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The Role of Magnetic Resonance Imaging in Sports Injuries: Current Applications and Clinical Importance - A Narrative Review

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Abstract
Background. Magnetic resonance imaging (MRI) is the reference imaging modality for evaluating sports-related musculoskeletal injuries because of its excellent soft tissue contrast and ability to assess ligaments, tendons, muscles, cartilage, and bone marrow without ionizing radiation.
Aim. To summarize the clinical applications of MRI in the diagnosis and management of sports-related musculoskeletal injuries and discuss emerging developments in quantitative MRI and artificial intelligence (AI).
Material and methods. A narrative review of recent reviews, systematic reviews, meta-analyses, and original studies on MRI in sports medicine was performed.
Results. Conventional MRI remains essential for diagnosing anterior cruciate ligament tears, meniscal injuries, muscle injuries, Achilles tendon disorders, and bone stress injuries, supporting treatment planning and rehabilitation. Quantitative MRI enables assessment of tissue composition and microstructural changes beyond conventional imaging, while AI shows promise in image acquisition, reconstruction, automated analysis, and clinical decision support. However, further validation and protocol standardization are required.
Conclusions. MRI remains central to sports injury evaluation. Advances in quantitative MRI and AI may improve diagnostic accuracy, workflow efficiency, and individualized patient management, although further prospective multicentre studies are needed before routine clinical implementation.

Keywords: magnetic resonance imaging, sports injuries, musculoskeletal imaging, anterior cruciate ligament, meniscal injuries, muscle injuries, Achilles tendon, bone stress injuries, quantitative MRI, artificial intelligence

1. Introduction

Sports injuries are frequently observed among athletes and represent an important subject of epidemiological research in sports medicine. In professional football, one of the most extensively studied sports, a systematic review and meta-analysis reported an overall injury incidence of 8.1 injuries per 1000 hours of player exposure. Match-related injuries occurred more frequently than training-related injuries, with incidences of 36 injuries per 1000 hours during matches and 3.7 injuries per 1000 hours during training. Lower extremity injuries were the most commonly reported injuries, demonstrating the high prevalence of musculoskeletal injuries in this population [1].

The International Olympic Committee (IOC) states that injury and illness surveillance and epidemiological studies are fundamental components of efforts aimed at protecting athlete health. The IOC recommends standardized methods for recording and reporting injuries because consistent definitions and data collection procedures improve the quality and comparability of epidemiological data obtained from different sports and athlete populations [2].

The evaluation of sports-related injuries requires accurate assessment of the injured structures and the extent of tissue damage. Imaging techniques play an important role in sports medicine because they assist clinicians in establishing a diagnosis and determining appropriate management strategies. According to Upadhyaya and Choudur, accurate diagnosis of sports injuries requires knowledge of injury patterns and the use of appropriate imaging modalities to evaluate the extent of tissue damage. Imaging can also be used during follow-up to assess changes occurring throughout the healing process after conservative or surgical treatment. In particular, MRI enables monitoring of soft tissue regeneration, evaluation of tissue remodeling, and supports clinical decision-making regarding an athlete's return to sport [3,4].

MRI and ultrasound are among the most frequently used imaging modalities for the assessment of sports-related soft tissue injuries. MRI is considered the reference imaging method for evaluating muscle injuries in athletes because it provides detailed visualization of soft tissues and allows assessment of the extent and severity of injury [5].

Recent advances in MRI have expanded its role beyond conventional morphological assessment of musculoskeletal injuries. Emerging quantitative MRI techniques, including T1ρ, T2 mapping, ultrashort echo time (UTE) imaging, and diffusion-based methods, enable the evaluation of tissue composition and microstructural changes that may not be visible on routine MRI sequences. These techniques have the potential to improve tissue characterization and provide additional information for the assessment of musculoskeletal disorders and injuries, supporting future advances in musculoskeletal and sports imaging [6,7].

