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Lesion-Specific Clinical Validation of Deep-Learning-Accelerated Knee MRI: Relevance to Orthopedic and Sports Medicine Practice

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Abstract

Background. Accelerated knee MRI protocols incorporating deep-learning reconstruction (DLR) may shorten examinations, but clinical performance varies by lesion and validation method.

Aim. To synthesize lesion-specific clinical evidence, assess acquisition-time reductions, and compare conventional-MRI comparator studies with arthroscopy-referenced validation.

Material and methods. A structured literature search identified 22 primary clinical studies. Evidence was classified by validation category and synthesized separately for anterior cruciate ligament (ACL), medial and lateral menisci, articular cartilage, and other structures.

Results. Acquisition time was commonly reduced by approximately one-third to one-half, although most protocols combined DLR with other acceleration methods. Clinically useful performance was generally preserved. Evidence was most consistent for ACL tears and generally supportive for medial meniscal tears. Lateral meniscal specificity remained high, but sensitivity was lower and formal non-inferiority was not consistently demonstrated. Cartilage findings were variable and protocol-dependent, while evidence for other structures was limited.

Conclusions. Current evidence supports consideration of clinical implementation of accelerated knee MRI protocols incorporating deep-learning reconstruction after local lesion-, protocol-, and vendor-specific validation, but does not establish universal interchangeability across systems or lesion types.

Key words: knee MRI; deep-learning reconstruction; accelerated MRI; anterior cruciate ligament; meniscus; articular cartilage; sports medicine

1. Introduction

Magnetic resonance imaging (MRI) is central to the evaluation of suspected internal derangement of the knee because it enables multiplanar assessment of ligaments, menisci, articular cartilage, bone marrow, and periarticular soft tissues without ionizing radiation. In acute knee trauma, MRI is particularly useful after appropriate initial assessment when ligamentous, meniscal, chondral, or other internal injury remains suspected [1]. This role is directly relevant to sports medicine: sport-related anterior cruciate ligament (ACL) injuries are common, meniscal pathology is an important concern in athletes, and chondral defects are frequently encountered in athletic knees [2-4]. The clinical studies included in this review, however, enrolled broader symptomatic, pediatric, degenerative, routinely referred, and surgically selected populations rather than predominantly athlete-only cohorts.

A practical limitation of conventional knee MRI is the duration of multisequence examinations. Longer protocols consume scanner capacity and extend the period during which patient movement may affect individual sequences. Conventional acceleration methods-including parallel imaging, simultaneous multislice acquisition, compressed sensing, k-space undersampling, reduced numbers of averages, and modified sequence parameters-can shorten acquisition, although increasing acceleration may introduce noise, aliasing, blurring, signal alteration, or other artifacts that impair subtle-lesion assessment [5,6,7,8,9,10].

Deep-learning reconstruction (DLR) and deep-learning superresolution can support more aggressive acceleration by reducing noise, mitigating undersampling-related degradation, or reconstructing images with greater apparent spatial resolution [5,6,11,12]. In most evaluated implementations, DLR was combined with changes in sampling, parallel-imaging factors, simultaneous multislice acquisition, sequence parameters, or overall protocol composition [13,14,15,16]. The appropriate collective term is therefore accelerated knee MRI protocols incorporating deep-learning reconstruction, rather than wording that attributes the entire acquisition-time reduction to deep learning alone.

Clinical evidence indicates that many such protocols substantially reduce acquisition time while generally preserving clinically useful assessment of major internal derangements [13,15,16,17,18,19,20]. Support is most consistent for ACL tears and generally favorable for medial meniscal tears, whereas lateral meniscal sensitivity is less consistent and cartilage

findings are variable and protocol-dependent. This lesion hierarchy provides a more clinically useful basis for implementation than overall image quality alone.

The evidence base includes retrospectively simulated and prospectively acquired conventional-MRI comparator studies, arthroscopy-referenced cohorts, identical-acquisition reconstruction comparisons, and real-world sequential implementation cohorts [13,15,16,17,19]. These frameworks provide complementary but non-equivalent evidence: comparator studies assess agreement or protocol-specific interchangeability, arthroscopy-referenced studies assess lesion-specific diagnostic performance in surgically selected populations, identical-acquisition studies evaluate reconstruction-related effects, and sequential cohorts describe performance after clinical implementation.

Recent reviews and perspectives have primarily addressed acceleration technologies, protocol design, broader musculoskeletal applications, and implementation challenges [5,6,11,12]. The present review instead organizes clinical evidence according to lesion type and validation method, allowing the principal positive finding-substantial time reduction with generally preserved clinical performance-to be interpreted alongside lesion-specific limitations, technical failure modes, and constraints on transfer between systems.

The aim of this narrative review with a structured literature search was to synthesize clinical studies of accelerated knee MRI protocols incorporating DLR, assess reported reductions in acquisition time, and compare lesion-specific evidence from conventional-MRI comparator studies and arthroscopy-referenced diagnostic studies, with particular attention to implications for orthopedic and sports medicine practice.

2. Materials and Methods

This narrative review used a structured literature search completed on July 1, 2026. PubMed and Google Scholar were searched using combinations of terms related to knee MRI, acceleration, deep-learning reconstruction, deep neural network reconstruction, superresolution, arthroscopy, diagnostic performance, interchangeability, non-inferiority, and simultaneous multislice acquisition. Crossref and publisher records, reference-list screening, cited-by searches, and exact-title and author searches were used to identify additional validation studies, related publications, and potentially overlapping cohorts.

Eligible primary studies evaluated human knee MRI in a clinical cohort using an accelerated acquisition that incorporated deep-learning reconstruction or deep-learning superresolution and included lesion-specific clinical validation against conventional MRI, another reconstruction method, or an independent reference standard. Studies limited to phantoms,

healthy volunteers without a relevant clinical cohort, technical or image-quality outcomes without clinical assessment, segmentation, autonomous diagnostic algorithms, radiomics, or other anatomical regions without separately extractable knee data were excluded.

The final corpus comprised 22 primary clinical studies. Full texts were unavailable for five studies [8,21,22,23,24]; clinical extraction from these studies was restricted to information explicitly reported in their abstracts. Official supplementary material was additionally used to verify acquisition parameters and times for the corresponding studies [8,23].

Extracted variables included study design and sample, scanner and reconstruction platform, acceleration strategy and acquisition time, comparator or reference standard, lesion-specific outcomes, relevant failure modes, and funding or conflicts of interest. Studies were classified according to their actual validation design as conventional-MRI comparator studies, arthroscopy-referenced studies, identical-acquisition reconstruction comparisons, or real-world sequential cohorts.

