Flipping the mJOA: Clinical utility of the modified Japanese Orthopaedic Association score as a tool for detecting degenerative cervical myelopathy

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ABSTRACT

Introduction: People with Degenerative Cervical Myelopathy (DCM) often experience diagnostic delay. This could lead to poorer outcomes, including disability.

Research question: Does the modified Japanese Orthopaedic Association scale (mJOA) have clinical utility as an early detection tool for possible DCM?

Materials and methods: This is a prospective study of consecutive adult patients, referred to a National Neurosurgical Centre with a neck problem. Assessing clinicians undertook standard clinical examination and calculated the mJOA score. A consultant radiologist independently reported radiological findings, after which the assessing clinician determined the diagnosis. The sensitivity and specificity of mJOA for DCM at various cut-points was statistically analysed using Receiver Operating Characteristics (ROC) curves.

Results: Of 201 patients (98 male, mean age 52.6 ± 13y) assessed over 13 months, 21 were diagnosed with DCM (prevalence 10.4%). Fifteen (71.4%) had a mJOA score classifying disease severity as mild, 4/21 (19%) had moderate disease and two (9.5%) had severe disease. A mJOA score ≤ 17 (cutpoint ≥ 1) showed sensitivity of 95% and specificity of 71% for the clinical diagnosis of DCM. mJOA score ≤ 16 (cutpoint ≥ 2) had sensitivity of 62% and specificity of 90%. The ROC area under the curve was 0.885 (95% confidence interval: 0.82 to 0.95). 87% of patients were correctly classified.

Discussion and conclusion: mJOA score ≤ 16 is 90% specific for a subsequent diagnosis of DCM in people with neck problems and has potential to be used as an early detection tool. Further research is needed to replicate these findings and establish feasibility and acceptability in primary care.

1. Introduction

Degenerative cervical myelopathy (DCM) is the most prevalent cause of non-traumatic spinal cord injury in adults (Kalsi-Ryan et al., 2013). DCM represents a collection of pathological entities including spondylosis, degenerative disc disease, ossification of the posterior longitudinal ligament (OPLL), and ossification of the ligamentum flavum which individually, or in combination, cause compression of the cervical spinal cord. This leads to clinical features of gait imbalance, loss of hand dexterity and sphincter dysfunction [(Tetreault et al., 2015), [(Nouri et al., 2015), (Davies et al., 2018). Historically, the prevalence of DCM has been underestimated and may be as high as 2.3% for the entire population based on extrapolated under-diagnosis and MRI findings

(Davies et al., 2022). The prevalence is likely to rise as the population ages. DCM can progress to irreversible neurological impairment, significant disability, and poor quality of life [(Oh et al., 2017), (Pope et al., 2020). Early identification and diagnosis is critical to limit the onset of long-term disability.

Many people with DCM experience significant diagnostic delay. This is typically around 1–2 years, based on respondents' recall of their journey to diagnosis in a cross-sectional internet-based survey, in which DCM was self-reported (Pope et al., 2020). Another similarly-designed study reported a mean time to diagnosis of 46.4 months, with just 20% of respondents recalling a diagnosis within six months of symptom onset (Munro et al., 2023). The extent of this delay is corroborated by retrospective analysis of patient records. Behrbalk and colleagues

identified a delay of 2.2 years from first report of symptom onset to diagnosis, albeit with wide variation, in 42 people with clinically-confirmed DCM. On average, it took five visits to a physician before the diagnosis was made (Behrbalk et al., 2013). These delays are concerning. People with moderate and severe DCM will be recommended to have decompressive surgery, which has been shown to improve or stabilise neurological function, disability and quality of life (Fehlings et al., 2017). Surgery is generally considered to be time-sensitive, as shorter duration of symptoms may be associated with better outcomes following surgery (Tetreault et al., 2019), though the extent of this varies between studies and may depend on how outcomes are measured and analysed (Evaniew et al., 2020) and which symptoms present first (Özkan et al., 2022). Irrespective of a clearly-defined "window" for optimal recovery with surgery, a timely diagnosis is desirable from the point of view of understanding symptoms, monitoring change over time, and informing future management.

