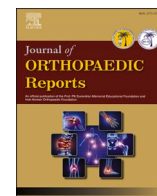




Contents lists available at ScienceDirect

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journal homepage: [www.journals.elsevier.com/journal-of-orthopaedic-reports](http://www.journals.elsevier.com/journal-of-orthopaedic-reports)

## Impact of T2-Weighted whole-spine sagittal MRI sequences on diagnostic and patient care trajectories: An illustrative case series

Rohil V. Chauhan<sup>a,b,\*</sup>, Olivia Simpson<sup>c</sup>, Anand H. Segar<sup>a,d,e</sup>, David Rice<sup>f,g</sup>, Steven G. White<sup>b</sup><sup>a</sup> Auckland Spine Surgery Centre, Auckland, New Zealand<sup>b</sup> Active Living and Rehabilitation: Aotearoa New Zealand, Health and Rehabilitation Research Institute, Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland, New Zealand<sup>c</sup> Sports and Spinal Physiotherapy, Auckland, New Zealand<sup>d</sup> Department of Orthopaedics, Auckland City Hospital, Auckland, New Zealand<sup>e</sup> Faculty of Health and Medical Sciences, The University of Auckland, Auckland, New Zealand<sup>f</sup> Health and Rehabilitation Research Institute, Auckland University of Technology, Auckland, New Zealand<sup>g</sup> Department of Anaesthesiology and Perioperative Medicine, North Shore Hospital, Auckland, New Zealand

## ARTICLE INFO

## Keywords:

MRI  
Whole spine sagittal MRI  
Diagnosis  
Musculoskeletal  
Orthopaedics  
Neurosurgery

## ABSTRACT

**Background:** T2-weighted whole-spine sagittal MRI (WSSMRI) sequences provide a rapid, comprehensive assessment of the neuroaxis and can reveal pathology beyond the symptomatic region. Despite minimal additional acquisition time, these sequences remain underutilized in specialist practice.

**Research question:** How are WSSMRI sequences used clinically to alter diagnostic and surgical decision-making?

**Material and methods:** Three non-consecutive, purposively selected patients assessed in an orthopaedic spine center for thoracolumbar complaints are presented. All patients underwent dedicated thoracolumbar MRI for their primary complaint, supplemented with T2-weighted WSSMRI sequences acquired on a Siemens Magnetom Lumina 3T scanner using digitally stitched cervicothoracic and thoracolumbar sagittal sequences, with 90 seconds image acquisition. Clinical information, imaging findings, and downstream management decisions were drawn from medical records with signed informed consent.

**Results:** In the first case, a 69-year-old male referred for lumbar radiculopathy was found to have concurrent cervical cord compression with myelomalacia, leading to surgical sequencing that prioritized cervical decompression ahead of lumbar intervention. The second case, a 52-year-old female with low back pain, revealed Chiari malformation type 1.5 with syringomyelia, prompting neurosurgical referral and ongoing clinical and radiological surveillance despite initial symptoms being attributed to lumbar pathology. The third case, a 48-year-old female with chronic post-traumatic axial thoracolumbar pain, demonstrated multilevel occult vertebral compression fractures on WSSMRI, which led to investigation and initiation of multidisciplinary osteoporosis management. In each instance, WSSMRI sequences identified pathology outside the symptomatic region and directly influenced care trajectories.

**Discussion and conclusion:** T2-weighted WSSMRI is a rapid, low-burden adjunct to routine thoracolumbar imaging that can uncover clinically significant findings and alter management. While its broader integration into practice offers clear benefits, challenges regarding incidental findings and downstream costs warrant further consideration.

## 1. Introduction

T2-weighted whole-spine sagittal magnetic resonance imaging (WSSMRI) sequences provide an adjunctive screening opportunity of the sagittal spinal and extra-spinal regions for identifying tandem pathology.<sup>1,2</sup> WSSMRI sequences are frequently acquired alongside

thoracolumbar MRI, primarily for vertebral segmentation, although previous studies have identified tandem pathology including, but not limited to, spinal cord compression, tumors and syringomyelia.<sup>1,3,4</sup>

Subject to the appropriate image fidelity, WSSMRI sequences can reveal incidental, but in some cases, clinically significant pathology beyond the region of primary concern.<sup>1</sup> The use of WSSMRI sequences in

\* Corresponding author. 96e Carlton Gore Rd, Newmarket, 1023, Auckland, New Zealand.

E-mail address: [rohil.chauhan@hotmail.com](mailto:rohil.chauhan@hotmail.com) (R.V. Chauhan).