Evidence was synthesized by lesion, validation framework, and diagnostic outcome. Anterior cruciate ligament, medial-meniscal, lateral-meniscal, and cartilage findings were analyzed separately; other structures were summarized more cautiously because positive cases were often sparse or outcomes were pooled. Conventional-MRI agreement was not interpreted as pathology-referenced diagnostic accuracy, and non-inferiority was reported only when a margin had been prespecified and formally tested. Related cohorts were retained when they addressed distinct questions but were not treated as independent replications.

Because this was a structured narrative review rather than a systematic review or meta-analysis, no formal risk-of-bias or evidence-certainty framework was applied. Study characteristics are summarized in Table 1, and lesion-specific findings are summarized in Table 2.

3. Clinical Validation Categories and Interpretation

The included studies were classified into four validation categories according to their comparator or reference standard. Each category answers a different part of the review question: whether an accelerated protocol can substitute for conventional MRI, whether it detects lesions against an independent reference, whether reconstruction itself affects interpretation, and whether performance is maintained after clinical implementation. The categories therefore structured the lesion-specific synthesis and defined the claims that each study could support.

Conventional-MRI comparator studies assess whether accelerated and standard protocols produce sufficiently similar radiologic interpretations for potential protocol substitution. Selected studies formally evaluated interchangeability using prespecified margins [13,17,25]. These studies provide evidence on agreement and comparable lesion detection, although they do not establish pathology-referenced sensitivity or specificity because conventional MRI is not an independent reference standard.

Arthroscopy-referenced studies compare MRI findings with operative findings and provide the most direct evidence of lesion-specific diagnostic performance [15,16,18,19,23]. They support estimates such as sensitivity and specificity and are central to determining whether clinically important lesions remain detectable after acceleration. Their applicability is greatest in surgically selected populations, which may differ from routine referral cohorts.

Identical-acquisition reconstruction comparisons evaluate conventional and deep-learning reconstructions while holding acquisition data and duration constant or closely matched [19,20,26]. They help isolate whether reconstruction changes lesion assessment or diagnostic performance, but do not demonstrate additional acquisition-time reduction attributable to DLR.

Real-world sequential cohorts evaluate protocols after implementation in routine clinical practice [16]. They extend controlled validation by assessing performance across larger patient groups, multiple readers, and ordinary workflow conditions. Because protocols were introduced during successive periods rather than randomly assigned, differences between cohorts cannot be attributed solely to acceleration or DLR.

Across all categories, interchangeability or non-inferiority was accepted only when a prespecified margin was formally tested. Nonsignificant differences and higher numerical estimates were not treated as evidence of equivalence, non-inferiority, or superiority. Together, the four categories provide complementary evidence on protocol substitution, lesion detection, reconstruction effects, and clinical implementation.

4. Acquisition-Time Reductions and Protocol Characteristics

Accelerated knee MRI protocols incorporating deep-learning reconstruction substantially shortened acquisition across heterogeneous clinical implementations. Reductions commonly ranged from approximately one-third to one-half, although selected protocols reported larger decreases at higher acceleration levels [7,8,10,13,16,24,27].

Observed accelerated protocol durations varied according to sequence composition, acceleration strategy, and whether a single sequence or a complete multisequence

examination was evaluated. Reported implementations included several protocols below 5 minutes, including a 4:29 single 3D proton-density fat-suppressed protocol, a 4:34 pediatric protocol, a 4:45 accelerated PROPELLER protocol, and adult and real-world protocols lasting 4:49 [15,16,23,27,28]. Across studies reporting whole- or protocol-level durations, accelerated acquisitions extended to approximately 14 minutes, while conventional or reference protocols ranged from approximately 7:30 to 28:50 [8,9,14].

These time savings generally resulted from combinations of parallel imaging, simultaneous multislice acquisition, reduced averages, altered matrices or phase-encoding steps, k-space undersampling, modified sequence parameters, sequence substitution, and DLR or deep-learning superresolution. Consequently, acquisition-time reduction should be attributed to the complete accelerated protocol rather than to DLR alone. Protocols with similar nominal acceleration factors may also differ in spatial resolution, contrast weighting, sequence composition, and artifact behavior.

Prospectively measured durations must be distinguished from simulated or projected estimates. Retrospectively undersampled data produced a theoretical duration of 4:20-6:00 in one study, while a separate 2-3-minute estimate was projected rather than prospectively acquired [17,25]. These values demonstrate technical potential but were not treated as observed clinical protocol durations.

Several studies instead compared conventional and deep-learning reconstructions using identical or closely matched acquisitions [19,20,26,29]. These designs clarify whether reconstruction affects image interpretation or lesion assessment, but they provide no evidence of additional acquisition-time reduction attributable to DLR itself.

Overall, the available studies demonstrate that substantial and clinically meaningful reductions in knee MRI acquisition time are achievable across several protocol configurations. Because time reduction alone does not establish preserved lesion detection, the diagnostic implications of these protocols are considered separately in the lesion-specific synthesis.

Key protocol and validation characteristics are summarized in Table 1; additional supporting studies are cited in the narrative.

Table 1. Key clinical validation studies of accelerated knee MRI incorporating DLR

Study and design	System, protocol, and time	Validation category	Principal result and decisive caveat
Recht et al. [17]; retrospective, multi-reader; n=108	3 T Siemens; simulated R4 + DLR; 8:11-11:20 to	MRI comparator; interchangeability	5% interchangeability criterion met; simulated acceleration; no pathology reference.