The aim of this narrative review is to summarize the current role of MRI in the diagnosis and management of sports-related musculoskeletal injuries. Particular attention is given to the clinical applications of MRI in ligament, meniscal, cartilage, muscle, tendon, and bone stress injuries, as well as its contribution to clinical decision-making and future developments in sports imaging.

2. Magnetic Resonance Imaging in Sports Medicine

MRI is a non-invasive imaging technique that uses a magnetic field and radiofrequency signals to generate detailed images of anatomical structures. Differences in tissue composition and relaxation properties provide MRI with high soft tissue contrast, allowing accurate visualization of musculoskeletal structures.

In sports medicine, MRI is particularly valuable for evaluating soft tissue structures, including ligaments, tendons, cartilage, menisci, and bone marrow. Unlike radiography and computed tomography, MRI does not use ionizing radiation and provides detailed assessment of structures that are frequently affected by sports-related injuries [8,9].

MRI protocols used in sports medicine rely on multiple complementary sequences that provide different types of information about musculoskeletal tissues. T1-weighted sequences are mainly used for anatomical assessment and evaluation of normal tissue structures, whereas fluid-sensitive sequences, including T2-weighted and fat-suppressed proton density (PD) sequences, are important for detecting pathological changes associated with injury. The use of fat-suppression techniques improves the visualization of fluid-related abnormalities, edema, and structural damage within soft tissues and bone marrow [9,10].

Fat-suppressed PD sequences and short tau inversion recovery (STIR) imaging are frequently used in musculoskeletal MRI because they improve the visualization of edema, ligament, tendon, cartilage, muscle, and bone marrow abnormalities. The selection of MRI sequences depends on the anatomical region examined and the clinical indication, allowing optimization of imaging protocols for specific sports-related injuries [9,10].

MRI offers several advantages in the evaluation of sports-related injuries, mainly due to its excellent soft tissue contrast and ability to provide detailed visualization of multiple anatomical structures. It allows assessment of muscles, tendons, ligaments, cartilage, and bone marrow within a single examination and provides multiplanar imaging without the use of ionizing radiation. These characteristics make MRI particularly useful for detecting structural abnormalities that may not be adequately visualized with other imaging techniques [3,8].

Despite its diagnostic value, MRI also has several limitations. Compared with radiography and ultrasound, MRI is generally more expensive, less accessible, and requires longer acquisition times. In addition, image quality may be affected by patient movement, and some patients may have contraindications related to implanted devices or other factors. Therefore, MRI selection should be based on clinical indications and considered together with other available imaging modalities [3].

Different imaging modalities have complementary roles in the evaluation of sports-related injuries. Conventional radiography is often used as an initial imaging technique for acute injuries because of its availability and effectiveness in detecting fractures and osseous abnormalities. However, its ability to assess soft tissue structures is limited. Computed tomography (CT) provides detailed evaluation of bone morphology and is useful in complex fractures, but it involves ionizing radiation and offers lower soft tissue contrast compared with MRI [3,8,11].

Ultrasound is a widely available and dynamic imaging technique that enables real-time assessment of superficial soft tissues, including tendons and muscles. However, ultrasound assessment is operator-dependent and may be limited in the evaluation of some deeper structures. In contrast, MRI provides superior soft tissue contrast, multiplanar imaging capabilities, and detailed assessment of soft tissue and bone marrow abnormalities, making it particularly valuable in sports-related musculoskeletal imaging [3,8,11].

3. Magnetic Resonance Imaging in the Diagnosis of Sports Injuries

3.1. Anterior Cruciate Ligament Injuries

Anterior cruciate ligament (ACL) injuries are initially evaluated based on clinical history, the mechanism of injury, and physical examination. Commonly used physical examination tests include the Lachman test, anterior drawer test, pivot shift test, and lever sign test. In a systematic review and meta-analysis evaluating the diagnostic performance of clinical tests for ACL injuries, Huang et al. analyzed studies using arthroscopy, surgical exploration, or MRI as reference standards. The pooled sensitivity ranged from 0.59 to 0.79, whereas the pooled specificity ranged from 0.87 to 0.97 [12,13].