<https://doi.org/10.1016/j.jorep.2026.100961>

Received 18 December 2025; Accepted 4 March 2026

Available online 9 March 2026

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spine surgical practice is not universal and in certain healthcare jurisdictions, particularly in the private secondary care sector, funding models limit additional radiological workup of suspected diagnoses beyond the index level. As a result, opportunities for early detection of clinically important findings may be missed, potentially delaying definitive management.<sup>1,2</sup>

While prior studies have examined the prevalence of WSSMRI-identified incidental findings in select patient groups,<sup>3,4</sup> there is limited literature demonstrating clinical cases where T2-weighted WSSMRI sequences have directly influenced diagnostic and management decision-making, thereby influencing the trajectory of care.

In this paper, we present three purposively selected, non-consecutive clinical cases of tandem spinal pathology in which WSSMRI, obtained alongside routine thoracolumbar MRI, facilitated expeditious changes in care pathways.

## 2. Material and methods

### 2.1. Study design

An uncontrolled illustrative case series design is used. We present three purposively, non-consecutive patients assessed in a multidisciplinary, secondary care, specialist spine center. Each case, albeit briefly, is presented in accordance with the CARE (CAse REport) guidelines for case reports and case series, and recommendations for reporting uncontrolled case series have been followed.<sup>5</sup>

### 2.2. Case selection

Three non-consecutive clinical cases were purposively selected from routine clinical practice (secondary care orthopaedic spine centre). Selection was based on their ability to demonstrate the diagnostic and clinical impact of T2-weighted WSSMRI sequences when performed alongside region-specific thoracolumbar MRI. These cases are not intended to represent a consecutive cohort but were chosen to illustrate distinct scenarios in which WSSMRI identified clinically meaningful tandem spinal pathology and subsequently altered patient management.

Signed informed consent was obtained from all patients for use of de-identified clinical details and medical imaging.

### 2.3. Data collection

Clinical presentation, examination findings, initial working diagnosis, and final diagnosis were obtained from electronic medical records. Imaging findings were extracted from consultation reports and the online Picture Archiving and Communication System (PACS). Changes to diagnostic and clinical care pathways were identified from the patient record, including alterations in surgical plan, onward referrals or additional investigations prompted by WSSMRI findings.

### 2.4. T2-weighted whole spine sagittal MRI protocol

For all three cases, T2-weighted WSSMRI sequences were acquired using a Siemens Lumina 3-T MRI scanner (Siemens Healthineers, Erlangen, Germany) with Deep Resolve artificial intelligence image enhancement.

Imaging was performed using the spinal mat coil in combination with the posterior portion of the head coil, with the anterior head coil component omitted. Scans were obtained with a 3 mm slice thickness, 0.6 mm inter-slice gap, 420 mm field of view, and a 336 acquisition matrix (up sampled to 672 via Deep Resolve).

Acquisition was performed in two stations: the top station, covering the cervical to upper thoracic spine, comprised 17 slices with TE 93 ms, TR 3350 ms, and an acquisition time of 38 seconds; the bottom station, covering the lower thoracic to lumbar spine, comprised 17 slices with TE 93 ms, TR 3050 ms, and an acquisition time of 43 seconds. The two

stations were automatically stitched into a single continuous sagittal dataset.

Scan planning was guided by two rapid (~20 second) gradient-echo localisers—one high (cervical/thoracic) and one low (thoracic/lumbar)—used for anatomical coverage and alignment. While these localisers were adequate for vertebral counting, their diagnostic quality was poor, prompting the acquisition of the high-resolution T2-weighted sequences. Including localiser sequences and scan planning, the complete whole-spine T2 acquisition required approximately two to two-and-a-half minutes per patient.

## 3. Case one - Degenerative cervical myelopathy

### 3.1. Presentation

A 69-year-old Indian male presented with a 5-month history of right-sided radicular leg pain following a fall. The pain radiated in an S1 distribution down the posterior thigh, calf, and lateral foot, worsening with prolonged standing and walking. Despite analgesics and physiotherapy management, he reported only 30% improvement since onset.

His medical history included medication-controlled hypertension and hypercholesterolemia, with no prior surgical history. He was a lifetime non-smoker and walked daily for exercise. Upon review of systems, he reported premonitory bilateral hand fingertip numbness and paresthesias, and mild balance disturbance, but with no history of falls.