	projected 4:20-6:00		
Subhas et al. [25]; retrospective; n=40	Field/vendor NR; simulated sixfold undersampling + DCNN; 2-3 min projected	MRI comparator; interchangeability	10% criterion met for ACL, menisci, and cartilage; small simulated cohort; no independent reference.
Chaudhari et al. [18]; prospective intraindividual; n=51 (43 arthroscopy)	3 T GE; 3D qDESS + DL superresolution; 15:00 to 5:00 (7:00 with coronal PD-FS)	MRI comparator + arthroscopy	Pooled meniscal/cruciate performance similar; cartilage sensitivity limited; pooled outcomes; no formal non-inferiority.
Johnson et al. [13]; prospective intraindividual; n=170	3 T Siemens; R2 vs R4 + DLR; 9:56 to 5:33	MRI comparator; interchangeability	5% criterion met across major structures; no pathology reference.
Lee et al. [14]; prospective multivendor; n=45 (15/platform)	3 T Philips/GE/Siemens; vendor-specific acceleration + DNN; 7:30-14:15 to 4:23-8:14 (~41%)	MRI/composite comparator	High cross-vendor concordance; small platform subgroups; composite reference incorporated MRI.
Foti et al. [8]*; prospective; n=71	3 T United Imaging; DL2/DL4/DL6; 28:50 to 14:25/7:13/4:49	MRI comparator	DL2/DL4 retained high lesion detection; DL6 had lower ACL and subtle-lesion sensitivity; abstract-level outcomes.
Vosshenrich et al., adults [15]; retrospective arthroscopy cohort; n=124	3 T Siemens; PI×3 + SMS×2 + DLR/superresolution; 4:49	Arthroscopy reference	Strong ACL and medial-meniscal performance; lateral-meniscal sensitivity 76%; favorable cartilage; surgical selection; no conventional comparator.
Vosshenrich et al., pediatric [23]*; retrospective arthroscopy cohort; n=44	3 T Siemens; PI×3 + SMS×2 + DLR/superresolution; 4:34	Arthroscopy reference	ACL sensitivity high; sensitivity 71% medial meniscus, 65% lateral meniscus, 55% cartilage; small pediatric cohort; abstract-level outcomes.
Walter et al. [19]; prospective; n=116	3 T Siemens; matched SMS×2/PI×2, CR vs DLR/superresolution; 6:20 vs 6:20	Identical acquisition + arthroscopy	ACL/medial-meniscal performance preserved; lateral-meniscal sensitivity 71-76%; cartilage sensitivity 50% to 65%; no DLR time saving.
Johnson et al. [16]; retrospective sequential cohorts; n=1,055: P2 n=226; S2P2 n=406; S2P3 n=423.	3 T Siemens; P2/S2P2/S2P3; 9:56/6:20/4:49	Sequential arthroscopy cohorts; non-inferiority	ACL sensitivity/specificity met non-inferiority; medial-meniscal sensitivity met it but specificity did not; lateral-meniscal sensitivity did not; no cartilage.
Wu et al. [20];	3 T GE; CR and DLR	Identical	Cartilage AUC higher with

prospective; (39 arthroscopy)	n=92 cartilage	from same acquisition; mapping (ARC2) to (ARC3)	4:49 T2 7:06 5:00	acquisition cartilage arthroscopy; separate T2-mapping acceleration	+ DLR, significant for one reader only; routine DLR did not shorten acquisition.

* For studies marked with an asterisk, clinical outcomes were extracted from abstracts; supplementary material verified acquisition parameters and times. Abbreviations: ACL, anterior cruciate ligament; AUC, area under the curve; CR, conventional reconstruction; DCNN, deep convolutional neural network; DLR, deep-learning reconstruction; NR, not reported; PD-FS, proton-density fat-suppressed; PI, parallel imaging; SMS, simultaneous multislice.

5. Lesion-Specific Evidence

The lesion-specific hierarchy is summarized in Table 2. Findings are interpreted according to validation category, with comparator agreement distinguished from arthroscopy-referenced diagnostic performance.

Table 2. Lesion-specific synthesis of clinical evidence

Lesion category	Evidence synthesis	Main uncertainty and clinical interpretation
Anterior cruciate ligament	Formal comparator studies met prespecified interchangeability criteria [13,17,25]. Arthroscopy-referenced results were strongest for anterior cruciate ligament: sensitivity/specificity were 100%/99% in adults [15], 95%/100% with matched reconstructions [19], and both accelerated cohorts met non-inferiority for sensitivity and specificity [16].	Sensitivity decreased to 91-96% at sixfold acceleration [8]; *pediatric specificity was 84% [23]*. Some studies had few positive cases, and sequential cohorts do not isolate causal technology effects. Most supportive lesion category; use remains protocol-, system-, and population-specific.
Medial meniscus	Formal comparator studies met interchangeability criteria [13,17,25]. Adult arthroscopy cohorts reported sensitivity/specificity of 90%/95% [15] and 91%/97% with deep-learning reconstruction [19]. Sensitivity met non-inferiority in both accelerated cohorts [16].	Specificity did not meet non-inferiority [16]; pediatric sensitivity was 71% [23]*. Selected single-sequence or 3D protocols showed lower reader consistency or unconfirmed findings [10,28]. Generally preserved, but local validation should examine specificity, pediatric performance, and sequence composition.
Lateral meniscus	Comparator studies generally supported interchangeability [13,17,25]. Specificity was approximately 94-100% in the principal arthroscopy cohorts, and both accelerated protocols met non-inferiority for specificity [16].	Sensitivity remained approximately 63-76% [15,16,19,23], and sensitivity non-inferiority was not met [16]. Lower sensitivity was also present with the conventional protocol. More uncertain than medial-meniscal assessment; local

		substitution should audit false-negative tears.
Articular cartilage	Selected comparator studies met interchangeability criteria [13,17,25]. With identical 6:20 acquisitions, deep-learning reconstruction increased sensitivity from 50% to 65% and area under the curve from 0.71 to 0.78 [19]; higher area-under-the-curve point estimates with deep-learning reconstruction were also reported [20].	Results varied by grade, compartment, grading system, sequence, and reconstruction. Low sensitivity, grading errors, smoothing, simulated defects, and difficulty detecting small or partial-thickness lesions were reported; no cartilage outcomes were reported in the real-world sequential study [16]. Validate representative grades, compartments, and the exact acquisition-reconstruction configuration.
Other structures	Comparator evidence supported feasible assessment of posterior cruciate ligament, collateral ligaments, bone marrow abnormalities, fractures, tendons, and other secondary findings in selected protocols [10,13,14,15,17,18,19,23,24,29,30].	Positive cases were often sparse or absent, endpoints were pooled, and independent reference standards were uncommon; reduced marrow-edema conspicuity occurred in some protocols. Evidence is limited or very limited, so routine quality assurance should be retained for uncommon secondary abnormalities.

* For studies marked with an asterisk, clinical outcomes were extracted from abstracts; only explicitly reported results were used.

5.1. Anterior Cruciate Ligament

Anterior cruciate ligament tears have the most consistent lesion-specific support across the available validation categories. Conventional-MRI comparator studies, arthroscopy-referenced cohorts, identical-acquisition reconstruction comparisons, and real-world implementation data generally support preserved ACL assessment. This convergence makes ACL the clearest lesion category for considering clinical implementation after local validation. Formal comparator evidence was consistently favorable. Retrospectively simulated acceleration produced an estimated 0.2% decrease in reader agreement after interchange, with the confidence interval remaining within the study-specific 5% margin [17]. A separate sixfold simulated comparison found 95.8% agreement between deep-convolutional-neural-network and original-image readings, compared with 95.0% between repeated original-image readings, meeting the prespecified 10% interchangeability criterion [25]. Both studies lacked an independent pathology reference. In a prospective comparison, concordant ordinal opinions were reported in 94.9% of cross-protocol and 95.8% of same-protocol assessments,

satisfying the predefined 5% interchangeability criterion [13]. Although a small difference in a secondary binary analysis was statistically significant, the overall interchangeability criterion was met. Collectively, these findings support protocol-specific interchangeability with conventional MRI.