In a systematic review evaluating the diagnostic pathway for acute ACL injuries, Allott et al. reported that the reliability of clinical examination may be reduced during the acute phase of injury. Pain, joint effusion and muscular guarding may limit the reliability of physical examination, contributing to delayed diagnosis of ACL injuries. The authors also reported that MRI and arthroscopy were the most frequently used reference standards for confirming ACL injuries in the studies included in their systematic review [12].

MRI enables evaluation of the anterior cruciate ligament together with associated intra-articular injuries, particularly meniscal lesions. Guenoun et al. evaluated the contribution of MRI in the diagnosis of traumatic ACL tears and emphasized that both direct and indirect MRI signs should be assessed to achieve high diagnostic performance. The authors also highlighted that MRI facilitates the detection of associated injuries, particularly meniscal lesions, which are important for therapeutic decision-making. Furthermore, assessment of partial ACL tears remains more challenging than evaluation of complete ruptures [14].

In a systematic review and meta-analysis assessing the diagnostic accuracy of MRI for suspected ACL tears, Phelan et al. compared MRI findings with arthroscopy as the reference standard. MRI achieved a pooled sensitivity of 87% and a pooled specificity of 93% when compared with arthroscopy as the reference standard. Similarly, in a systematic review comparing MRI with knee arthroscopy for ACL diagnosis, Ali analyzed the diagnostic performance reported in the included studies. Sensitivity values ranged from 81% to 98.6%, whereas specificity ranged from 73.68% to 100%, supporting the high diagnostic accuracy of MRI. MRI also enables assessment of associated intra-articular injuries, including meniscal lesions and other soft-tissue abnormalities, while providing a non-invasive alternative to diagnostic arthroscopy [14,15,16].

The diagnostic accuracy of MRI depends on the recognition of characteristic direct and indirect imaging findings associated with ACL injury. Direct MRI signs of ACL rupture include discontinuity of ligament fibres, abnormal ligament orientation, increased signal intensity within the ligament and non-visualization of the ACL. These findings are particularly useful in the assessment of complete ACL tears. However, partial ACL injuries remain more difficult to diagnose because preserved ligament fibres may complicate MRI interpretation [14].

In addition to direct visualization of ligament damage, associated indirect MRI findings may support the diagnosis of ACL injury. In their evaluation of MRI findings in traumatic ACL tears, Guenoun et al. described bone contusions, anterior tibial translation and Segond fracture as additional imaging features associated with ACL tears [14].

3.2. Meniscal Injuries in Athletes

Meniscal injuries are evaluated using MRI, which enables assessment of meniscal morphology and internal signal abnormalities. In their review focusing on MRI reporting of meniscal pathology, Bolog and Andreisek described the imaging criteria used for the diagnosis and characterization of meniscal tears. MRI diagnosis of meniscal tears is primarily based on the presence of abnormal signal intensity extending to the articular surface or distortion of normal meniscal morphology. Accurate description of the location, orientation and extent of a tear allows detailed characterization of the lesion [17].

Meniscal tears can be classified according to their morphology and orientation. Meniscal tears include longitudinal, radial, horizontal, complex, bucket-handle and flap tears. Bolog and Andreisek emphasized that MRI assessment should include evaluation of tear morphology,

location and involvement of the meniscal surfaces to provide a structured description of the lesion. [17].
In a systematic review and meta-analysis evaluating the diagnostic accuracy of MRI for suspected ACL and meniscal tears, Phelan et al. compared MRI findings with arthroscopy as the reference standard. MRI demonstrated different diagnostic performance for medial and lateral meniscal tears. The pooled sensitivity and specificity were 89% and 88% for medial meniscal tears and 78% and 95% for lateral meniscal tears, respectively [16].
In a systematic review assessing the diagnostic accuracy and treatment efficacy of ramp lesions, Moreira et al. evaluated studies comparing MRI findings with arthroscopy. A specific type of meniscal injury associated with ACL deficiency is the ramp lesion, which involves the peripheral attachment of the posterior horn of the medial meniscus. MRI demonstrated limited sensitivity but high specificity for the detection of ramp lesions, with pooled sensitivity of 65.1% and specificity of 91.6% compared with arthroscopy [18].