The reasons for diagnostic delay are multifaceted. A recent narrative review points to low awareness of DCM (Davies et al., 2022). The diagnosis relies on triangulation of patient-reported symptoms with clinical findings of upper motor neuron signs and MRI evidence of cord compression, but clinical signs can be subtle and non-specific (Jiang et al., 2023) and MRI evidence alone is not definitive for clinical DCM due to the high incidence of non-myelopathic spinal cord compression in healthy individuals (Nouri et al., 2022). Many people with DCM present with non-conventional symptoms (Munro et al., 2023) which could divert investigations away from myelopathy as a potential diagnosis. Current diagnostic criteria do not clearly predict, or necessarily detect, when patients have reached the threshold for irreversible spinal cord dysfunction. There is a need for clinical tools to improve early detection, particularly in primary care where most patients first present (Behrbalk et al., 2013).

The modified Japanese Orthopaedic Association scale (mJOA) (Benzel et al., 1991) is a well-established outcome measure for DCM (Kato et al., 2015). It categorises severity of DCM based on established thresholds (Tetreault et al., 2017). It is typically used after a diagnosis of DCM has been confirmed and as an outcome measure for change over time, using the Recovery Rate formula proposed by Hirabayashi (Hirabayashi et al., 1981). It is scored from 0 to 18 with 18 indicating no loss of neurological function and 0, complete loss of function. To our knowledge, it has not been used as an early detection tool. However, it shows face validity for this purpose. It is quick to administer and captures, in a single score, the symptoms that raise suspicion of DCM. Capturing patient-reported symptoms of myelopathy is particularly important given that DCM can present without clinical neurological signs (Jiang et al., 2023). It could assist with clinical decision-making at first assessment by synthesising the key points from subjective assessment into a single score for onward referral to specialist spine care, including potential fast-track for urgent surgical review of people with moderate and severe DCM and/or monitor for any progressive deterioration in function in patients who require follow up review. We therefore asked the question, could the mJOA, applied at initial clinical assessment, be a useful screening tool of possible DCM in people seeking tertiary care for neck problems?

The aim of this study is to explore the clinical utility of the mJOA as an indicator of possible DCM in clinical assessment of people with a neck problem.

The objectives were 1) to explore agreement between the initial mJOA score and clinical diagnosis of DCM, 2) to determine the sensitivity and specificity of mJOA in distinguishing DCM from non-DCM diagnostic categories.

2. Methods

This was a prospective cohort study of adults attending a National Neurosurgical Centre with new referral for a neck problem, who were assessed at their first appointment by a clinical specialist physiotherapist. Ethical approval was granted by the hospital Research Ethics Committee. Patients were eligible for inclusion if they were 1) aged over 18 years, 2) referred to the clinic with a neck problem from primary care or another specialty, and 3) had up-to-date Magnetic Resonance Imaging (MRI) of the cervical spine at the time of data extraction. Patients were excluded if they had another known neurological condition that could confound neurological assessment, previous cervical spine surgery, or contraindication to MRI. As the study was exploratory and the expected incidence of DCM was unknown in this cohort, we did not calculate a sample size *a priori* but instead defined the data collection to a 12-month timeframe. This intended to allow pragmatic evaluation of the clinical utility in the target population.

The assessing clinician undertook standard clinical examination. The mJOA score was calculated contemporaneously from the clinical examination, without reference to the radiological findings. In our centre, outcome measures are conducted as standard practice at first assessment and the mJOA is one of these. MRI scans were independently reported by a consultant radiologist. The assessing clinician then determined one of the following diagnostic categories: mechanical neck pain, cervical radicular arm pain, cervical radiculopathy, DCM, or other diagnosis. DCM was diagnosed using recommended objective criteria, specifically, one clinical symptom, one objective sign, and radiological evidence of spinal cord compression on imaging (Fehlings et al., 2013). People with a diagnosis of DCM were then classified in severity using established criteria based on the mJOA (Tetreault et al., 2017). Data were extracted by an independent research assistant who reviewed all patient records for eligibility.