Additional comparator evidence was supportive but methodologically less definitive. A multivendor study reported ACL sensitivity of 80-100%, specificity of 97.5-100%, and AUC values of 0.89-1.00 across three readers, although its composite reference incorporated conventional MRI findings and clinical records [14]. In a prospective comparison available through its abstract, sensitivity and specificity were reported within 98-100% for twofold and fourfold protocols, whereas sensitivity decreased to 91-96% with sixfold acceleration; sixfold specificity and lesion denominators were not reported [8]. Both protocols in a smaller single-sequence comparison detected all seven conventional-MRI-reference-positive complete ACL tears, but the low number of positive cases and absence of arthroscopy limit precision [30].

Arthroscopy-referenced cohorts provided the strongest lesion-specific estimates. In an adult cohort evaluated with a sub-5-minute protocol, ACL sensitivity was 100%, specificity 99%, accuracy 99%, and AUC 0.99 [15]. In a smaller pediatric cohort, sensitivity was also 100%, while specificity was 84%, accuracy 93%, and AUC 0.92 [23]. Lesion denominators were not reported in the pediatric abstract, and probable overlap with the pediatric population in the real-world sequential study [16] means that these findings should not be treated as an independent replication. A further arthroscopy study reported similar point estimates for conventional and accelerated imaging, but pooled ACL and posterior cruciate ligament outcomes prevented an ACL-specific conclusion [18].

Identical-acquisition comparisons further support preserved reconstruction-specific performance. Conventional and DL-superresolution reconstructions from matched 6:20 acquisitions produced identical ACL sensitivity, specificity, and AUC values of 95%, 100%, and 0.98, respectively [19]. At 5.0 T, strong DLR showed numerically higher agreement with arthroscopy than non-DLR reconstruction, with κ values of 0.942 and 0.915 [26]. Superiority was not formally tested, and only two arthroscopy-negative cases were included.

The largest arthroscopy-referenced dataset came from real-world sequential cohorts. Sensitivity and specificity for complete ACL tears were 0.85 and 0.98 with the conventional P2 protocol, 0.96 and 1.00 with S2P2, and 0.98 and 1.00 with the S2P3 protocol incorporating DLR [16]. Both accelerated cohorts met the prespecified non-inferiority criterion for sensitivity and specificity. Because the protocols were implemented during successive clinical

periods rather than compared through randomization or within-patient assessment, the higher later estimates cannot be attributed causally to acceleration or DLR.

Taken together, comparator and arthroscopy-referenced studies provide the most consistent support for preserved ACL performance. Appropriately validated accelerated protocols can therefore be considered for ACL assessment, although the evidence remains specific to the evaluated protocols, systems, and populations.

5.2. Medial Meniscus

Diagnostic performance was generally preserved for medial meniscal tears across multiple validation categories. Formal comparator studies and adult arthroscopy cohorts were consistently supportive, making the medial meniscus the second most consistently supported lesion category after the ACL.

Formal comparator studies demonstrated preserved agreement with conventional MRI. The estimated change in reader agreement was −2.3% in one simulated-acceleration study, remaining within its predefined interchangeability margin [17]. A separate sixfold simulated comparison found 92.5% agreement between deep-learning-reconstructed and original images, compared with 90.0% between repeated original-image readings, meeting the prespecified 10% criterion [25]. In a prospective comparison, concordant ordinal opinions occurred in 86.4% of cross-protocol and 87.3% of same-protocol assessments, satisfying the study-specific interchangeability criterion [13]. A multivendor study additionally reported sensitivity of 100%, specificity of 96.8-100%, and AUC values of 0.98-1.00, although its composite reference incorporated MRI findings and clinical information rather than arthroscopy [14].

Adult arthroscopy cohorts reinforced these comparator findings. A sub-5-minute protocol achieved sensitivity of 90%, specificity of 95%, accuracy of 94%, and an AUC of 0.93 [15]. In an identical-duration reconstruction comparison, sensitivity was 90% with conventional reconstruction and 91% with DL superresolution, while specificity was 97% and AUC 0.94 for both methods [19]. No formal equivalence or non-inferiority margin was tested. At 5.0 T, agreement with arthroscopy was numerically higher with strong DLR than without DLR, with κ values of 0.969 and 0.909, respectively, but superiority was not formally evaluated [26].

The large real-world sequential cohort provided a more qualified result. Medial-meniscal sensitivity was 0.94 with P2, 0.95 with S2P2, and 0.94 with S2P3; both accelerated protocols met the prespecified non-inferiority criterion for sensitivity [16]. Specificity was 0.91, 0.88, and 0.89, respectively, and non-inferiority was not established for either accelerated protocol.

The absence of a statistically significant difference did not substitute for satisfaction of the prespecified margin.

Less favorable findings identify protocols requiring closer local review. In the pediatric arthroscopy cohort, sensitivity was 71%, although specificity remained 97%, accuracy 93%, and AUC 0.84; lesion denominators were unavailable in the abstract [23]. A single 3D proton-density fat-suppressed implementation showed lower interreader agreement than the multisequence 2D protocol, while another 3D superresolution protocol generated additional suspected medial-meniscal findings that were not confirmed and showed lower reader consistency [10,28]. Other studies reported only pooled or side-unspecified meniscal outcomes and therefore did not provide clean medial-meniscus estimates [8,18,29,30].

Overall, the evidence supports clinically useful medial-meniscal assessment with appropriately validated accelerated protocols. Particular attention remains warranted for specificity, pediatric populations, and abbreviated single-sequence or 3D implementations.

5.3. Lateral Meniscus

Evidence for lateral meniscal tears was less consistent than for medial meniscal tears. Conventional-MRI comparator studies generally supported preserved interpretation, and specificity remained high in arthroscopy-referenced cohorts. However, sensitivity was repeatedly lower, and formal non-inferiority was not consistently demonstrated.

Formal comparator studies produced broadly favorable agreement results. A simulated-acceleration study reported an estimated 0.7% decrease in reader agreement, with the confidence interval remaining within its predefined interchangeability margin [17]. In another simulated comparison, agreement was 86.7% between deep-learning-reconstructed and original images and 88.3% between repeated original-image readings; the prespecified 10% interchangeability criterion was met, although the estimate was less precise than for the ACL or medial meniscus [25]. A prospective study likewise met its interchangeability criterion, with concordant ordinal opinions in 86.9% of cross-protocol and 88.2% of same-protocol assessments [13]. A multivendor comparison reported complete concordance across readers, but the small number of positive cases and composite MRI-based reference limited precision [14].