3.3. Cartilage Injuries and Osteochondral Lesions

Articular cartilage assessment represents an important component of knee MRI evaluation. MRI allows characterization of cartilage abnormalities through analysis of both structural changes and tissue composition. In their radiological review, Crema et al. summarized current MRI approaches used for the evaluation of knee articular cartilage, including conventional morphological sequences and advanced compositional MRI techniques. Conventional MRI sequences are used for detection of morphological abnormalities, whereas compositional techniques provide additional information regarding changes within cartilage tissue [19].
Crema et al. reviewed the application of advanced cartilage MRI methods, including T2 mapping, T1ρ imaging and delayed gadolinium-enhanced MRI of cartilage (dGEMRIC). According to the authors, these techniques enable evaluation of cartilage composition and biochemical properties, providing information that cannot be obtained solely from conventional morphological assessment. Such methods have been investigated for the detection and characterization of cartilage changes in the knee joint [19].
Cartilage abnormalities have also been investigated in patients with ACL injuries. In a prospective cohort study, Potter et al. evaluated cartilage damage following acute isolated ACL tears using MRI assessment and longitudinal follow-up. The study included 40 patients (42 knees) with acute isolated ACL injury, and MRI examinations were used to assess cartilage status after injury and during follow-up. The authors evaluated cartilage

abnormalities at the time of injury and monitored longitudinal changes in cartilage morphology during follow-up using MRI [20].

3.4. Muscle and Tendon Injuries in Athletes

MRI is used for the evaluation of hamstring muscle injuries and provides detailed assessment of the anatomical structures involved in these lesions. In a radiological review, Koulouris and Connell described MRI findings associated with injuries of the hamstring muscle complex and discussed imaging characteristics of these lesions. MRI enables detailed assessment of muscle injury, including the location, extent and involvement of the musculotendinous junction [21].

The anatomical distribution of hamstring injuries has been further investigated in studies based on MRI findings. In a systematic review, Grange et al. analysed the location of acute hamstring injuries using MRI data from 34 studies including 2761 injuries. The authors evaluated the distribution of injuries within the hamstring muscle complex and reported that the long head of the biceps femoris was the most frequently affected muscle component, while the myotendinous junction was the most involved anatomical region [22].

MRI findings have also been assessed together with clinical follow-up after acute hamstring injury. In a longitudinal study, Askling et al. investigated acute first-time hamstring strains occurring during high-speed running using clinical assessment and MRI. The study included athletes with acute hamstring injuries, and MRI was used to characterize injury findings together with follow-up assessment during recovery. The authors analysed the relationship between the initial MRI findings, clinical assessment and recovery following acute hamstring injury [23].

MRI is also used for the assessment of Achilles tendon abnormalities and enables detailed evaluation of tendon morphology and structural integrity. In their comprehensive review, Szaro et al. described MRI findings associated with Achilles tendon pathology. The authors reported that tendon abnormalities may be characterized by tendon thickening, increased intratendinous signal intensity and disruption of normal tendon architecture. MRI also enables evaluation of partial and complete tendon ruptures by demonstrating abnormalities of tendon continuity and the extent of tendon disruption [24].

In a prospective study, Khan et al. evaluated the diagnostic value of ultrasound and magnetic resonance imaging in patients with chronic Achilles tendinopathy. The authors compared MRI and ultrasound findings with clinical assessment and investigated their ability to predict clinical outcome during follow-up. MRI was used to evaluate tendon morphology and intratendinous signal abnormalities, and baseline MRI severity was found to be associated with clinical status at 12-month follow-up, whereas baseline ultrasound findings were not predictive of outcome [25].

