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T2-Weighted Whole Spine Sagittal MRI for the Identification of Cervical Cord Compression in Degenerative Spinal Conditions: A Systematic Review

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Study Design: PRISMA-compliant systematic review.

Objective: This review aimed to evaluate the clinical prevalence and significance of cervical cord compression (CCC) identified on T2-weighted whole spine sagittal MRI (WSSMRI) sequences.

Summary of Background Data: WSSMRI sequences are frequently acquired alongside thoracolumbar MRI for vertebral segmentation, but may also detect previously unrecognized CCC, a key risk factor for degenerative cervical myelopathy. The clinical significance of WSSMRI-identified CCC remains unclear.

Materials and Methods: Five databases were searched for studies evaluating CCC on T2-weighted WSSMRI in adults undergoing MRI for degenerative spinal conditions from inception to September 2026. Two reviewers independently performed study selection and data extraction. Data were synthesized descriptively, with subgroup analyses by age (60 y or older) and symptomatic lumbar spinal stenosis (LSS).

Results: The search yielded 552 articles, of which 48 full texts were reviewed, and six studies were included for analysis. All six studies were retrospective observational cohorts from tertiary orthopedic/neurosurgical settings. Across the six included studies, 2634 participants were included (mean age = 56.9), of whom 375 had WSSMRI-identified CCC (aggregate prevalence: 14.2%; range: 5.4%–53%). The aggregate prevalence among patients aged 60 years or older and among patients with symptomatic LSS was 28.3% (range: 23.7%–53%) and 23.9% (23.7%–23.9%), respectively. Three studies provided detail regarding symptomatic CCC, whereby 47 out of 147 CCC cases exhibited myelopathic symptoms (32.0%). Overall, studies had a low to moderate risk of bias (5–7/7) and were of moderate quality (4–7/9).

Conclusion: T2-weighted WSSMRI may serve as an adjunctive and opportunistic imaging sequence for identifying CCC. While a more quantitative prevalence estimate was not appropriate due to heterogeneous image evaluation methods, CCC was frequently identified in older adults and those with lumbar spinal stenosis, where tandem spinal pathology is common. Further studies are needed to assess its comparative performance and accuracy compared with cervical spine MRI.

Keywords: magnetic resonance imaging, whole spine sagittal MRI, neuroradiology, cervical cord compression, degenerative cervical myelopathy

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Cervical cord compression (CCC) is a critical radiologic finding arising from degenerative, congenital, traumatic, neoplastic, and/or inflammatory aetiologies.[1] While degenerative cervical stenosis and CCC are incidentally detected in up to 24.2% of asymptomatic adults based on population-based studies, CCC is a well-established predictor for the development and progression of degenerative cervical myelopathy (DCM).[2]

Early identification of CCC, particularly its symptomatic form, DCM, is crucial given its association with progressive and often irreversible neurological sequelae.[1,2] Both CCC and DCM have been identified when screened for in several at-risk groups, most commonly in patients presenting for evaluation of degenerative spinal complaints, such as lumbar spinal stenosis (LSS).[3,4] Notably, up to 60% of patients with symptomatic LSS exhibit concomitant radiologic CCC, a phenomenon described as tandem spinal stenosis.[3] While not always symptomatic, identification of tandem CCC in the preoperative setting in patients undergoing thoracolumbar and complex adult deformity surgery may have implications for surgical staging, approach,[5] intraoperative anesthetic positioning,[6] and differential diagnostic considerations for patients with nonconcordant neurological symptoms.[7]

Typically, the assessment of tandem CCC would require further dedicated regional imaging of the cervical spine. T2-

weighted whole spine sagittal magnetic resonance imaging (WSSMRI) (Figure 1B) sequences may present an opportunity to identify tandem CCC without dedicated regional MRI. WSSMRI sequences are often incorporated into thoracic and lumbar spine MRI protocols for vertebral segmentation and screening for incidental pathology.[8] Although inherently limited by the absence of axial sequences and contingent on sufficient image acquisition parameters, T2-weighted WSSMRI sequences may provide an opportunistic visualization of CCC in patients undergoing radiological/surgical evaluation for thoracic and lumbar spinal pathology.

While the prevalence of CCC is well established using conventional whole spine or cervical spine MRI sequences, its prevalence utilizing T2-weighted WSSMRI sequences remains largely unexplored. This systematic review aims to evaluate the prevalence of WSSMRI-identified CCC, clinical adoption of WSSMRI, evaluation parameters, and clinical implications.

Study objectives

This systematic review aims to evaluate the published literature on the use of T2-weighted WSSMRI sequences in the assessment of CCC. As part of a multiphase research initiative, this review will provide foundational evidence on the opportunistic identification of CCC using WSSMRI, informing its potential role as a prompt for further clinical evaluation in patients at risk of developing DCM.

Review Questions

Primary aims:

1. What is the prevalence of CCC identified through T2-weighted WSSMRI sequences?
2. What is the clinical significance of WSSMRI-identified CCC, particularly in terms of symptomatic state and surgical indication?

Secondary aims:

1. What methods are used to grade the degree of WSSMRI-identified CCC?
2. What imaging acquisition parameters are utilized for WSSMRI in the assessment of CCC?

Materials and Methods

Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Supplemental Material 1, https://links.lww.com/BN9/A30). The protocol was prospectively registered on PROSPERO (ID: CRD42024524243) with minor amendments described in Section 2.8.

Databases and search strategy

A preliminary search was performed via Scopus and Google Scholar to screen for topic relevance and identify keywords associated with WSSMRI. Keywords and descriptors were selected alongside expert radiology consultation, considering three elements: (1) whole spine sagittal sequences; (2) magnetic resonance imaging; and (3) cervical stenosis and CCC. Upon consultation with a library search expert, a six-word proximity search was adopted to increase the relevance of findings between "whole spine" and "MRI" keywords.