2.1. Statistical analysis

Statistical analysis was conducted in Stata 17 SE (StataCorp, Texas, USA). Descriptive statistics (means, frequencies) reported the findings of clinical assessment and the prevalence of each diagnostic category. Evidence of an association between the mJOA score and the diagnostic category of DCM was explored using logistic regression. The validity of mJOA as a screening tool was evaluated by calculating its Receiver Operating Characteristics and associated sensitivity and specificity, using the "roctab" command in Stata. The diagnostic category was dichotomised into "DCM" and "not DCM" as the reference variable. The assumptions of the statistical model stipulate that higher values of the classifier variable (mJOA) must indicate higher risk of the reference variable (DCM diagnosis), so to satisfy these assumptions, mJOA was reverse-coded with the maximum score of 18 recoded to 0, 17 to 1 and so forth. The reverse-coded mJOA was then inputted as the classifier variable.

3. Results

3.1. Participants

Between November 01, 2020 and November 30, 2021, 201 consecutive patients (98 male) met the eligibility criteria and were included in this analysis. The mean age was 52.6 years (SD 13.0y, range, 19-82y). Primary care physicians referred 183 patients (91%). The remaining patients were referred by consultants in other specialties. The median duration of symptoms from subjectively reported onset to date of assessment in the clinic was 12 months (range 1–23 months). Pain was the most prevalent presenting problem, reported by 170/201 (85%), followed by arm pain (reported by 62%), non-dermatomal sensory disturbance (29%) and upper limb weakness (19%).

3.2. Diagnostic categories and prevalence of DCM

Table 1 shows prevalence of diagnostic categories. The most common diagnostic category was radicular arm pain (n = 86, 43%), followed by mechanical neck pain (n = 67, 33%) and cervical radiculopathy (n =

Table 1
Frequency of diagnostic categories and mJOA scores.

mJOA score	Mechanical neck pain		Cervical radicular arm pain		Cervical radiculopathy		Other		All non-DCM diagnoses		Degenerative cervical myelopathy		All Patients	
	N	%	N	%	N	%	N	%	**N**	**%**	**N**	**%**	N	%
≤9	0	0	0	0	0	0	0	0	**0**	**0**	**0**	**0**	0	0
10	0	0	0	0	0	0	0	0	**0**	**0**	**1**	**4.8**	1	0.5
11	0	0	0	0	0	3.8	0	0	**0**	**0**	**1**	**4.8**	1	0.5
13	0	0	0	0	1	0	0	0	**1**	**0.6**	**1**	**4.8**	2	1.0
14	0	0	0	0	0	11.5	0	0	**0**	**0**	**3**	**14.3**	3	1.5
15	3	4.5	1	1.2	3	7.7	0	0	**7**	**3.9**	**3**	**14.3**	10	5.0
16	6	9.0	2	2.3	2	34.6	0	0	**10**	**5.6**	**4**	**19.0**	14	7.0
17	10	14.9	16	18.6	9	42.3	0	0	**35**	**19.4**	**7**	**33.3**	42	20.9
18	48	71.6	67	77.9	11	100	1	100	**127**	**70.6**	**1**	**4.8**	128	63.7
Total	67	100	86	100	26	0	1	100	**180**	**100**	**21**	**100.0**	201	100.0

26, 13%). Using the standard diagnostic criteria, 21 patients had DCM, giving an overall prevalence of 10.5%. One patient had another diagnosis. Of the 21 patients diagnosed with DCM, 15/21 (71.4%) had a mJOA score classifying disease severity as mild, 4/21 (19%) had moderate disease and two (9.5%) had severe disease.

3.3. Modified Japanese Orthopaedic association scores

Table 1 cross-tabulated the frequency of mJOA scores for each diagnostic category. Of 180 patients who did not have DCM, 127 (70.6%) were recorded as having the maximum score of 18 on the mJOA, indicating no loss of neurological function. Thirty-five (19.4%) scored 17, indicating mild loss of function in one category, and 10 (5.6%) scored 16. A further eight (4.5%) scored 15 or lower.

Of the 21 patients who had DCM, 15 (71.4%) had a mJOA score classifying disease severity as mild: one (4.8%) had a score of 18, seven (33%) scored 17, four (19%) scored 16 and three (14%) scored 15. Four of 21 patients with DCM (19%) had moderate disease (mJOA scores 12–14) and two (9.5%) had severe disease (mJOA score <12).

