RTS and recovery of the previous activity level. In a mixed cohort of patients after all-inside repair of bucket-handle tears and full-thickness radial tears, 87.2% returned to sport, but only 48.9% reached their preinjury level. However, interpretation of these findings is limited by the fact that 54.6% of repairs were combined with ACL reconstruction (28).

A similar difference between return to sport and post-return performance was reported by Erickson et al. in professional baseball players after meniscal repair. The authors found that 74% of players returned to sport after a mean of 209 days, while 68% returned to the same or a higher level of competition. Repair failure requiring later meniscectomy within 2 years occurred in 19% of players. A more detailed analysis of sports performance also showed that pitcher usage decreased, without a significant decline in performance. Among hitters, most performance measures remained similar, but the number of stolen bases and on-base percentage decreased significantly (21). These findings show that a full assessment of return to sport should also include the level of competition and the quality of performance after return.

Marigi et al. also showed the difference between general return to sport and return to a specific sport in wrestlers treated surgically for isolated meniscal tears. The authors found that 89% of patients returned to sport, but only 65% returned to competitive wrestling (29). However, only 29 of the 85 wrestlers underwent meniscal repair, while the remaining 56 were treated with partial meniscectomy. This result shows that a high overall RTS rate may overstate readiness to return to sports that involve contact, deep knee flexion, rotation and sudden changes in load. The meta-analysis by Tsakiri et al. on isolated bucket-handle tears in young adults also shows the limitations of simply reporting return to sport. The postoperative Tegner score was 5.94, which the authors interpreted as a return mainly to recreational sport. At the same time, fewer than 2% of patients achieved a score above 7, which is more consistent with high-level competitive sport (30). However, the analysis included only five studies involving 168 knees, and their methodological quality ranged from fair to poor. These findings should therefore be interpreted with caution. A good clinical outcome and return to activity do not necessarily mean return to a high level of sport.

4. Discussion and Clinical Implications

The available evidence shows that neither the return-to-sport rate nor the time to return is sufficient to assess treatment success after isolated meniscal repair. Individual studies use different definitions of return-to-activity endpoints and the criteria for return-to-sport clearance

are not standardised. Fried et al. found considerable variation in rehabilitation protocols and insufficient reporting of RTP criteria, which limits direct comparison between studies (10). Reported RTS rates should therefore be interpreted together with the level of activity achieved, the demands of the sport and the definition of the endpoint used.

The main clinical implication is that healing time and functional readiness should be treated as two complementary factors. Time sets the minimum period needed to protect the repair during healing, while clinical and functional assessment determines whether the patient can safely progress to the next stage of rehabilitation. Rehabilitation should therefore progress according to both time and the achievement of specific milestones (8,17). A good result in a single functional test should not shorten the protection period required for a specific tear type. Similarly, time alone should not lead to progression of training loads when knee deficits are still present.

Return to sport should not follow the same plan in every patient. Postoperative management depends on several factors, including tear characteristics, repair technique and the rehabilitation protocol used (7). Stable vertical longitudinal tears usually allow less restrictive load progression and are associated with a more favourable clinical course. Radial, root, horizontal and complex tears require greater caution and usually more restrictive rehabilitation protocols. These differences are most important during the early stages of postoperative management because they mainly affect protection of the repair site and the rate of load progression.

In the later stages, return to sport should be gradual. After reaching sufficient clinical and functional readiness, the patient should first return to controlled forms of training, followed by sport-specific tasks, unrestricted training and finally competition. Hanna et al. stressed that the decision to return should be adjusted to the type of pathology, the athlete's competitive level and their individual needs and expectations (6). The goals of this process may differ between recreational and competitive athletes. For recreational athletes, a safe return to the chosen activity without recurrence of symptoms may be a sufficient outcome. Competitive athletes, especially professionals, aim to regain full load tolerance and return to their preinjury level. The ability to resume training or competition without regaining preinjury performance is therefore not a sufficient endpoint.

Return to sport is not the same as full treatment success. The outcome of meniscal repair should be assessed from several perspectives, including not only whether and when RTS occurred, but also repair durability, the risk of re-tear and reoperation and the long-term consequences for the joint. The biological benefits of preserving meniscal tissue, including a possible reduction in the risk of knee osteoarthritis progression, may support choosing repair when it is technically

feasible despite the risk of failure (3,4). Partial meniscectomy may allow earlier RTS, but this should not be understood as a better long-term outcome.

The main limitation of the current literature is the wide variation in endpoint definitions, study populations, rehabilitation protocols and return-to-sport criteria. Schwach et al. rated the level of evidence for RTR and RTS criteria as low because the criteria were heterogeneous and often selected arbitrarily, and they highlighted the need for standardisation (9). Other problems include differences in tear types and locations, definitions of repair failure and the presence of concomitant procedures, especially ACL reconstruction. The small number of studies directly comparing all-inside and inside-out repair prevents reliable identification of one technique as universally better for all patients. Together, these limitations hinder the development of a universal RTS algorithm after isolated meniscal repair. As a narrative review, this work does not include a formal risk-of-bias assessment of all included publications or a meta-analysis. The clinical implications presented here should therefore be viewed as a synthesis of the available evidence rather than a validated management protocol.

Future studies should include prospective, multicentre cohorts of patients after isolated meniscal repair. Consistent definitions of return to running, return to sport, return to play and return to performance are needed. Results should be reported separately according to tear type and location, repair technique, competitive level, sport and patient characteristics. Treatment outcomes should include not only the time of RTS, but also the level of activity after return, tolerance of full sport-specific loads, recurrence of symptoms, retears, reoperations and long-term outcomes. Studies should also use consistent clinical and functional criteria and assess whether meeting these criteria is associated with a lower risk of repair failure after return to sport.

5. Conclusions

Return to sport after isolated meniscal repair is a multistage process and should not be assessed only by the time since surgery or by the fact that activity has been resumed. Decisions on rehabilitation progression should combine a minimum period needed to protect the repair during healing with assessment of symptoms, range of motion, muscle strength, neuromuscular control and load tolerance. Management should be individualised according to tear type and location, repair stability, patient characteristics and the demands of the specific sport.

RTS alone does not mean full treatment success. Outcome assessment should also include the level of activity achieved after return, the degree of recovery of preinjury function, repair durability, the risk of retear and reoperation and the long-term consequences for the knee joint.

Meniscal preservation remains an important treatment goal when repair is technically possible, although partial meniscectomy may allow an earlier return to activity.

Because of the heterogeneity of available studies, inconsistent endpoint definitions and the lack of validated functional criteria, no universal RTS algorithm can currently be recommended after isolated meniscal repair. Further studies should use standardised definitions of the different stages of return to activity and report clinical, sport-specific and long-term outcomes separately.

Disclosure

Author Contributions

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All authors have read and agreed with the published version of the manuscript.

Funding Statement

The research did not receive any special funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Acknowledgements

Not applicable.

Conflicts of Interest

The authors report that there is no conflict of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process

In preparing this work, the authors used ChatGPT (OpenAI) for the purpose of English translation and grammar and stylistic editing. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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