The final search (available as Supplemental Material 2, https://links.lww.com/BN9/A31) was performed on MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), SPORTDiscus, Scopus and Allied and Complementary Medicine Database (AMED).

Eligibility criteria

Table 1 shows a detailed summary of the inclusion and exclusion criteria. Only studies assessing WSSMRI-identified CCC in clinical populations of adults were considered for inclusion. All included studies had to document the use of a grading scale to assess CCC. Studies evaluating patients with nondegenerative CCC were excluded.

Study selection

All retrieved search records were exported into Covidence for deduplication and screening. Title and abstract screening was independently conducted by two reviewers (RVC, CR) to exclude overtly unrelated studies, yielding an overall agreement of 91.8% between items and a moderate level of inter-rater reliability (Cohen κ: 0.47). Both reviewers independently completed full-text screening by applying the predetermined eligibility criteria (Table 1). Any disagreements following the title and abstract screening and full-text screening stages were discussed, and a third reviewer (AHS) was available to adjudicate if consensus was not reached.

The reference lists of all included articles were manually screened to identify additional eligible studies not captured by the electronic search. Where reference screening yielded more than one additional eligible study not identified in the original search, the search strategy was reviewed and amended to consider the possibility that other articles have been overlooked.

Data extraction and quality appraisal

A data extraction tool was developed and iteratively refined by piloting three randomly selected studies after title and abstract screening. The final tool consisted of three sections: (1) study-level characteristics, methods and outcomes; (2) risk of bias assessment; and (3) study quality assessment. Two reviewers independently performed data extraction and quality assessment (RVC, CR), and a third reviewer (AHS) was available to adjudicate if there was a lack of consensus.

Study-level characteristics

The following data were extracted from all included articles: (1) article information; (2) participant information; (3) methodology—grading classification, imaging parameters for WSSMRI; and (4) outcomes—prevalence of CCC, grading of CCC, multilevel involvement, clinical significance (symptomatic or not), and impact (surgical necessity) of CCC.

Risk of bias assessment

Risk of bias of the individual studies was assessed using seven items adapted from the 10-question tool developed by Hoy *et al.*,[9] selected for their relevance to prevalence studies and high inter-rater reliability (overall agreement: 91%; κ statistic: 0.82) (Supplemental Material 3, https://links.lww.com/BN9/A33). Each "yes" rating carried a score of one, with studies classified as low risk (6–7), moderate risk (3–5), or high risk (0–2).