As expected, logistic regression showed that the diagnosis of DCM was strongly associated with the mJOA score (odds ratio 3.0, 95% confidence interval 2.0–4.6, p < 0.001). This indicated that it was appropriate to proceed to receiver operating characteristics (ROC) analyses.

3.4. Receiver operating characteristics analysis

ROC analyses were conducted using the non-parametric "roctab" command in Stata. The variable mJOA was reverse-coded with 18 recoded to 0, 17 to 1 and so forth, so that higher values indicated higher risk. Table 2 shows the results. A mJOA score of ≤17 (cutpoint ≥1) had a sensitivity of 95% and a specificity of 71% for the clinical diagnosis of DCM. 73% of patients were correctly classified as having DCM or not.

The 54/201 patients (27%) who were incorrectly classified as potentially having DCM at this cut-score included 15 of 26 (58%) who had cervical radiculopathy, 19 of the 67 (28%) who had mechanical neck pain, and 19 of 86 (22%) who had cervical radicular arm pain. A cut-score of 17 misclassified one patient of 21 (5%) who had DCM (but who scored 18 on mJOA).

A mJOA score of ≤16 (cutpoint ≥2) had a sensitivity of 62% and a specificity of 90%. 87% of patients were correctly classified as having DCM or not. The ROC area under the curve was 0.885 (95% confidence interval: 0.82 to 0.95), shown in Fig. 1. The 26 patients who were incorrectly classified included six of 26 (23%) with cervical radiculopathy, three of 86 (3.5%) with radicular arm pain, and nine of 67(13.4%) with mechanical neck pain, who were all screened as having DCM. A cut-score of 16 misclassified eight of 21 (38%) people who had clinical DCM but scored 17 or 18 on the mJOA.

4. Discussion

Diagnostic delay is an established problem in DCM and there is an urgent need for earlier detection. A validated screening tool could be useful as both an educational resource for healthcare professionals (by flagging the symptoms to ask about) and a clinical "fast track", by supporting identification of people who present with symptoms of possible DCM. Rather than developing a new tool from scratch, we "flipped" the mJOA from its established use as a measure of severity of confirmed DCM by applying it at first assessment, before diagnosis, with the aim of exploring whether it could be useful in screening for eventual DCM. Overall, we found that the mJOA showed promise as a clinically useful tool for early detection. This study's strengths include its prospective assessment, sample size and inclusion of people with a wide spectrum of neck complaints, from mechanical neck pain to DCM, which affected about one in 10 patients. This study was conducted in a national neurosurgical centre and regional spine care service by healthcare
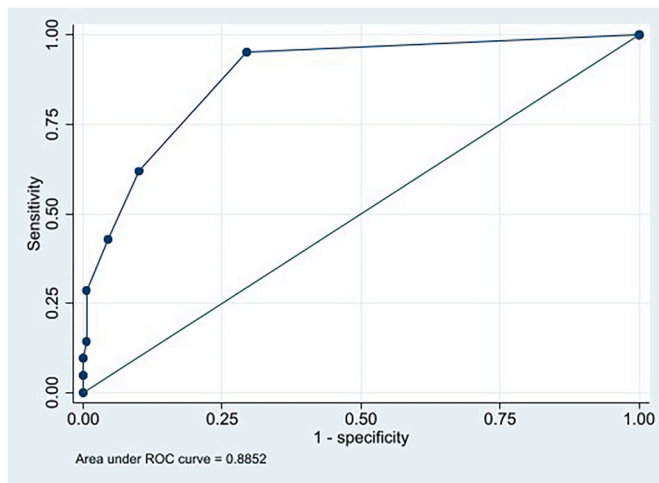
Table 2
Detailed report of sensitivity and specificity of the mJOA scale at each possible cutpoint for the eventual diagnosis of degenerative cervical myelopathy.

mJOA score	Cutpoint	Sensitivity	Specificity	Correctly classified	Positive likelihood ratio	Negative likelihood ratio
18	(≥ 0)	100.00%	0.00%	10.45%	1	
17	(≥ 1)	95.24%	70.56%	73.13%	3.2345	0.0675
16	(≥ 2)	61.90%	90.00%	87.06%	6.1905	0.4233
15	(≥ 3)	42.86%	95.56%	90.05%	9.6429	0.598
14	(≥ 4)	28.57%	99.44%	92.04%	51.4284	0.7183
13	(≥ 5)	14.29%	99.44%	90.55%	25.7142	0.8619
12	(≥ 7)	9.52%	100.00%	90.55%		0.9048
11	(≥ 8)	4.76%	100.00%	90.05%		0.9524
10	(>8)	0.00%	100.00%	89.55%		1

	Obs	ROC area	Std. error	Asymptotic normal (95% confidence interval)	
	201	0.8852	0.0347	0.81719	0.95318

Abbreviations: Obs = number of observations; ROC = receiver operating characteristics.