Although MRI is widely regarded as a valuable imaging modality in musculoskeletal injuries, Garras et al. reported that its routine use in acute Achilles tendon rupture may not provide additional diagnostic benefit over careful clinical examination. The authors recommended reserving MRI for cases with inconclusive clinical findings or when preoperative planning is required [26].

3.5. Stress Fractures and Bone Stress Injuries in Athletes

Bone stress injuries (BSIs) are overuse-related bone injuries that develop when repetitive mechanical loading exceeds the capacity of bone remodeling. According to Warden et al., BSIs represent a pathological continuum beginning with a stress reaction and progressing to stress fracture and, ultimately, complete fracture if repetitive loading persists. In their clinical review, the authors summarized the pathophysiology, diagnosis and management of BSIs in runners. Similarly, Song and Koo described BSIs as a spectrum of stress-related bone abnormalities and emphasized that MRI is the imaging modality of choice for confirming the diagnosis and grading bone stress injuries because it enables visualization of stress-related bone abnormalities with high sensitivity and specificity [27,28].

The diagnostic performance of MRI has also been evaluated for specific types of bone stress injuries. In a systematic review and narrative synthesis, Esh et al. analysed four studies involving adolescent and young adult athletes with low back pain and assessed the diagnostic accuracy of MRI for posterior element bone stress injuries of the lumbar spine. MRI findings were compared with SPECT-CT or computed tomography as reference standards. The authors reported high specificity and good sensitivity of MRI but emphasized that the findings should be interpreted with caution because of the limited number of available studies and their methodological limitations [29].

The prognostic value of MRI has also been investigated in athletes with bone stress injuries. In a systematic review and meta-analysis, Hoenig et al. analysed 16 studies including 560 bone stress injuries to evaluate the association between MRI grading and return to sports. The authors reported that higher MRI grades were associated with longer time to return to sports. In addition, bone stress injuries involving trabecular-rich anatomical sites were associated with longer time to return to sports than injuries affecting cortical-rich bone, indicating that MRI grading may provide useful prognostic information during the management of bone stress injuries [30].

4. Emerging Imaging Techniques and Future Perspectives

4.1. Quantitative MRI Techniques

Conventional MRI remains the standard imaging modality for evaluating musculoskeletal injuries in athletes because it enables detailed visualization of anatomical structures. Nevertheless, conventional MRI primarily depicts morphological abnormalities and provides limited information about early biochemical or physiological alterations within tissues. Recent advances in quantitative MRI have expanded imaging capabilities by allowing objective measurement of tissue-specific characteristics that cannot be assessed using routine MRI sequences. In their review, Hayashi et al. highlighted the potential value of these techniques in sports medicine, particularly for injury assessment, rehabilitation monitoring, and evaluation of tissue recovery, while noting that most applications remain confined to the research setting [31].

Several quantitative MRI techniques have been investigated for the assessment of musculoskeletal tissues. T2 mapping has primarily been applied to the quantitative evaluation of skeletal muscle physiology by measuring changes associated with tissue water content following exercise and injury. Diffusion tensor imaging (DTI) provides information on skeletal muscle microstructure by analysing water diffusion and has been explored for assessing muscle architecture and monitoring recovery after injury. UTE imaging has mainly been investigated for the evaluation of tendons and ligaments because of its ability to visualize highly organized tissues with very short T2 relaxation times. Although these techniques have demonstrated promising results, further validation and standardization are required before their routine implementation in clinical sports medicine [31].

The clinical application of these techniques has also been investigated in prospective studies. Monte et al. evaluated DTI and quantitative T2 mapping in athletes recovering from acute hamstring injury. DTI parameters demonstrated significant changes during muscle healing and gradually normalized during recovery, whereas quantitative T2 mapping showed no significant temporal changes. The authors concluded that DTI may be useful for monitoring muscle recovery, although further studies are required to establish its prognostic value for return to sport [32].