Arthroscopy-referenced studies showed consistently high specificity but lower sensitivity. An adult sub-5-minute protocol achieved sensitivity of 76%, specificity of 97%, accuracy of 90%, and an AUC of 0.86, with nine false-negative tears [15]. In the pediatric cohort, sensitivity was 65%, specificity 100%, accuracy 86%, and AUC 0.82; lesion denominators were

unavailable in the abstract [23]. These findings indicate that high specificity does not eliminate the risk of missed lateral meniscal tears.

The identical-duration reconstruction comparison produced sensitivity of 71% with conventional reconstruction and 76% with DL superresolution, while specificity was 99% for both and AUC values were 0.85 and 0.87, respectively [19]. The difference was not statistically significant, and formal non-inferiority or superiority was not established. At 5.0 T, strong DLR showed perfect observed concordance with arthroscopy compared with $\kappa = 0.940$ without DLR, but this isolated result was not formally tested and should remain protocol-specific [26].

The largest real-world study confirmed the sensitivity limitation. Sensitivity was 0.68 with P2, 0.63 with S2P2, and 0.67 with S2P3, whereas specificity was 0.94 for all three protocols [16]. Both accelerated protocols met the prespecified non-inferiority criterion for specificity but not for sensitivity. Importantly, sensitivity was also comparatively low with the conventional protocol, so the limitation cannot be attributed uniquely to acceleration or DLR.

Overall, accelerated protocols generally preserved lateral-meniscal specificity and comparator agreement, but sensitivity remained approximately 63-76% in the principal arthroscopy cohorts. Local validation should therefore include targeted assessment of false-negative lateral meniscal tears before protocol substitution.

5.4. Articular Cartilage

Cartilage assessment showed preserved comparator agreement and reconstruction-specific gains in selected settings, but results were more variable and protocol-dependent than for ACL or medial-meniscal assessment. Performance differed according to lesion grade, compartment, grading system, sequence design, spatial resolution, reconstruction method, and reference standard.

Formal conventional-MRI comparator studies were generally supportive. Three protocols met their prespecified interchangeability criteria for cartilage assessment [13,17,25]. In the prospective comparison, concordant ordinal opinions across six cartilage surfaces ranged from 79.6% to 86.9% between protocols and from 80.0% to 88.5% within the same protocol [13]. A separate accelerated PROPELLER implementation produced higher reader-rated retropatellar-cartilage image quality than standard PROPELLER, although no independent operative reference was used [27]. These findings support protocol-specific agreement but do not establish pathology-referenced grading accuracy.

Arthroscopy-referenced results demonstrated substantial grade and protocol dependence. Overall sensitivity, specificity, and accuracy were 58%, 73%, and 66% for conventional MRI and 54%, 66%, and 60% for morphologic qDESS alone [18]. Adding T2 mapping increased sensitivity to 73% but reduced specificity to 55%, without improving overall accuracy. Early and partial-thickness abnormalities remained more difficult than higher-grade lesions. In an adult sub-5-minute cohort, trinary cartilage grading achieved sensitivity of 85%, specificity of 88%, accuracy of 88%, and an AUC of 0.81 [15]. Direct comparison with studies using more detailed grading systems is limited by the simplified classification and compartment-level analysis. In the pediatric cohort, sensitivity was only 55%, despite specificity of 100%, accuracy of 98%, and an AUC of 0.77; lesion denominators and grade-specific results were unavailable from the abstract [23].

Identical-acquisition comparisons provided evidence of reconstruction-specific benefit. With unchanged 6:20 acquisitions, DL superresolution increased cartilage sensitivity from 50% to 65% and AUC from 0.71 to 0.78, while specificity remained 91% [19]. The AUC difference was statistically significant, although sensitivity remained moderate and the result was specific to the evaluated grading method and protocol. Another arthroscopy subcohort showed higher DLR AUC estimates for both readers, but the difference between conventional and DLR images was statistically significant for only one reader [20]. At 5.0 T, strong DLR produced numerically higher agreement with arthroscopy for femoral and patellar cartilage, but superiority was not formally tested, severe degeneration was excluded, and grade-specific results were unavailable [26].

Other comparator studies identified important implementation boundaries. Cartilage grading was usually concordant in a multivendor study, but smoothing caused one undergraded examination and an artifact caused one simulated defect and overgrading [14]. One fourfold parallel-imaging protocol showed poorer cartilage delineation and signal alteration capable of mimicking damage, whereas a variant combining parallel imaging and simultaneous multislice acquisition received more favorable ratings [9]. A 3D superresolution protocol showed generally favorable agreement but more variable lesion detection and confidence because of reconstruction artifacts [10]. Sensitivity was numerically lower with an abbreviated 3D nDixon sequence, prompting caution when small chondral lesions are the principal target [30]. A single-sequence 3D comparison was retained only descriptively because its lateral-cartilage inferential results were internally inconsistent [28], while synthetic DLR imaging showed high agreement for osteoarthritis-related cartilage features without an independent pathology reference [29].

Overall, cartilage results were variable and protocol-dependent. Selected reconstructions improved sensitivity or AUC, but low sensitivity, grading errors, smoothing, simulated defects, and difficulty detecting small or partial-thickness lesions were also reported. The largest sequential implementation cohort did not assess cartilage [16]. Clinical adoption should therefore include local validation across representative lesion grades, relevant compartments, and the exact acquisition-reconstruction configuration.

5.5. Other Structures

Evidence for posterior cruciate ligament (PCL) tears was very limited. Comparator studies supported feasible assessment and met protocol-specific interchangeability criteria [13,17], but arthroscopy cohorts contained too few positive cases for stable lesion-specific estimates. Cruciate outcomes were pooled in one study, two arthroscopy cohorts included only one PCL tear each, and another cohort contained no PCL tears [15,18,19,30]. Additional results were variable or lacked formal comparison [14,26].

Collateral-ligament assessment was also supported primarily by comparator evidence. Interchangeability criteria were met in two studies, and an abbreviated 3D protocol showed unchanged performance for a combined collateral-ligament endpoint [13,17,30]. However, only eight lesions contributed to that endpoint. Other protocols showed discrepancies in low- or moderate-grade sprains, imprecise fibular-collateral-ligament estimates, or low positive agreement for pooled ligament abnormalities [14,18,29]. Adequately powered arthroscopy-referenced analyses of individual collateral ligaments were not available.

Bone-marrow abnormalities generally showed preserved comparator agreement [13,14,17]. Nevertheless, reduced depiction of bone-marrow edema with qDESS and lower edema contrast with an abbreviated 3D nDixon sequence indicate that conspicuity remains sequence-dependent [18,30].