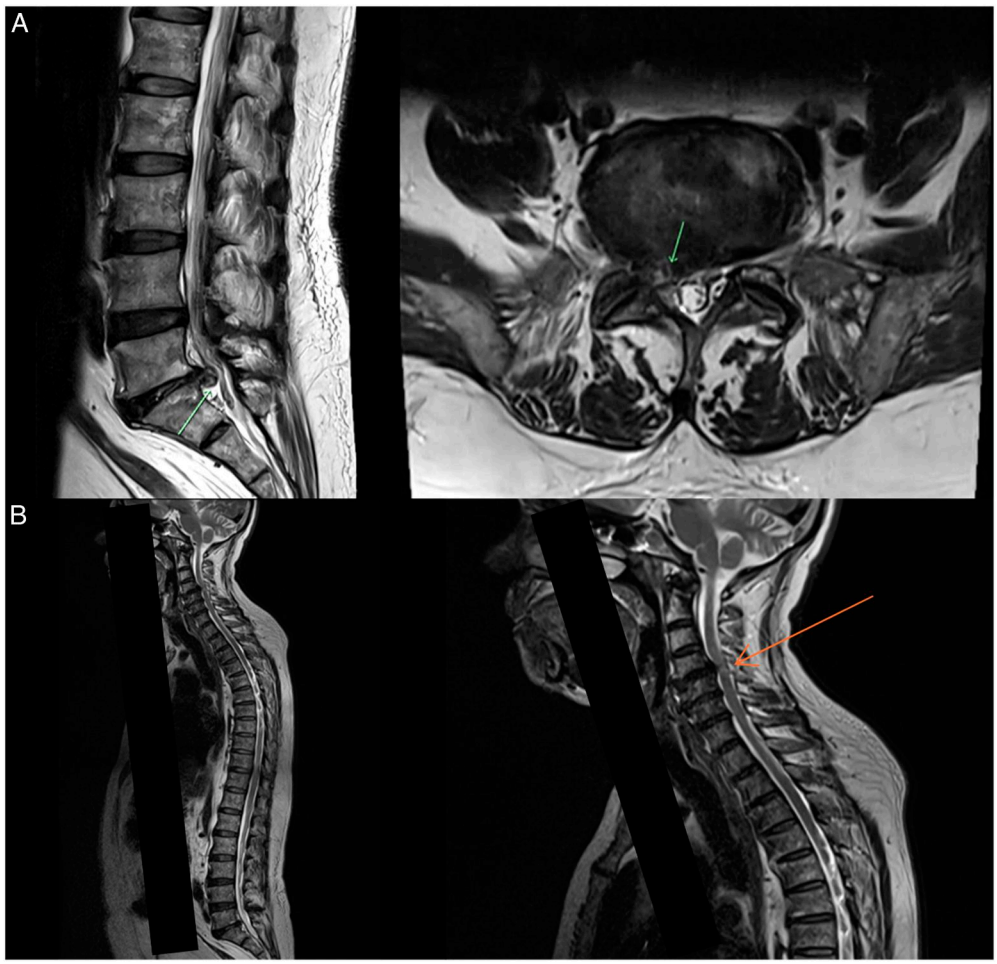


Figure 1. Illustrative clinical case vignette demonstrating the utilization of WSSMRI alongside lumbar spinal imaging. Clinical case vignette: A 69-year-old male presented for orthopedic evaluation with symptoms associated with right S1 radiculopathy. Lumbar spine MRI (A) confirmed an L5/S1 disc herniation with subarticular right S1 nerve root compression (green arrows), while a magnified midsagittal view of the cervical spine on T2-weighted WSSMRI (B) also revealed C4/5 cord compression with trace myelomalacia (orange arrow). Further clinical examination revealed global deep tendon hyperreflexia and bilaterally present Hoffmann and inverted supinator signs, prompting referral for further diagnostic (cervical spine MRI) and surgical consultation. The patient was subsequently diagnosed with moderate degenerative cervical myelopathy (mJOA 14) and underwent C3–7 laminoplasty with a stable three-month postoperative neurological outcome. Adapted from Chauhan *et al*.[30] with permission. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation. mJOA indicates modified Japanese Orthopaedic Association score; MRI, magnetic resonance imaging; WSSMRI, whole spine sagittal magnetic resonance imaging.

Two reviewers (RVC, CR) independently scored 42 items (7 items, per 6 studies), achieving 88.1% overall agreement and moderate inter-rater reliability (Cohen $\kappa = 0.59$).

Quality assessment

Study quality was appraised using a modified version of the Joanna Briggs Institute Prevalence Critical Appraisal tool, adopted from Smith *et al*.[1] Nine items most relevant to the present review's aims were included to appraise the quality of individual studies (Supplemental Material 4, https://links.lww.com/BN9/A34). Each study was scored from 0 to 9, with 9 indicating high quality, 4 to 7 moderate quality, and 1 to 3 low quality.

Data analysis

For review question 1, prevalence was calculated by dividing the number of participants with WSSMRI-identified CCC by the total aggregated sample size across the included studies. For review question 2, the number of symptomatic CCC cases and those undergoing surgical intervention was calculated relative to the total aggregated number of CCC cases from included studies reporting these details. Data extracted for review questions 3 and 4 were analyzed narratively without further statistical analysis.

Although subgroup analyses were not prospectively planned, post hoc exploratory comparisons were performed across two groups: (1) studies recruiting participants aged 60 years or older; and (2) studies assessing patients with symptomatic lumbar spinal stenosis (LSS),both established at-risk groups for tandem spinal pathology. CCC prevalence estimates were descriptively summarized for these subgroups. However, due to the small number of studies per subgroup and heterogeneity in study design, no inferential statistical testing was performed.

A meta-analysis was initially planned to calculate the pooled CCC prevalence, but was not undertaken due to substantial methodological heterogeneity, particularly regarding the grading scales

Table 1

Detailed Summary of Inclusion and Exclusion Criteria

Inclusion criteria	Participants: all adult patients over the age of 18 y presenting for clinical and MRI evaluation of spinal-related pain
	Intervention(s)/exposure(s): use of T2-weighted WSSMRI in the assessment of CCC alongside usual region-specific MRI for the presenting condition
	Outcome measurements: key outcomes included the reporting of prevalence of WSSMRI-identified CCC. In addition, studies had to document the use of an appropriate grading scale to assess the degree of central stenosis and CCC
	Studies: observational studies (retrospective and prospective) published in peer-reviewed journals, with full text available in the English language
Exclusion criteria	Participants: studies evaluating patients with nondegenerative CCC causes
	Outcome measurements: use of WSSMRI for purposes unrelated to CCC assessment (*e.g.*, posture or sagittal balance assessment)
	Studies: single case reports, editorials, conference abstracts, or review articles lacking original data were excluded

CCC indicates cervical cord compression; MRI, magnetic resonance imaging; WSSMRI, whole spine sagittal magnetic resonance imaging.

used to define CCC. The lack of consistent definitions of various CCC grades and thresholds meant that statistically pooling the data would introduce bias and reduce interpretability.

Data synthesis

Key study characteristics, WSSMRI acquisition parameters, CCC grading systems, and reported outcomes were tabulated in Microsoft Excel and presented using both narrative and tabular formats. Risk of bias assessments were visually synthesized using the *robvis* web-based tool, displaying domain-specific and overall judgments across the seven-item framework.

Changes to PROSPERO systematic review protocol

Minor amendments have been made to the originally described protocol (PROSPERO ID: CRD42024524243) to achieve greater relevance to the study aims and maintain standards in line with PRISMA guidelines. These changes were not updated in the online record.

Firstly, in accordance with best-practice standards, two reviewers independently performed article screening and data extraction, whereas a single reviewer was previously documented in the protocol. Second, the Hoy *et al.*[9] risk of bias tool was used rather than the Newcastle-Ottawa Scale, given its high inter-rater reliability and its successful application in a similar MRI-based prevalence study.[1] Finally, we added the modified version of the Joanna Briggs Institute Critical Appraisal tool (JBI) checklist to assess the quality of individual studies, given its greater relevance to the study aims.

Results

Study selection

The final search, performed in September 2026, yielded 552 peer-reviewed articles, which was reduced to 467 after duplicate removal (Figure 2). A further 419 articles were excluded following title and abstract screening. Full-text review of the remaining 48 articles identified six studies that met the eligibility criteria and were included in the final analysis.[10–15] The main reasons for study exclusion were the lack of CCC assessment and the use of imaging other than WSSMRI (Figure 2).

Study characteristics

Table 2 summarizes the characteristics of the included studies.

Study design

All six included studies were retrospective observational studies with varying sample sizes between 93 and 1555 participants per study (median: 213.0).