### 3.2. Examination

Examination revealed a pain-free lumbar range of motion, reduced light touch sensation over the right lateral foot, and a positive right straight leg raise to 45°. Upper motor neuron signs revealed a difficulty to perform tandem gait (5-step), globally hyperreflexic deep tendon reflexes (3+) and a positive Hoffman sign bilaterally.

### 3.3. Diagnosis

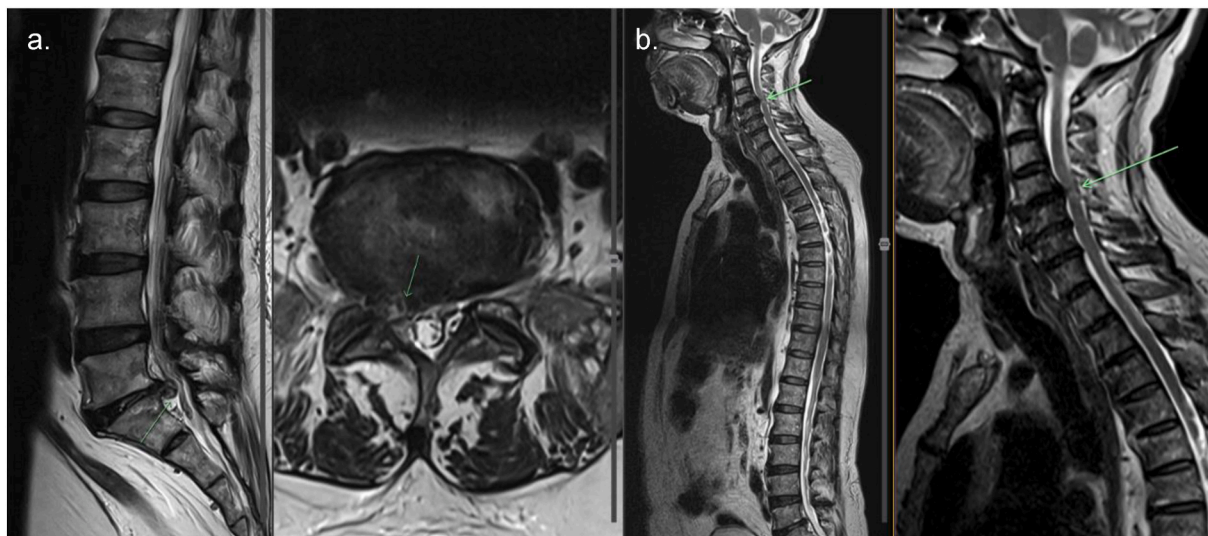
MRI of his lumbar spine revealed a large right paracentral disc extrusion at L5/S1 compressing the right S1 nerve root (Fig. 1a). Further careful review of the accompanying T2-weighted WSSMRI sequence revealed C4/5 spinal cord compression with myelomalacia (Fig. 1b).

### 3.4. Treatment

The patient was informed of all management options for his leg-dominant symptoms, including further conservative management, CT-guided nerve root steroid injection for pain management, or surgical decompression. Given the persisting symptoms, the patient preference was for surgical decompression, although given the concomitant spinal cord compression with associated myelopathic features, further evaluation and management of his cervical spine was deemed more emergent. The patient was referred for a dedicated cervical spine MRI and for surgical workup at the public hospital.

### 3.5. Outcome

Upon orthopaedic consultation four months following referral, the patient's myelopathic symptoms were stable with a modified Japanese Orthopaedic Association (mJOA) score of 14, and cervical spine MRI confirmed C4/5 compression and myelomalacia, with moderate degrees of central stenosis at C5/6 and C6/7. The patient subsequently underwent an uncomplicated C3-7 laminoplasty with a stable 3-month post-operative outcome. Unsupervised range of motion, cervicothoracic muscle strengthening and balance exercises were prescribed by a physiotherapist at 3-months postop, and the radicular right leg pain was largely intermittent at this point and self-managed, without the need for further medical input.



**Fig. 1. Lumbosacral MRI alongside WSSMRI revealing tandem cord pathology**

**Fig. 1.** (a) T2-weighted sagittal and axial lumbar spine MRI revealing a right-sided L5/S1 disc extrusion compressing the right S1 nerve in the subarticular recess (green arrows); (b) T2-weighted WSSMRI sequence alongside a magnified mid-sagittal slice revealing spinal cord compression at C4/5 with evidence of myelomalacia. This image is published with the patient/participant's consent.