Evidence for fractures and other secondary structures was sparse. One comparison showed unchanged detection of seven fractures, while most studies included few or no positive cases suitable for dedicated analysis [15,18,25,30]. Tendons, the extensor mechanism, synovitis, medial patellofemoral ligament injuries, muscle abnormalities, and related findings were evaluated only through isolated, pooled, or comparator-based outcomes [10,13,17,18,19,23,29,30].

Overall, accelerated protocols allowed assessment of a broad range of secondary knee structures, but lesion-specific evidence remains limited because positive cases and appropriate independent reference standards were sparse. These findings support continued routine quality assurance for uncommon ligamentous, osseous, marrow, and tendon abnormalities rather than confidence equivalent to that established for ACL and meniscal assessment.

6. Technical Failure Modes and Quality-Control Considerations

Most evaluated protocols maintained favorable overall image quality and clinically useful lesion assessment. Nevertheless, technical and interpretive errors varied according to acquisition strategy, reconstruction platform, acceleration level, sequence design, and field strength. Recognizing these patterns provides practical targets for protocol acceptance testing and postimplementation quality review.

Banding and streaking were reported predominantly at 1.5 T and occasionally interfered with diagnostic assessment, whereas corresponding 3-T examinations were less affected [7]. Other evaluated protocols showed residual parallel-imaging artifacts, aliasing, blurring, edge degradation, signal dropout, or reconstruction-related abnormalities [10,17,20,25,26]. DLR may reduce visible noise and undersampling-related degradation, but it cannot be assumed to remove artifacts originating from the acquisition itself.

Smoothing and altered tissue signal can affect interpretation despite favorable overall image appearance. Reported examples included cartilage undergrading, an artifact simulating a cartilage defect, and signal alteration capable of mimicking cartilage damage [9,14]. Performance also differed between two accelerated variants evaluated within the same study, reinforcing that validation applies to the complete acquisition-reconstruction configuration rather than to the nominal acceleration factor alone.

Reduced subtle-lesion performance occurred in selected highly accelerated or abbreviated implementations. More aggressive undersampling caused loss of subtle meniscal signal during model optimization, and sixfold acceleration produced lower reported ACL sensitivity than less accelerated variants in one prospective comparison available through its abstract [8,17]. Reconstruction artifacts and additional unconfirmed meniscal findings affected one 3D superresolution protocol, while small chondral lesions were less conspicuous with an

abbreviated single-sequence implementation [10,30]. Other protocols using similar nominal acceleration performed favorably, indicating that these findings are implementation-specific rather than evidence that a particular acceleration factor is inherently unsuitable.

Motion-related performance remains incompletely characterized. Shorter examinations reduce the interval during which movement can occur, but motion was assessed inconsistently, and some studies excluded technically inadequate examinations. The practical effect on motion-related image degradation should therefore be evaluated during local deployment.

Targeted assessment of hallucinations and omissions was uncommon. One arthroscopy-referenced reconstruction study used additional readers specifically to evaluate these outcomes and reported no systematic hallucinated or omitted findings in the evaluated cohort [19]. This is reassuring for that implementation but does not establish that all DLR platforms or protocols are free from such errors.

These findings do not negate the broader evidence of preserved clinical performance. They identify concrete acceptance-testing priorities: field-specific artifacts, subtle meniscal and cartilage lesions, signal alteration, false-positive findings, motion, and possible reconstruction-related omissions.

7. Generalizability and Clinical Implementation

The evidence spans multiple institutions, countries, vendors, and reconstruction approaches and includes prospective comparator studies, arthroscopy cohorts, and routine implementation data. This breadth supports clinical translation, but transfer between systems should be established for the exact configuration used locally rather than inferred from nominally similar acceleration factors.

Most evidence was obtained at 3 T. Data at 1.5 T were more limited, while one identical-acquisition reconstruction study evaluated a distinct 5.0-T setting [7,26]. Field-strength dependence is clinically relevant because banding and streaking occurred predominantly at 1.5 T in one prospective comparison [7]. Multiple vendors and both commercial and research reconstruction platforms were represented, but much of the central lesion-specific evidence remained concentrated in a limited number of scanner and reconstruction families. The only direct prospective multivendor comparison included 15 participants per platform; it supports cross-vendor feasibility but does not establish universal interchangeability [14].

The 22 publications also represent fewer than 22 fully independent replications. Some studies shared development datasets, institutions, investigators, scanner environments, or probably overlapping patient populations [13,15,16,17,19,23]. These relationships do not invalidate the

individual findings, but they reduce the strength of apparent replication and increase the value of validation in independent centers.

Vendor involvement and commercial relationships were common, including supplied research sequences, vendor-employed authors, grants, patents, consulting, and other disclosed relationships [7,9,10,13,14,15,16,17,19,20,21,22,23,26,29,30]. Such involvement is expected when evaluating proprietary reconstruction technologies and should not be treated as evidence of invalidity. It nevertheless reinforces the need for transparent disclosure and independent replication because performance may depend on software version, training data, scanner configuration, and local sequence optimization.

Clinical implementation should validate the complete acquisition-reconstruction pathway, including scanner and field strength, sequence composition, acceleration settings, reconstruction software and version, and local reader environment. Acceptance testing should assess lesion-specific outcomes rather than image quality alone, with particular attention to lateral-meniscal false negatives, cartilage grading, subtle lesions, field-dependent artifacts, and technically inadequate examinations. Changes to software, hardware, field strength, or protocol parameters should prompt targeted re-evaluation.

Current evidence therefore supports implementation after local lesion-, protocol-, and vendor-specific validation. This does not require every center to reproduce the entire published evidence base, but it does require confirmation that the intended configuration preserves clinically important performance in the local setting.

8. Clinical Relevance to Orthopedic and Sports Medicine Practice

ACL injuries, meniscal tears, and chondral abnormalities are important components of knee assessment in athletes and physically active patients [2-4]. Although the included validation studies were not predominantly conducted in athlete-only cohorts, their lesion-specific findings are relevant to orthopedic and sports medicine practice because these structures commonly determine the scope and interpretation of knee MRI.

The strongest support concerns ACL assessment, with generally favorable evidence also available for the medial meniscus. Appropriately validated accelerated protocols may therefore provide a clinically useful alternative to conventional examinations when these lesions are principal diagnostic concerns [13,15,16,17,19,25]. This conclusion should not be extended uniformly to all internal derangements. Lower lateral-meniscal sensitivity and variable cartilage performance indicate that protocol acceptance in sports-oriented practice

should specifically include subtle meniscal tears, partial-thickness chondral abnormalities, relevant cartilage compartments, and grading consistency.