Participants

A total of 2634 participants were included across the six selected studies, with average participant ages ranging from 48 to 83.3 years (median: 63.1 yr). All participants were recruited from tertiary care university-affiliated hospitals. Notably, all six studies recruited participants from countries within the Asian continent, with four studies from Korea,[10,11,13,15] one from India,[14] and one from Israel.[12]

Although all studies examined adult orthopedic or neurosurgical patient populations undergoing routine clinical evaluation for spinal-related pain, there was considerable variability in inclusion criteria. Three studies included patients aged 60 years or older,[10,13,15] and three studies included patients with symptomatic lumbar spinal stenosis.[10,12,13] Two studies excluded individuals with clinical signs or symptoms of myelopathy at recruitment.[10,13]

MRI acquisition parameters across included studies

MRI acquisition parameters for WSSMRI were inconsistently reported across the six included studies. Only Park *et al.*[13] and Smorgick *et al.*[12] provided detailed image acquisition parameters sufficient for replication (Table 3).

Four studies utilized 1.5-Tesla MRI systems to acquire T2-weighted sagittal sequences.[10–13] Both Han *et al.*[11] and Smorgick *et al.*[12] described multistation acquisition techniques, with cranial and caudal segments separately imaged and digitally merged to generate continuous WSSMRI sequences. No acquisition parameters were reported by Jagtap *et al.*[14] or Yuk *et al.*,[15] aside from noting the use of T2-weighted WSSMRI sequences.

Outcome measurement

All six included studies utilized grading scales to evaluate the degree of central canal stenosis and defined the threshold for determining WSSMRI-identified CCC. Four distinct grading scales were utilized across the studies (Table 4). There was substantial heterogeneity when comparing item descriptors assigned to each grade and the defining thresholds for CCC across the four scales.

Four studies reported independent multiobserver assessments of WSSMRI,[10–13] but only two reported reliability analyses.[10,13] When comparing the Cohen kappa scores of the two scales used in these two studies, the Cervical Cord Compression Index (CCI) demonstrated greater interobserver (CCI: 0.78, substantial agreement; modified Kang: 0.53, moderate) and intraobserver reliability (CCI: 0.82, almost perfect agreement; modified Kang: 0.71, substantial),[10] compared with the modified Kang criteria (Table 4).[13]

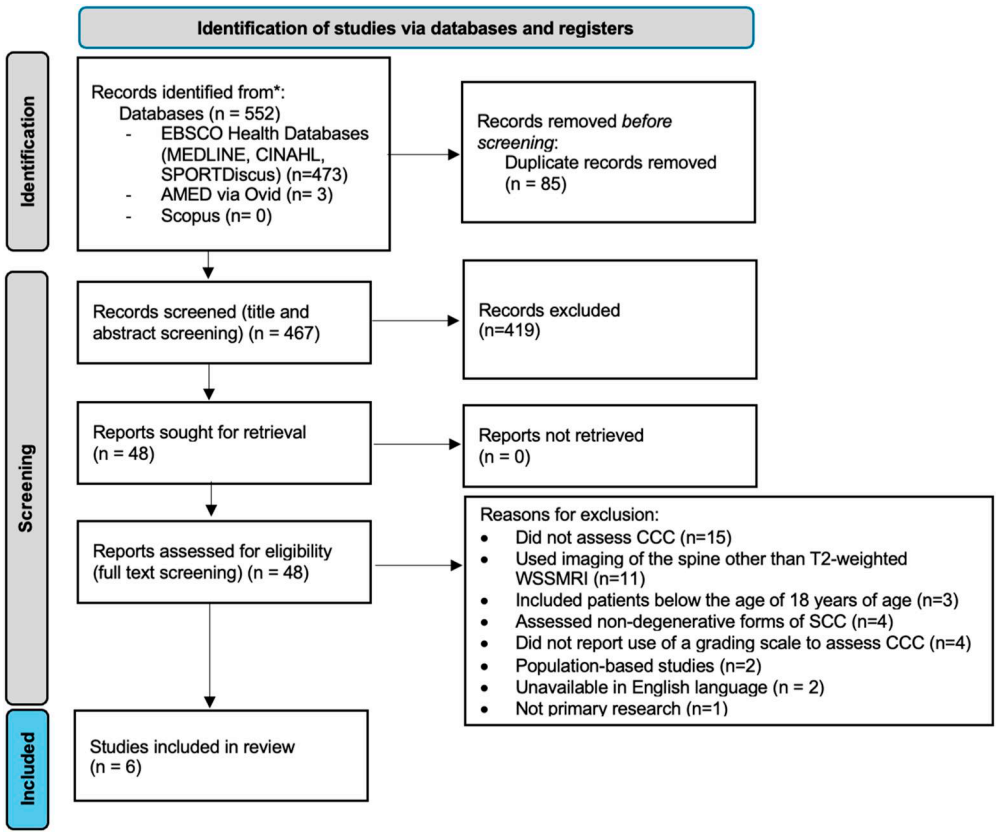


Figure 2. Systematic literature search flowchart. Adapted from the PRISMA systematic review protocol. AMED indicates Allied and Complementary Medicine Database; CCC, cervical cord compression; CINAHL, Cumulative Index to Nursing and Allied Health Literature; MEDLINE, Medical Literature Analysis and Retrieval System Online; WSSMRI: whole spine sagittal magnetic resonance imaging.

Key findings

Prevalence of WSSMRI-identified CCC

Among the six included studies, the prevalence of WSSMRI-identified CCC exhibited considerable variability, ranging from 5.4% to 53.0%. However, four out of six studies reported more consistent prevalences within a range of 23.7% to 25.6%.[10–13] The unweighted mean prevalence was 25.9%, with a median of 23.9%. Across the total cohort of 2634 participants, the overall number of CCC cases was 375, yielding an aggregate prevalence of 14.2%.