#### 4. Case two - Chiari malformation with syringomyelia

##### 4.1. Presentation

A 52-year-old New Zealand Māori female presented with a four-month history of persistent, first-time axial lower back pain following a fall. Her pain was aggravated by forward bending and walking for more than 5 min, making her occupational duties as a stock shelve difficult to perform. She reported no sustained improvements from 4-months of prior physiotherapy input.

Her past medical history included medication-controlled gout, type 2 diabetes mellitus, chronic fatigue syndrome, depression, obstructive sleep apnoea, and fibromyalgia. Current analgesics included amitriptyline, tramadol, and pregabalin. On review of systems, she described a progressive decline in walking speed, capacity, and coordination over the preceding two to three years, associated with five unexplained falls over the past year and frequent reliance on walls for support at home. Additional complaints included a one-year history of persistent axial neck pain, recurrent headaches, blurred vision, memory difficulties, bilateral hand weakness and episodic breathlessness.

##### 4.2. Examination

The patient demonstrated an unsteady, spastic-like gait with a marked sway on Romberg's test and inability to perform tandem gait safely. She had full lumbar range of motion with terminal range pain and generalised bilateral paraspinal palpatory tenderness. Cervical range of motion was full and pain-free. Manual muscle testing revealed non-myotomal weakness of the right upper and lower limbs (3+/5) and generalised reduced strength on the left side (4/5). Reflexes, Babinski, Hoffman's, and inverted supinator signs were all unremarkable, and no clonus was elicited.

##### 4.3. Investigations and diagnosis

Plain radiographs and MRI of the lumbar spine revealed normal sagittal alignment and largely unremarkable appearances of the lumbar discs and facet joints. As such, there was no specific identifiable lumbar spinal pathology to explain the persistent axial lower back pain. Importantly, T2-weighted WSSMRI sequences performed alongside the lumbar MRI revealed cerebellar tonsillar ectopia consistent with Chiari

malformation and an associated cervicothoracic syrinx (Fig. 2a).

##### 4.4. Treatment and outcome

The patient was reassured that her lower back pain did not warrant surgical intervention and was referred for a physiotherapist-led rehabilitation program. Furthermore, she was referred to a tertiary hospital neurosurgical service for further evaluation of the WSSMRI-identified Chiari malformation.

The consulting neurosurgeon arranged for further dedicated imaging of the cervical spine and brain (see Fig. 2c and d above) confirming the Chiari malformation type 1.5 with a stable appearance of the cervicothoracic syrinx. Given the radiologic stability, symptom stability and the patient's preference, a non-interventional approach was adopted with structured serial observation. Follow up consultation with a repeat MRI was performed six months later, without any change to the treatment plan given the stable imaging findings. At present, the patient continues under six monthly clinical and radiological surveillance.

#### 5. Case three - Multilevel occult osteoporotic thoracolumbar vertebral fractures

##### 5.1. Presentation

A 48-year-old Caucasian female presented with a one-year history of persistent midline lumbar pain and stiffness following a high-speed (30 km/hr), front-on motor vehicle collision. Post-accident, she presented acutely to the local emergency department, with plain radiographs revealing vertebral endplate fractures to L3, L4 and L5 vertebrae and a rib fracture. Given the lack of improvement in pain at the one-year mark with GP-administered analgesics and general stay-active advice, she was referred to the spine center for evaluation.

On further evaluation, she also reported widespread axial midline pain and stiffness in the thoracic spine, bilateral pedal paraesthesia dorsally and poor balance, with difficulty with supine lying for prolonged periods, prolonged walking or carrying heavy objects. Her prior medical history included medication-controlled hypertension and hypothyroidism, a maternal family history of osteoporosis, and she was a current nicotine vaper.



**Fig. 2. WSSMRI and brain imaging revealing Chiari malformation and syringomyelia**

**Fig. 2.** (a) T2-weighted WSSMRI sequence with cerebellar tonsillar ectopia (green arrow); (b) Magnified mid-sagittal WSSMRI sequence revealing a cervicothoracic syrinx (green arrow); (c) T2-weighted axial T3 syrinx measuring 0.73cm (AP) x 0.47cm with a ratio (1:2) of 1.56; (d) T1-weighted sagittal brain MRI sequence revealing up to 16mm tonsillar descent with inferior medullary descent through the foramen magnum (green arrows). This image is published with the patient/participant's consent.