Substantial reductions in acquisition time may have practical value in settings with high imaging demand. Shorter examinations may improve patient tolerance, reduce the interval during which motion can occur, facilitate scheduling, and increase scanner capacity. These are plausible operational advantages rather than consistently demonstrated outcomes of the included studies. One abbreviated protocol showed slightly more favorable motion-artifact ratings, but patient comfort, repeat examinations, throughput, reporting time, access, and cost-effectiveness were not evaluated systematically [30]. Their actual benefit should therefore be assessed within the intended clinical workflow.

The present evidence supports accelerated MRI as a potentially more efficient diagnostic examination, not as an intervention proven to change subsequent recovery. The included studies did not evaluate whether shorter protocols alter treatment decisions, rehabilitation duration, return to sport, functional outcomes, or reinjury risk. Implementation in orthopedic and sports medicine practice should consequently be based on preserved lesion-specific performance and local protocol validation, while any downstream effects on care pathways require separate investigation.

9. Limitations

The evidence base was clinically and methodologically heterogeneous. Studies differed in patient selection, scanner and reconstruction platform, field strength, sequence composition, acceleration strategy, lesion definitions, grading systems, reference standards, and reported outcomes. These differences, together with the distinct purposes of comparator, arthroscopy-referenced, identical-acquisition, and sequential studies, precluded meaningful quantitative pooling. Conventional-MRI comparator studies may preserve errors shared by both protocols, whereas arthroscopy cohorts are surgically selected and may not represent routine referral populations. Positive cases were also sparse for several secondary structures, and cartilage assessment varied substantially across grading systems and compartments.

External replication remains incomplete. Several publications shared institutions, investigators, development datasets, scanner environments, or probably overlapping populations, and much of the principal evidence was concentrated in selected commercial platforms. Vendor participation and industry relationships were common and appropriately disclosed. These factors do not invalidate the reported findings, but they reduce the extent to

which the literature can be interpreted as independent confirmation across unrelated systems and centers.

Full texts were unavailable for five studies, limiting extraction to information explicitly reported in abstracts and, where available, official supplementary material. This restricted assessment of lesion denominators, exclusions, blinding, subgroup analyses, and detailed methods. In addition, this was a structured narrative review rather than an exhaustive systematic review. Although database searching was supplemented by backward and forward citation review, additional eligible publications may have been missed, and no formal risk-of-bias or evidence-certainty instrument was applied.

Most cohorts were not athlete-specific, so relevance to sports medicine is based on the clinical importance of the evaluated lesions rather than direct validation in athletic populations. These limitations narrow the precision and transferability of the conclusions but do not overturn the consistent evidence that many evaluated protocols substantially reduced acquisition time while preserving clinically useful performance, particularly for ACL and medial-meniscal assessment.

10. Conclusions

Clinical evidence indicates that accelerated knee MRI protocols incorporating deep-learning reconstruction can substantially shorten acquisition, commonly by approximately one-third to one-half, while generally preserving clinically useful assessment of major internal derangements. These reductions usually resulted from combined acquisition and reconstruction strategies rather than DLR alone. Evidence was most consistent for ACL tears and generally supportive for medial meniscal tears. Lateral meniscal specificity remained high, but sensitivity was lower and formal non-inferiority was not consistently demonstrated. Cartilage performance varied according to protocol, lesion grade, compartment, and reconstruction method, while evidence for other structures remained limited.

Current evidence therefore supports consideration of clinical implementation after local lesion-, protocol-, and vendor-specific validation of the intended acquisition-reconstruction configuration. Such validation should include targeted assessment of lateral meniscal tears, cartilage lesions, subtle abnormalities, and relevant technical failure modes. For orthopedic and sports medicine practice, the principal implication is that these protocols may provide a more efficient diagnostic alternative when locally validated, rather than being assumed universally interchangeable across systems and lesion types.

Disclosure

Author Contributions

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References

1. Expert Panel on Musculoskeletal Imaging; Taljanovic MS, Chang EY, Ha AS, Bartolotta RJ, Bucknor M, Chen KC, et al. ACR Appropriateness Criteria® acute trauma to the knee. *J Am Coll Radiol.* 2020;17(5 Suppl):S12-S25. https://doi.org/10.1016/j.jacr.2020.01.041

2. Martinez-Calderon J, Infante-Cano M, Matias-Soto J, Perez-Cabezas V, Galan-Mercant A, Garcia-Muñoz C. The incidence of sport-related anterior cruciate ligament injuries: an overview of systematic reviews including 51 meta-analyses. *J Funct Morphol Kinesiol.* 2025;10(2):174. https://doi.org/10.3390/jfmk10020174

3. Vaishya R, Kambhampati SBS, Vaish A. Meniscal injuries in Olympic and elite athletes. *Indian J Orthop.* 2020;54(3):281-293. https://doi.org/10.1007/s43465-020-00049-y

4. Flanigan DC, Harris JD, Trinh TQ, Siston RA, Brophy RH. Prevalence of chondral defects in athletes' knees: a systematic review. *Med Sci Sports Exerc.* 2010;42(10):1795-1801. https://doi.org/10.1249/MSS.0b013e3181d9eea0

5. Fritz J, Guggenberger R, Del Grande F. Rapid musculoskeletal MRI in 2021: clinical application of advanced accelerated techniques. *AJR Am J Roentgenol.* 2021;216(3):718-733. https://doi.org/10.2214/AJR.20.22902

6. Vosshenrich J, Koerzdoerfer G, Fritz J. Modern acceleration in musculoskeletal MRI: applications, implications, and challenges. *Skeletal Radiol.* 2024;53(9):1799-1813. https://doi.org/10.1007/s00256-024-04634-2

7. Herrmann J, Keller G, Gassenmaier S, Nickel D, Koerzdoerfer G, Mostapha M, et al. Feasibility of an accelerated 2D-multi-contrast knee MRI protocol using deep-learning image reconstruction: a prospective intraindividual comparison with a standard MRI protocol. *Eur Radiol.* 2022;32(9):6215-6229. https://doi.org/10.1007/s00330-022-08753-z

8. Foti G, Spoto F, Spezia A, Romano L, Caia S, Camerani F, et al. Deep learning-driven abbreviated knee MRI protocols: diagnostic accuracy in clinical practice. *Radiol Med.* 2025;130(9):1460-1471. https://doi.org/10.1007/s11547-025-02038-3

9. Reschke P, Gotta J, Gruenewald LD, Ait Bachir A, Strecker R, Nickel D, et al. Deep learning in knee MRI: a prospective study to enhance efficiency, diagnostic confidence and sustainability. *Acad Radiol.* 2025;32(6):3585-3596. https://doi.org/10.1016/j.acra.2025.03.018

10. Smekens C, Beirinckx Q, Bosmans F, Vanhevel F, Snoeckx A, Sijbers J, et al. Deep learning-enhanced accelerated 2D TSE and 3D superresolution Dixon TSE for rapid comprehensive knee joint assessment. *Invest Radiol.* 2025;60(3):220-233. https://doi.org/10.1097/RLI.0000000000001118