Influence of age on the prevalence of WSSMRI-identified CCC

Three studies evaluated patients aged 60 years or older, with a total sample of 653 participants.[10,13,15] The aggregate prevalence of CCC across these studies was 28.3% (n = 185; range: 5.4%–53%).

Using the approach by Smith *et al.*,[1] where "young" (mean age younger than 60 yr) and "aged" (mean age older than 60 yr) subgroups were created and compared, we calculated the aggregate prevalence in the young subgroup to be 9.6% (3 studies; 190/1981), compared with 28.3% for the aged subgroup (3 studies; 185/653).

Influence of symptomatic lumbar spinal stenosis on the prevalence of WSSMRI-identified CCC

Three studies evaluated CCC prevalence in patients with symptomatic LSS, with a total sample of 725 subjects.[10,12,13] The aggregate prevalence of CCC across these studies was 23.9% (n = 173). Notably, the reported prevalence within each of these three was highly consistent, 23.7%,[10] 23.9%,[13] and 23.8%.[12]

Prevalence of symptomatic WSSMRI-identified CCC

Only three studies reported on myelopathic symptoms among CCC cases.[10,12,14] Across these three studies, 147 participants had WSSMRI-identified CCC. Of these, 47 individuals exhibited clinical features associated with cervical myelopathy, corresponding to an aggregated symptomatic CCC prevalence of 32.0% (47/147).

Interestingly, Lee *et al.*[10] specifically excluded participants with clinical signs or symptoms of cervical myelopathy. Despite this exclusion criterion, they reported that 14.0% of patients with CCC experienced nonspecific discomfort or intermittent upper-limb numbness, while 12.9% reported intermittent neck pain or stiffness, both of which are associated with cervical myelopathy.

Table 2

Characteristics of Included Studies

References	Recruitment Source	Design	Clinical Population (Inclusion)	Exclusion Criteria	Sample Size (n)	CCC Grading Scale	Country	Mean Age (Years) [Range]	CCC Prevalence (%)	Risk of Bias (/7)	Study Quality (/9)
Han *et al.*[11]	Neurosurgical department; tertiary care; university affiliated	Retrospective	Admitted for surgical management of degenerative spinal diseases	Nondegenerative pathology (*e.g.*, tumor, trauma, or infections)	254	Modified Takahashi criteria	Korea	56.3 [19–83]	65 (25.6)	Low (6)	Moderate (6)
Lee *et al.*[10]	Orthopedic department; tertiary care; university affiliated	Retrospective	LSS with neurogenic claudication	Presence of clinical signs or symptoms of cervical radiculopathy or myelopathy	93	Cervical Cord Compression Index	Korea	69.9 [61–80]	22 (23.7)	Low (7)	Moderate (6)
Jagtap *et al.*[14]	Orthopedic department; tertiary care; university affiliated	Retrospective	Presenting for orthopedic assessment of lower back or neck-related pain	Previous cervical spinal surgery or congenital spinal deformities	1555	Modified Takahashi criteria	India	48 [NA]	84 (5.4)	Moderate (5)	Moderate (4)
Park *et al.*[13]	Orthopedic department; tertiary care; university affiliated	Retrospective	Patients aged 80 yr or older with LSS and neurogenic claudication	Presence of clinical signs/symptoms of cervical or thoracic myelopathy, fractures, spondylolisthesis, tumor, OPLL, and OYL	460	Modified Kang criteria	Korea	83.3 [80–98]	110 (23.9)	Low (6)	Moderate (7)
Smorgick *et al.*[12]	Orthopedic department; tertiary care; university affiliated	Retrospective	LSS with neurogenic claudication	NA	172*	Wakayama Spine Study criteria	Israel	51.3 [±17.5]	41 (23.8)	Low (6)	Moderate (5)
Yuk *et al.*[15]	Orthopedic and neurosurgical department; tertiary care; university affiliated	Retrospective	Patients aged 60 yr or older presenting for evaluation of lumbar pathologies	Previous cervical spinal surgery or vertebral fracture	100	Cervical Cord Compression Index	Korea	74.21 [60–90]	53 (53)	Low (7)	Moderate (7)

*This number represents the only subset of participants from Smorgick *et al.*[12] that was reported in a sufficient manner for outcome extraction, and is therefore the only extracted analytic subset from the total sample of 1145 participants. This is acknowledged as a limitation in the present review.

LSS indicates lumbar spinal stenosis; MRI, magnetic resonance imaging; OPLL, ossification of posterior longitudinal ligament; OYL, ossification of yellow ligament.

Table 3

Image Acquisition Parameters for Whole Spine Sagittal MRI

References	MRI Acquisition Parameters
Han *et al.*[11]	1.5-Tesla scanner (Magnetom Avanto; Siemens Medical Solutions, Erlangen, Germany)
	16-channel spine matrix coil
	Separate cranial and caudal spinal regions scanned and merged using syngo MR B15 software
Lee *et al.*[10]	1.5-Tesla MRI system
	Acquisition parameters not further specified
Park *et al.*[13]	1.5-Tesla superconductive MRI (Intera; Koninklijke Philips Electronics N.V., Amsterdam, the Netherlands)
	TR = 2346 ms
	TE = 100 ms
	Echo train length = 16
	Slice thickness = 4 mm
	Field of view (FOV) = 320 mm
	Matrix size = 548×272
	Number of excitations (NEX) = 4
Smorgick *et al.*[12]	1.5-Tesla scanner (AERA; Siemens Medical Solutions, Germany)
	4-channel spine matrix coil
	Separate cranial and caudal acquisitions merged using NUMARIS/4 Syngo MR E11 software
	TR = 4000 ms
	TE = 101 ms
	Slice thickness = 0.3 cm
	Number of slices = 18
	Spatial resolution = 0.78×1.08 mm

FOV indicates field of view; MRI, magnetic resonance imaging; NEX, number of excitations; TE, echo time; TR, repetition time.