Fig. 1. Receiver operating characteristics (ROC) curve showing sensitivity and specificity of mJOA to classify patients as having DCM or no DCM. The reference variable (DCM Diagnosis) was determined by the assessing clinician and independent radiology report, following the criteria of at least one symptom and at least one sign of upper motor neuron pathology and radiological evidence of cord compression.

professionals who were specialised in spine care, and will need to be replicated in other settings.

The findings support future study of the feasibility of applying the mJOA in primary care as an aid for early identification for DCM and to monitor for any subsequent neurological deterioration. This could serve a number of purposes. Firstly, it collates the signs and symptoms into one checklist, raising awareness of the clinical picture of DCM. Awareness of DCM is considered to be low in primary care (Behrbalk et al., 2013), partly due to the legacy view that it is a rare disease (Davies et al., 2018) and also because it is not routinely screened as a "red flag" when clinicians assess people with neck pain for serious pathology (McCartney et al., 2018). DCM affects the ageing spine and in older people, mild loss of balance, for example, might not stand out as an indicator of potential spinal cord compression unless considered within the context of other signs and symptoms, which the mJOA prompts. Second, in assessing a number of domains of neurological function, it could distinguish DCM from its common mimics including carpal tunnel syndrome and osteoarthritis of the hand. Third, it allows for clear communication as a single score, giving conviction to the assessment findings and potentially prompting onward urgency of referral. Finally, it could act as an adjunct to standard neurological clinical examination, where key signs can be difficult to detect or show low sensitivity (McCartney et al., 2018).

One condition that also presents with gradual onset of initially non-specific symptoms, is Amyotrophic Lateral Sclerosis/Motor Neurone Disease (ALS/MND). Diagnostic delay is also encountered for ALS/MND and the typical time to diagnosis, 10–16 months from symptom onset (Richards et al., 2020), is comparable to DCM. Several countries, including Australia and the UK, have undertaken interventions to raise awareness about detecting MND in primary care, using a memorable phrase "painless, progressive weakness" and a one-page diagnostic tool to prompt GPs to query MND and initiate early referral (MNDAustralia, 2022). The UK NICE guideline recommends robust protocols and pathways to inform healthcare professionals about MND and support recognition and rapid onward referral (NICE, 2019). For DCM, the mJOA shows potential to become part of an intervention for recognition of clinical symptoms and signs and early detection.

When exploring screening or early detection tools, it is crucial to balance the probability of detecting the disease with the risk of over-investigation and over-treating (Evans et al., 2011). A test with high sensitivity but low specificity for DCM could "rule in" too many people for an urgent MRI and surgical review who may not need it, thereby

diverting resources away from others who do. Using a cut-score of ≤17, one in four patients was incorrectly classified. A person will score 17 if they have mild difficulty on just one of the four categories, a finding that in itself would not be specific for DCM. The most frequent diagnosis to be misclassified was cervical radiculopathy, who scored 17 with mild sensory loss. Our data suggest using a cut-score of ≤16 for expediting MRI and surgical review. This score was 62% sensitive and 90% specific for a subsequent diagnosis of DCM and correctly classified 87% of our 201 patients as having or not having DCM, before correlation with imaging. A cut-score of 16 may mitigate against a "grey area" created by one non-specific symptom because people scoring 16 have either mild loss in two categories or moderate dysfunction in one category, which in itself warrants further investigation, in addition to the positive likelihood ratio from this study. Importantly, the mJOA does not distinguish between unilateral and bilateral sensory loss, which could raise the risk of misclassifying radiculopathy as myelopathy, in which unilateral sensory loss is a feature. In a recent study, sensory disturbance was the presenting symptom in 19% of 411 people with DCM but it was not reported if this was bilateral or unilateral (Özkan et al., 2022).