### 5.2. Examination

On examination, 5-step tandem gait and Romberg signs were both intact. An increased thoracic kyphosis was observed in standing, with a marked multi-directional loss of thoracic and lumbar range of motion,

reproducing familiar midline thoracolumbar back pain. There was midline palpatory tenderness in the mid to lower lumbar spine. Neurologically, she had intact motor strength and intact and symmetrical deep tendon reflexes (2+) in bilateral lower limbs, with bilateral pedal light touch sensation loss dorsally, and intact sharp-blunt sensory



**Fig. 3. WSSMRI sequences revealing multilevel spinal vertebral compression fractures**

**Fig. 3 -** (a) T2-weighted WSSMRI sequence revealing upper thoracic compression fractures (green arrows); (b) magnified WSSMRI further detailing mature wedge compression fractures between T3-T5, maximal at T4 with greater than approximately 60% loss of vertebral body height anteriorly and 40% loss posteriorly (topmost green arrow); (c) T2-weighted sagittal lumbar spine MRI revealing multilevel L3-L5 superior vertebral endplate collapse secondary to Schmorl's nodes (green arrows). This image is published with the patient/participant's consent.

discrimination.

### 5.3. Investigations and diagnosis

Upon review of prior lumbar spinal imaging, T2-weighted WSSMRI sequences revealed previously unreported multi-level upper thoracic wedge fractures (Fig. 3a) and previously identified L3-L5 superior endplate fractures (Fig. 3b). Maximum loss of height was at T4, with approximately 60% loss of height anteriorly and 40% posteriorly. Dual-energy X-ray absorptiometry (DEXA) was subsequently arranged, demonstrating osteoporosis, with a lumbar spine T-score of  $-2.6$  and osteopenia at the hip (T-score  $-2.0$ ). The reporting endocrinologist estimated, without treatment, the patient had a 10-year fracture risk of 15–20%.

### 5.4. Treatment

Multimodal pharmacologic and non-pharmacologic osteoporosis management was initiated, including annual zoledronic acid infusions, calcium and vitamin D supplementation and targeted exercise rehabilitation. Rehabilitation included a physiotherapist-guided program of weight-bearing strengthening, balance exercises and hydrotherapy. She was also referred to a dietician for nutritional support and a musculoskeletal pain physician for pain management.

### 5.5. Outcome

Over the course of six months of rehabilitation, the patient regained significant global and trunk strength, improved spinal range of motion, was much more physically active, and had less pain-related disability. Her thoracic and lumbar pain continued to be present but diminished in severity. The patient plans to continue weight-bearing gym work, has improved her diet, and will have regular monitoring of her osteoporosis to decrease her long-term risk of future osteoporotic fractures.

## 6. Discussion

This illustrative case series demonstrates the diagnostic and clinical impact of incorporating T2-weighted WSSMRI sequences as an adjunct to region-specific spinal imaging. Across three distinct clinical cases, WSSMRI revealed pathology outside the index region of concern that fundamentally altered clinical decision-making and patient trajectories. While WSSMRI sequences are typically not diagnostic as standalone imaging, these cases and previous imaging studies demonstrate the opportunistic value it provides in identifying clinically meaningful spinal and extra-spinal pathology, in tandem with dedicated imaging of the thoracolumbar spine.<sup>1,3</sup>

Although WSSMRI sequences can be obtained within minutes, require no contrast, and impose minimal additional burden on image acquisition protocols, their adoption remains inconsistent.<sup>6</sup> Spinal imaging, at least in the first instance, is often confined to the symptomatic region, an approach that risks missing coexisting spinal pathology or alternative explanations for complex or non-concordant clinical symptomatology. The three cases presented in this paper demonstrate the potential to influence clinical and diagnostic decision-making through corroboration of findings from a comprehensive clinical evaluation with WSSMRI findings. In turn, this may facilitate appropriate referral, influence surgical sequencing and alter clinical management.

In case one, in the context of persistent unilateral radiculopathy requiring surgical intervention, WSSMRI-identified cervical cord compression alongside myelopathic clinical features, directly influencing surgical sequencing. Surgical decompression for cervical myelopathy was appropriately prioritized ahead of any lumbar spinal decompression. Early recognition and management of symptomatic spinal cord compression is critical to reduce the neurofunctional burden and disability associated with delayed surgery<sup>7-9</sup>. In case two, although

the consulting neurosurgeon did not attribute the entirety of the patient's symptoms to Chiari malformation and syringomyelia, onward referral and structured surveillance were undertaken, with repeat cervical and brain imaging alongside six-monthly review to monitor interval changes in tonsillar descent and syrinx morphology. In the final case, the evaluation of WSSMRI sequences in a case of post-traumatic axial spinal pain revealed multilevel occult vertebral compression fractures. This triggered investigation for osteoporosis, leading to implementation of pharmacologic and lifestyle interventions, in line with best practice guidelines<sup>10,11</sup>. Collectively, these cases demonstrate the diverse ways in which WSSMRI sequences may influence diagnostic and/or surgical-based reasoning and prompt proactive clinical care.