Progression of WSSMRI-identified CCC to surgical intervention

Only two studies reported the prevalence of CCC cases that underwent surgery.[10,11] Han *et al.*,[11] despite not detailing the prevalence of myelopathy, reported that five out of 65 CCC cases underwent surgery for cord compression in an unspecified time period following initial evaluation. Lee *et al.*[10] reported that none of the 22 CCC cases underwent surgery.

Influence of CCC grading classification on prevalence

Four distinct grading scales were utilized to define WSSMRI-identified CCC (see Table 4 for detail). The most frequently applied grading scales were the modified Takahashi criteria,[11,14] and the Cervical Cord Compression Index.[10,15] Two studies utilizing the modified Takahashi criteria reported CCC prevalence of 5.4% and 25.6%,[11,14] whereas those using the CCI typically demonstrated higher prevalence, ranging from 23.7% to 53%.[10,15] However, given the limited number of studies per grading scale, and other sources of heterogeneity, it is not possible to determine whether specific grading scales systematically overestimate or underestimate CCC prevalence.

Risk of bias and study quality

All included studies had an overall low-to-moderate risk of bias as determined by the modified Hoy *et al.*[9] tool. All studies demonstrated consistent fulfillment of key methodological items relating to sample selection, data collection, and acceptable definitions for CCC, and the use of consistent data collection methods (corresponding to items 3 and 5–7) (Figure 3). Nonetheless, several studies exhibited important reporting limitations. Jagtap *et al.*[14] did not provide sufficient detail regarding characteristics of the included population, and Park *et al.*[13] recruited a narrowly defined sample (patients aged over 80 years with symptomatic lumbar spinal stenosis). Smorgick *et al.*[12] did not report sampling methods and did not specify CCC prevalence in their full cohort (n = 1145). As a result, only a defined subsample (n = 172) with symptomatic lumbar spinal stenosis was deemed appropriate for pooled prevalence estimates in this review.

All studies were of moderate methodological quality, ranging from 4 to 7 out of 9. Jagtap *et al.*[14] had the lowest score of 4/9, relating to the lack of detail reported regarding the study setting and population and the lack of multiple independent imaging reviewers. None of the included studies documented a sample size calculation, likely pertaining to the exploratory and observational nature of the studies.

Discussion

Principal findings and interpretation

This systematic review provides the first focused synthesis of the application of T2-weighted WSSMRI for the identification of CCC in patients presenting for evaluation of other spinal-related disorders. Based on this review, which included six studies and over 2600 patients, the aggregated prevalence of WSSMRI-identified CCC was 14.2% (5.4%–53%). As anticipated, the prevalence was greater in patients with symptomatic lumbar spinal stenosis (23.9%) and in patients 60 years or older (28.3%), both subgroups with an established risk of tandem spinal pathology.[3] However, these combined prevalence estimates should be interpreted with caution given heterogeneity in the populations and image evaluation methods among the included studies.

Despite their heterogeneity, these studies demonstrate the conceptual utility of T2-weighted WSSMRI in the opportunistic identification of CCC. While cervical spine MRI remains the gold standard,[16] WSSMRI sequences are frequently embedded

Table 4

Comparison of Grading Scales Used to Characterize Cervical Central Stenosis and Cord Compression Across Studies

Grading Scales	Description	Utilized by	Reliability (Cohen κ)
Modified Takahashi criteria	Grade 0 = no thecal sac compression Grade 1 = minimal subarachnoid space compression Grade 2 = mild cord compression Grade 3 = moderate cord compression or cord signal change Threshold for CCC: > grade 1	Han *et al.*[11]	NA
		Jagtap *et al.*[14]	NA
CCI	Aggregated scores of extent of anterior and posterior compression: Anterior compression points: 0 = no compression 1 = disc bulging, but intact CSF signal 2 = no CSF signal, but no cord compression 3 = cord compression Posterior compression points: 0 = no compression 1 = mild compression by ligament flavum, but intact CSF signal 2 = no CSF signal, but no cord compression 3 = cord compression CCI = sum of anterior + posterior compression point Grade 0 = 0 Grade 1 = 1–2 Grade 2 = 3–4 Grade 3 = 5–6 Threshold for CCC: > CCI grade 2*	Lee *et al.*[10]	Interobserver: 0.78, substantial agreement Intraobserver: 0.82, almost perfect agreement
		Yuk *et al.*[15]	NA
Modified Kang criteria	A = no stenosis B = obliteration of more than 50% of the subarachnoid space of the anterior or posterior epidural spaces without any sign of cord deformity Threshold for CCC: B	Park *et al.*[13]	Interobserver: 0.53, moderate agreement Intraobserver: 0.71, substantial agreement
Wakayama Spine Study criteria	Grade 1 = no compression of the spinal cord with subarachnoid space absent Grade 2 = compression of less than one-third of the spinal cord Grade 3 = compression of more than one-third but less than two-thirds of the spinal cord Grade 4 = compression of more than two-thirds of the spinal cord Threshold for CCC: ≥ grade 3	Smorgick *et al.*[12]	NA

*A discrepancy in reporting the threshold for grading CCC using the CCI grading was noted between Lee *et al.*[10] and Yuk *et al.*[15] The authors were contacted to respond, but given the lack of a response, this is acknowledged as a limitation in the present review.

CCC indicates cervical cord compression; CCI, Cervical Cord Compression Index; CSF, cerebrospinal fluid; NA, not available—indicating reliability analysis was not reported.

in thoracolumbar spine MRI protocols for vertebral segmentation and offer an opportunity to visualize incidental coexisting tandem pathology.[8,17] Notably, approximately one-third of CCC cases identified on WSSMRI in this review had clinical features consistent with myelopathy.