The greatest amount of evidence regarding quantitative MRI is currently available for the evaluation of articular cartilage. In a systematic review and meta-analysis, Emanuel et al. assessed 21 studies investigating the relationship between quantitative MRI parameters and the biochemical composition of knee cartilage. Among the analysed techniques, dGEMRIC demonstrated the strongest association with proteoglycan concentration ($r = 0.59$), whereas T1ρ relaxation times were inversely correlated with proteoglycan content ($r = -0.54$). In contrast, T2 mapping was not associated with collagen concentration but reflected the organization of collagen fibres and tissue anisotropy. These findings indicate that individual quantitative MRI techniques assess different aspects of cartilage composition and should be considered complementary rather than interchangeable [33].

Despite encouraging results, quantitative MRI techniques have not yet become part of routine clinical imaging in sports medicine. According to Hayashi et al., further prospective studies involving larger patient populations and harmonization of imaging protocols are necessary to improve reproducibility and determine the clinical usefulness of these methods in everyday practice [31].

4.2. Artificial Intelligence in Musculoskeletal Imaging

Artificial intelligence (AI) has become an increasingly important component of musculoskeletal imaging and is progressively being incorporated into routine radiological workflows. AI includes machine learning and deep learning algorithms capable of extracting information from medical images, identifying imaging features, and assisting radiologists during image interpretation. Recent technological developments have expanded the role of AI beyond diagnostic image analysis to include image acquisition, reconstruction, automated segmentation, workflow optimization, and report generation, highlighting its growing importance in modern musculoskeletal radiology [34,35].

AI has also contributed to improvements in MRI acquisition and image reconstruction. Deep learning–based reconstruction algorithms have been developed to shorten examination times while preserving, or even enhancing, diagnostic image quality. In addition, AI has been applied to the generation of synthetic images and quantitative parametric maps, expanding the range of imaging information that can be obtained from MRI examinations and potentially improving the efficiency of musculoskeletal imaging [34,35].

In image interpretation, AI has shown considerable potential as a supportive tool for radiologists. Deep learning algorithms have been investigated for automatic segmentation of musculoskeletal structures, detection and classification of pathological findings, quantitative image analysis, and assistance with radiological reporting. As emphasized by Guermazi et al., currently available AI systems are generally designed to perform narrowly defined diagnostic tasks rather than to replace comprehensive image interpretation. Consequently, AI is considered a decision-support technology intended to complement radiologists' expertise and improve workflow efficiency rather than substitute clinical judgement [35].

A well-known example of AI application in musculoskeletal MRI is the MRNet deep learning model developed by Bien et al. The model was developed and validated using 1,370 knee MRI examinations to identify anterior cruciate ligament tears, meniscal tears, and other abnormalities. The authors demonstrated high diagnostic performance on both internal and external validation datasets. Furthermore, providing MRNet predictions during image interpretation significantly improved the specificity of ACL tear diagnosis among clinical experts, supporting the potential role of AI-assisted systems in musculoskeletal MRI interpretation. Nevertheless, the authors emphasized that additional prospective validation is required before widespread implementation in routine clinical practice [36].

Despite the rapid development of AI technologies, several challenges continue to limit their routine clinical implementation. Tong et al. emphasized the importance of high-quality annotated datasets, appropriate model development and validation procedures, and continuous monitoring to ensure reliable clinical performance of AI systems. Guermazi et al. additionally emphasized the need for standardized evaluation methods, seamless integration with existing radiology workflows, and careful consideration of ethical, legal, and regulatory aspects associated with AI-assisted medical decision-making. Based on the currently available evidence, AI should therefore be regarded as a tool that enhances radiologists' performance and supports clinical decision-making rather than replacing the expertise of medical professionals [34,35].

These findings are consistent with more recent evidence. In a systematic review and meta-analysis including 11 studies, Zhao et al. reported that AI algorithms achieved pooled sensitivity of 87% and specificity of 89% for detecting the presence of meniscal tears on MRI. However, the diagnostic performance was lower for accurate localization of tears, emphasizing the need for further external validation and continued development of AI models before routine clinical implementation [37].