Several studies have demonstrated the added value of T2-weighted WSSMRI, particularly in the context of tandem spinal stenosis and myelopathy. Reported prevalence rates of concomitant cervical cord compression among patients undergoing thoracolumbar surgical evaluation range from 23% to 53%.<sup>3,12</sup> In the post-traumatic setting, WSSMRI successfully identifies secondary vertebral compression or burst fractures in up to 35% of cases.<sup>13</sup> The present cases provide real-world examples of how WSSMRI sequences can be used in surgical practice.

Medicolegal considerations merit consideration in the decision to adopt WSSMRI in spinal imaging protocols. In an era where delayed or missed diagnoses are increasingly subject to litigation, the omission of WSSMRI sequences in patients presenting with red-flag features or atypical neurological symptoms may carry risk; equally when information is provided clinically, but not acted upon.<sup>14</sup> When pathology beyond the symptomatic region is subsequently uncovered, questions may arise as to whether earlier use of a rapid, readily available WSSMRI sequence could have altered outcomes. Establishing clear protocols for when to incorporate these sequences, which are currently absent, may therefore mitigate medicolegal concerns by demonstrating adherence to a robust standard of care.

Conversely, routine adoption of whole spine imaging carries its own challenges. By surveying the entire neuroaxis, such sequences inevitably increase the detection of incidental findings, many of which may be clinically irrelevant.<sup>1,15</sup> These findings create further demands for evaluation, reporting, and follow-up, potentially driving patient anxiety, unnecessary additional imaging, invasive investigations, and downstream costs.<sup>16</sup> In some instances, this cascade can lead to harmful overtreatment, or procedures of limited value.<sup>17</sup> The medicolegal risk is therefore three-fold: not only from failing to image broadly where warranted, but also from 1) over-investigating, 2) acting unnecessarily on incidental abnormalities or 3) missing the clinical significance of incidental findings.<sup>18</sup> Striking the right balance requires both clinical judgment and evidence-based recommendations to clarify when the benefits of screening using whole spine imaging, such as WSSMRI, outweigh its potential harms.<sup>18</sup>

Several limitations are recognized in the present paper. The present series is illustrative rather than epidemiological. Cases were purposively selected for their educational value, and therefore no inference can be made regarding the prevalence or frequency of incidental findings on whole spine imaging. Nor does this case series evaluate the reliability or accuracy of T2-weighted WSSMRI sequences compared with conventional imaging. These limitations notwithstanding, the cases serve to demonstrate examples where tandem spinal pathology can be detected, and the impact such detection can have on clinical decision-making.

Future studies should move beyond illustrative examples to evaluate the diagnostic yield, potential unintended consequences of routine WSSMRI sequences and health-economic impact. Prospective research, ideally in multi-center settings, will be required to determine whether systematic incorporation of these sequences improves patient outcomes and justifies their widespread adoption.

## 7. Conclusion

This illustrative case series demonstrates that T2-weighted WSMRI sequences, when performed alongside thoracolumbar imaging, have the potential to reveal clinically significant pathology outside the index region and meaningfully alter patient care trajectories. While its broader adoption has the potential to reduce missed diagnoses and optimize surgical planning, challenges related to the evaluation and management of incidental findings are important to consider. Further studies are needed to develop guidelines for widespread adoption to maximize clinical benefit while minimizing patient harm, unnecessary follow-up investigations and downstream costs.

## Informed consent

Signed informed consent was gained from all participants in the present case series for use of deidentified clinical information and medical imaging.

## CRedit Contributions

RVC – Conceptualization, Data curation, Investigation, Visualization, Writing – original draft preparation.

OS – Conceptualization, Investigation, Writing – reviewing and editing.

AHS – Resources, Validation, Writing – reviewing and editing.

DR – Writing – reviewing and editing.

SGW – Writing – reviewing and editing.

## Ethical statement

Formal IRB review was not required as cases were individual case reports whereby informed patient consent was gained for use of patient histories and medical imaging in a deidentified manner.

## Funding

This research was supported, in part, by a contract from the Health Research Council of New Zealand.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

The authors have no acknowledgments to note.

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