A recent systematic review and meta-analysis by Smith *et al.*[1] reported a similar prevalence of CCC utilizing dedicated cervical spine MRI. Again, image evaluation methods varied among the studies included in this review by Smith *et al.*[1] These authors included 19 studies with a total of 6755 subjects in their analysis, reporting a pooled prevalence of 13.9%. While this prevalence is similar to the 14.2% identified in our present review using WSSMRI sequences, there are notable differences between the studies that make direct comparison difficult. Firstly, Smith *et al.*[1] included 11 population-based studies (n = 3686), including asymptomatic patients undergoing cervical spine MRI without clinical indication. Our present review deliberately excluded population-based WSSMRI studies to reflect the importance of corroborating radiologic CCC with clinical findings and its use in groups with a higher established risk of tandem spinal pathology. As such, two studies that were included in the Smith and colleagues review were excluded from ours.[18,19] Secondly, only seven of the 19 studies included by Smith *et al.*[1] reported thresholds used in defining CCC, which may increase variability in determining positive and negative cases both within and between included studies. In the present study, we only included studies which documented the use of a grading scale to determine the degree of central stenosis and defined a threshold for CCC. As such, we excluded three studies that were retained by Smith and colleagues.[8,20,21] While there was variability in the grading scales and CCC thresholds used by the six included studies in the present review, our intentional consideration to only include studies using defined grading scales allowed for more robust comparisons across studies.

An important consideration is whether WSSMRI-identified CCC in the included studies represented truly incidental or previously unrecognized pathology, rather than CCC identified in patients with pre-existing cervical symptoms. The available literature does not allow this distinction to be made reliably, as baseline cervical symptoms and myelopathic features were inconsistently reported, and only two of the six studies explicitly excluded participants with clinical signs or



Figure 3. Risk of bias assessment of included studies using the modified Hoy *et al.*[9] tool.

symptoms of myelopathy.[10,13] However, among the four studies with relatively consistent prevalence estimates, there was substantial overlap between studies that explicitly excluded myelopathy (23.7%–23.9%) and those that did not report this exclusion (23.8%–25.6%). This descriptive comparison should be interpreted cautiously given the small number and heterogeneity of studies, but suggests that the similar prevalence estimates across these four studies were not confined to cohorts that permitted patients with established myelopathic features.

Symptomatic WSSMRI-identified CCC and surgical implications

The present review found that approximately one-third of patients with T2-weighted WSSMRI-identified CCC exhibited myelopathic clinical features. While this was only based on three included studies, this is an important finding given the diagnostic delays and subsequent irreversible neurological impairments faced by individuals with DCM.[22,23]

Nouri *et al.*[24] evaluated patients presenting for orthopedic and neurosurgical consultation of lumbar spine complaints for concomitant signs and symptoms of DCM. Upon identification of myelopathic features, cervical spine MRI was arranged. Their preliminary findings identified 10% of patients to have DCM.[24] While this approach reflects a comprehensive clinical evaluation of spinal cord dysfunction in a group of patients with a high pretest probability of having concomitant DCM, routine evaluation for myelopathic signs and symptoms is not necessarily standard practice in the surgical evaluation of thoracolumbar-related conditions. As such, high-grade central stenosis and CCC are likely missed in these clinical populations. CCC identified on additional T2-weighted WSSMRI sequences may serve as an important prompt for the additional clinical evaluation of myelopathic features in patients presenting for evaluation of thoracolumbar spinal complaints.

While the majority of CCC cases incidentally identified on WSSMRI sequences are asymptomatic, Smith *et al.*[1] reported that 10% of CCC cases identified on cervical spine MRI subsequently developed symptoms of DCM over a four-year follow-up period. Based on a systematic review by Wilson *et al.*,[2] 23% of individuals with asymptomatic CCC develop clinical features of DCM a median of 44 months later. As such, radiographic CCC, even in its asymptomatic form, remains a fundamental risk factor for the development of DCM. Given the subtle and insidious trajectory of early-stage and mild DCM, it is important to identify radiographic CCC and to provide patients with an explanation of its significance.[25,26] Such recognition can also inform risk stratification before tandem spinal interventions and prompt ongoing clinical surveillance.[5]

This study also aimed to evaluate the proportion of CCC cases identified by WSSMRI who proceeded to surgery. However, we were unable to answer this question definitively as there were only two studies that made mention of surgical indication. Han *et al.*[11] reported that five of the 65 CCC cases proceeded to surgery. Lee *et al.*,[10] who excluded participants with myelopathic signs and/or symptoms from their dataset, still went on to report that nearly 60% of 22 WSSMRI-identified CCC cases had sensory upper-limb disturbances and 55% had neck pain/stiffness, none of which proceeded to surgery. However, the timeframes over which cases did or did not proceed to surgery were not reported, making this data difficult to interpret.

Heterogeneity in WSSMRI acquisition and evaluation

A marked variation in the CCC prevalence was observed across the six included studies, ranging from 5.4% to 53.0%. Notably, two studies, Jagtap *et al.*[14] and Yuk *et al.*[15] were outliers, while the remaining four studies reported very similar prevalences, all between 23% and 26%.[10–13] Several potential factors can be considered to explain the two outlying findings, including image acquisition protocols, thresholds for the grading scales used to define CCC, and the study sample populations.