Overall, current evidence indicates that AI has considerable potential to improve musculoskeletal MRI by supporting image acquisition, quantitative analysis, lesion detection, and radiological workflow. Nevertheless, broader clinical implementation will depend on standardized validation, multicentre prospective studies, and seamless integration of AI systems into routine clinical practice. As these technologies continue to evolve, AI is expected to become an increasingly important adjunct to radiologists, contributing to more accurate, efficient, and personalized imaging in sports medicine [34,35,37].

4.3. Future Directions

Future developments in musculoskeletal imaging are expected to focus on further refinement of quantitative MRI techniques and the broader integration of artificial intelligence into clinical imaging workflows. Recent advances suggest that quantitative imaging biomarkers and AI-based image analysis may facilitate earlier identification of tissue changes, more objective assessment of musculoskeletal injuries, and improved monitoring of tissue healing. These developments have the potential to support clinical decision-making and contribute to more individualized management of musculoskeletal disorders in sports medicine [31,34,35].

Continued improvements in image acquisition, deep learning–based reconstruction, and automated post-processing are also expected to increase the clinical feasibility of advanced MRI techniques. Faster imaging protocols combined with AI-assisted image analysis may improve workflow efficiency while maintaining high diagnostic image quality, thereby facilitating wider implementation of quantitative MRI in routine musculoskeletal imaging [34,35].

Despite these promising developments, several challenges remain before these technologies can be routinely incorporated into clinical practice. Future research should focus on multicentre prospective studies, external validation of AI algorithms, standardization of quantitative MRI protocols, and harmonization of image analysis methods across institutions. Addressing these challenges will be essential to improve the reproducibility, reliability, and clinical applicability of emerging imaging techniques in musculoskeletal radiology [34,35].

Table 1. Conventional MRI versus emerging MRI techniques in sports medicine

Feature	**Conventional MRI**	**Quantitative MRI**	**Artificial intelligence**

Main purpose	Morphological assessment	Tissue composition and microstructure	Image analysis and decision support
Clinical use	Routine practice	Mainly research	Limited clinical implementation
Advantages	High soft tissue contrast, established protocols	Objective quantitative assessment	Faster workflow, automated analysis
Limitations	Mainly structural evaluation	Lack of standardization	Need for external validation
Future role	Diagnostic standard	Precision monitoring	Clinical support tool

Source: Authors' own elaboration based on the reviewed literature [3,6,7,31–37].

5. Conclusions

MRI remains the imaging modality of choice for the evaluation of sports-related musculoskeletal injuries owing to its excellent soft tissue contrast and ability to provide comprehensive assessment of ligaments, tendons, muscles, cartilage, and bone marrow. Conventional MRI plays a central role in the diagnosis of common athletic injuries, including anterior cruciate ligament tears, meniscal lesions, muscle injuries, Achilles tendon disorders, and bone stress injuries, facilitating accurate diagnosis and appropriate treatment planning [8–30].

Recent technological advances have further expanded the role of MRI in sports medicine. Quantitative MRI techniques provide objective information regarding tissue composition and microstructural characteristics that cannot be assessed using conventional MRI sequences and may improve the evaluation of tissue degeneration, tissue healing, and response to treatment. Although these techniques have demonstrated promising results, further clinical validation and standardization are required before their widespread implementation in routine clinical practice [31–33].

Artificial intelligence represents another important area of development in musculoskeletal imaging. AI-assisted image acquisition, image reconstruction, automated segmentation, and automated image analysis have demonstrated considerable potential to improve workflow efficiency and support radiological decision-making. Nevertheless, further external validation of AI algorithms, standardized evaluation frameworks, and seamless integration into routine clinical workflows remain necessary before these technologies can be widely implemented in everyday clinical practice [34–37].

Overall, continued advances in quantitative MRI and artificial intelligence are expected to further enhance the diagnostic capabilities of musculoskeletal imaging. The integration of these emerging technologies with conventional MRI may contribute to more objective tissue assessment, improved monitoring of musculoskeletal injuries, and increasingly individualized patient management in sports medicine [31,34,35].

Disclosure

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