11. Yoon MA, Gold GE, Chaudhari AS. Accelerated musculoskeletal magnetic resonance imaging. *J Magn Reson Imaging.* 2024;60(5):1806-1822. https://doi.org/10.1002/jmri.29205

12. Leonhardt Y, Vosshenrich J, Fritz J. Best fast MRI protocols for the knee: advantages and limitations. *Skeletal Radiol.* 2026;55(7):1457-1468. https://doi.org/10.1007/s00256-026-05197-0

13. Johnson PM, Lin DJ, Zbontar J, Zitnick CL, Sriram A, Muckley M, et al. Deep learning reconstruction enables prospectively accelerated clinical knee MRI. *Radiology.* 2023;307(2):e220425. https://doi.org/10.1148/radiol.220425

14. Lee J, Jung M, Park J, Kim S, Im Y, Lee N, et al. Highly accelerated knee magnetic resonance imaging using deep neural network (DNN)-based reconstruction: prospective, multi-reader, multi-vendor study. *Sci Rep.* 2023;13(1):17264. https://doi.org/10.1038/s41598-023-44248-7

15. Vosshenrich J, Breit HC, Donners R, Obmann MM, Walter SS, Serfaty A, et al. Clinical implementation of sixfold-accelerated deep learning superresolution knee MRI in under 5 minutes: arthroscopy-validated diagnostic performance. *AJR Am J Roentgenol.* 2025;225(1):e2532878. https://doi.org/10.2214/AJR.25.32878

16. Johnson PM, Dogra S, Westerhoff M, Fritz J, Lin DJ, Recht MP. Real-world diagnostic performance of knee MRI protocols accelerated using simultaneous multi-slice acquisition and deep learning reconstruction. *Skeletal Radiol.* 2026;55(3):571-577. https://doi.org/10.1007/s00256-025-05058-2

17. Recht MP, Zbontar J, Sodickson DK, Knoll F, Yakubova N, Sriram A, et al. Using deep learning to accelerate knee MRI at 3 T: results of an interchangeability study. *AJR Am J Roentgenol.* 2020;215(6):1421-1429. https://doi.org/10.2214/AJR.20.23313

18. Chaudhari AS, Grissom MJ, Fang Z, Sveinsson B, Lee JH, Gold GE, et al. Diagnostic accuracy of quantitative multicontrast 5-minute knee MRI using prospective artificial intelligence image quality enhancement. *AJR Am J Roentgenol.* 2021;216(6):1614-1625. https://doi.org/10.2214/AJR.20.24172

19. Walter SS, Vosshenrich J, Cantarelli Rodrigues T, Dalili D, Fritz B, Kijowski R, et al. Deep learning superresolution for simultaneous multislice parallel imaging-accelerated knee MRI using arthroscopy validation. *Radiology.* 2025;314(1):e241249. https://doi.org/10.1148/radiol.241249

20. Wu X, Liu WV, Wang K, Jiang J, Liu C, Zha Y. Prospective study assessing the validity of accelerated 2D Fast Spin Echo (2D FSE) based high-resolution knee MRI and T2 mapping using deep learning reconstruction. *BMC Musculoskelet Disord.* 2026;27:125. https://doi.org/10.1186/s12891-025-09482-2

21. Kim MW, Lee SM, Park C, Lee D, Kim KS, Jeong HS, et al. Deep learning-enhanced parallel imaging and simultaneous multislice acceleration reconstruction in knee MRI. *Invest Radiol.* 2022;57(12):826-833. https://doi.org/10.1097/RLI.0000000000000900

22. Bedoya MA, Iwasaka-Neder J, Tsai A, Johnston PR, Körzdörfer G, Nickel D, et al. Deep learning MR reconstruction in knees and ankles in children and young adults. Is it ready for clinical use? *Skeletal Radiol.* 2025;54(3):509-529. https://doi.org/10.1007/s00256-024-04769-2

23. Vosshenrich J, Breit HC, Donners R, Obmann MM, Harder D, Ahlawat S, et al. Arthroscopy-validated diagnostic performance of sub-5-min deep learning super-resolution 3T knee MRI in children and adolescents. *Skeletal Radiol.* 2025;54(12):2705-2716. https://doi.org/10.1007/s00256-025-04969-4

24. Wen S, Xu Y, Yang G, Huang F, Zeng Z. Evaluation of deep learning reconstruction in accelerated knee MRI: comparison of visual and diagnostic performance metrics. *Radiologie (Heidelb).* 2025;65(Suppl 1):74-80. https://doi.org/10.1007/s00117-025-01464-8

25. Subhas N, Li H, Yang M, Winalski CS, Polster J, Obuchowski N, et al. Diagnostic interchangeability of deep convolutional neural networks reconstructed knee MR images: preliminary experience. *Quant Imaging Med Surg.* 2020;10(9):1748-1762. https://doi.org/10.21037/qims-20-664

26. Wang P, Li Z, Zhu C, Mu R, Liu C, Yang J, et al. Validation and feasibility of a deep learning-based reconstruction technology in 5.0 tesla knee joint MR imaging. *Front Radiol.* 2026;6:1776035. https://doi.org/10.3389/fradi.2026.1776035

27. Kaniewska M, Deininger-Czermak E, Lohezic M, Ensle F, Guggenberger R. Deep learning convolutional neural network reconstruction and radial k-space acquisition MR technique for enhanced detection of retropatellar cartilage lesions of the knee joint. *Diagnostics (Basel).* 2023;13(14):2438. https://doi.org/10.3390/diagnostics13142438

28. Nikolova E, Kroschke J, Obermüller C, Zecca F, Pawlus K, Jungblut L, et al. Deep-learning reconstructed 3D MRI for comprehensive knee assessment: comparison with a multisequence 2D protocol at 1.5 T. *Eur J Radiol.* 2025;193:112458. https://doi.org/10.1016/j.ejrad.2025.112458

29. Wang K, Liu WV, Yang R, Li L, Lu X, Lei H, et al. Super-resolution synthetic MRI using deep learning reconstruction for accurate diagnosis of knee osteoarthritis. *Insights Imaging.* 2025;16(1):44. https://doi.org/10.1186/s13244-025-01911-z

30. Gillet R, Boubaker F, Clara M, Ambarki K, Stemmer A, Drouot G, et al. Optimizing knee MRI: 3D proton density turbo spin echo nDixon sequence vs. 2D high-resolution turbo spin echo in half the acquisition time. *Eur J Radiol.* 2026;195:112552. https://doi.org/10.1016/j.ejrad.2025.112552