A critical methodological concern is the absence of documented T2-weighted WSSMRI acquisition parameters in both Jagtap *et al.*[14] and Yuk *et al.*[15] Without these acquisition details, it is difficult to evaluate image fidelity or assess the reliability of cerebrospinal fluid and cord signal interpretation, particularly in the absence of axial sequences.[8]

Grading scales used to define CCC also varied substantially. Four distinct grading scales were used across the six studies, each with different thresholds for defining CCC. This inconsistency undermines interstudy comparability and precluded quantitative synthesis via meta-analysis. For example, Yuk *et al.*[15] applied the CCI, a grading scale applying a composite of anterior and posterior cord compression with a higher diagnostic threshold than other scales. On face value, this appears more specific and could therefore underestimate the true prevalence, yet these authors still reported the highest prevalence of 53%. Despite recruiting from a Korean tertiary cohort similar to three other studies,[10,11,13] Yuk and colleagues also reported a 29% prevalence of myelomalacia, a radiologic marker of chronic spinal cord compression and apoptotic cell death.[27] The high prevalence and disproportionately high rate of myelomalacia suggest that this cohort may have been a clinically distinct population, presenting with more advanced CCC. However, these authors did not evaluate patients clinically for accompanying myelopathic signs or symptoms.

In contrast, the study by Jagtap *et al.*,[14] the largest study included in this review (n = 1555), reported the lowest prevalence (5.4%). Despite using the modified Takahashi scale, which has a relatively lower threshold for classifying CCC, the reported prevalence remained low. This study also had the lowest average participant age (48.0 yr), which is a likely contributor to the lower prevalence identified. The lack of defining features about the study cohort make further inferences difficult. Thresholds and access to MRI are known to differ in various health jurisdictions, which may also be a factor to explain this difference, as Jagtap *et al.*[14] was the only study conducted in India.

Limitations

Several limitations within the current evidence base are important to emphasize. Firstly, all six included studies had retrospective study designs. The generalizability of findings is constrained by the predominance of single-center data, all from tertiary referral institutions and all from the Asian continent, where the prevalence of DCM and radiologic cervical spondylotic features are thought to be higher than in other continents, especially with regard to ossification of the posterior longitudinal ligament.[28]

Inconsistent or incomplete reporting was also noted. In particular, the two studies employing the cervical cord compression index reported different thresholds for defining CCC, with discrepancies both between and within studies regarding the use of ">2" *versus* "≥ 2" criteria.[10,15] In addition, Smorgick *et al.*[12] did not report CCC prevalence for their full cohort (n = 1145), instead presenting a cohort classified as having "cervical spinal stenosis." Consequently, only the subset of patients from Smorgick *et al.*'s[12] study with LSS (n = 172) was included in the present synthesis. Attempts to clarify the aforementioned inconsistencies through direct correspondence with the study authors were unsuccessful, despite follow-up. Across studies, there was also a lack of consistent reporting of clinical myelopathic features, the number of cases progressing to surgery, and image acquisition parameters. The limitations of pooling studies with heterogeneous populations and WSSMRI evaluation methods are acknowledged; therefore, aggregated prevalence estimates should be interpreted with caution.

At the review level, the methods were in accordance with PRISMA guidelines. Despite this, changes were made to the originally developed review protocol, which have been highlighted in Section 2.8. These changes, including the change from single to dual-rater article screening, and changes in the selection of risk-of-bias and study quality tools to align with those used by Smith *et al.*,[1] strengthened the methodology and therefore the review findings.

Future research directions

Increasingly, neuroimaging research aims to progress the adoption of microstructural, anatomic, and quantitative MRI in the identification of biomarkers predictive of future neurological impairment and detection of subclinical spinal cord impairment.[17,29] While these approaches continue to gain traction, the identification of CCC warrants patient counseling and, in some cases, structured clinical surveillance.

Future research efforts should consider prospective study designs with standardized reporting of image acquisition parameters, alongside adoption of a grading scale with established reliability and assessment of diagnostic accuracy. Reporting of associated myelopathic signs and symptoms and a defined follow-up period to assess the percentage of WSSMRI-identified cases progressing to surgical intervention will allow for not only evaluation of the diagnostic utility, but also its impact on downstream decision-making.[30]

Conclusion

This review provides the first focused synthesis of T2-weighted WSSMRI to identify CCC in patients undergoing surgical consultation, yielding an aggregated prevalence of 14.2% (range: 5.4% to 53%). While this figure was similar to recent meta-analytic data using cervical spine MRI, aggregated prevalence estimates should be interpreted with caution given heterogeneous populations and WSSMRI evaluation methods. Importantly, almost one-third of patients with WSSMRI-identified CCC in reporting studies had clinical features of cervical myelopathy, highlighting the potential value of combining WSSMRI with clinical examination to detect both tandem spinal stenosis and degenerative cervical myelopathy. Future prospective studies should be conducted to determine the comparative performance of T2-weighted WSSMRI and cervical spine MRI.

KEY POINTS

- T2-weighted whole spine sagittal MRI sequences (WSSMRI), often used for vertebral segmentation, have the potential to opportunistically detect cord compression in the cervical spine of patients presenting for spine surgical evaluation.
- The prevalence of WSSMRI-identified cord compression among six included studies was 14.2%, similar to studies performed with dedicated cervical spine MR imaging.
- Prevalence was higher in older adults and patients with symptomatic lumbar spinal stenosis.
- Around one-third of reported cord compression cases had myelopathic clinical features.
- Prospective studies are needed to compare WSSMRI with dedicated cervical MRI.

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CRediT contributions

R.V.C.: conceptualization, project administration, methodology, investigation, data curation, formal analysis, visualization, writing—original draft preparation. A.H.S.: methodology, validation, supervision, writing—review and editing. C.R.: data curation, formal analysis, investigation, writing—review and editing. D.R.: conceptualization, methodology, supervision, visualization, writing—review and editing. S.G.W.: conceptualization, methodology, supervision, visualization, writing—review and editing.

Declaration of competing interests

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