The specificity and sensitivity of mJOA as a screening tool are comparable with another instrument, the DOWN questionnaire developed by Barkoh et al. (2019), for detecting DCM. They are targeted differently, as the DOWN questionnaire is designed for patient report, whereas the mJOA is assessed by a clinician. The DOWN questionnaire was validated in a case-control study with two equal sized groups. Our study had a smaller number of people with DCM due to its lower incidence (10%) in our study sample compared to Barkoh's (in which the proportion with DCM was 50%). This is an important consideration for screening, as the validity of a screening tool will depend on the prevalence of the event or condition in the population (Wilson et al., 1968). Our study found an incidence of DCM diagnosis that is closer to the population prevalence reported in other studies (Smith et al., 2020). In exploring the confounding diagnoses that were associated with misclassification, similar to Barkoh, we found that cervical radiculopathy was the most frequently misclassified. The two instruments could be complementary. The DOWN is shorter, patient-reported, and captures binary yes/no responses to each of four questions, whereas the mJOA rates each component on a 0–4 point scale, but requires clinician input.

It is worth noting that the cut-score of 16 would not have expedited imaging and surgical review for almost two in five people who ultimately had DCM. Although these people were mildly symptomatic, it is important that the score of 16 would be viewed as "ruling in" rather than "ruling out" DCM, and judicious clinical assessment, with a high index of suspicion, should inform the management of people with non-conventional symptoms. This highlights the problem faced in the implementation of tools or interventions to support earlier diagnosis of DCM, namely, the lack of precise understanding of the disease's natural history, particularly for mild DCM (Nouri et al., 2022). The World Health Organisation Wilson and Jungner Criteria for disease screening define as the seventh principle "The natural history of the condition should be adequately understood" (Wilson et al., 1968) and this requirement is retained in recent consolidated principles (Dobrow et al., 2018). This principle refers to population-level screening whereas our study focused on people who already have some symptoms. Nonetheless, on current evidence, the principle of understanding natural history is not met for DCM. One prospective study evaluated the long-term natural history of pre-symptomatic DCM in 112 people with MRI evidence of cord compression but no clinical symptoms or signs) and found that 13.4% converted to symptomatic DCM within two years (Kadanka et al., 2017). This means that progression is not evitable, but crucially, it is not yet possible to predict who will deteriorate. Although it is recommended that surgery be offered for mild DCM given the risk of progression (Fehlings et al., 2017), the acceptability of surgery to people with very mild symptoms has not been investigated. The potential benefits must be weighed against the risk of complications with spinal surgery. One prospective registry study identified a 15% incidence of

adverse events in the first year following surgery (de Dios et al., 2022). In our clinical experience, not all patients with mild DCM opt for surgery. Little is known about outcomes for people who choose not to have surgery, partly because research in DCM is heavily weighted towards evaluating surgical intervention (Mowforth et al., 2020). Therefore, in exploring clinical utility of mJOA as an early detection tool, we must acknowledge that when advising patients detected with mild DCM, we are less certain about the likely outcome and the "next steps" are unclear.

This raises the consideration of clinical surveillance for people with mild DCM. Clinical surveillance has been identified as a top research priority by RECODE-DCM however the feasibility, efficacy or cost-effectiveness of clinical surveillance have not yet been investigated. It is not clear if this should happen in primary care or a specialist centre and what instruments, tools or methods should be used to monitor people with DCM for disease progression. Similarly, there is conflicting evidence on the optimal time to from symptom onset to diagnosis and surgery, important for considering whether surveillance has a time-limit. Studies exploring symptom duration as a predictor of outcome after surgery have identified cut-off points for better outcome ranging from four months (Tetreault et al., 2019) to twelve months (Archer et al., 2020) to two years (Levy et al., 2023) from symptom onset to surgery, whereas other studies have not found clear evidence of association between duration of symptoms and clinical outcomes [12, (Asuzu et al., 2022). This may be explained by the varying definitions of "good" outcome used by studies. All of these points create uncertainty about the next steps for people diagnosed with mild DCM. However, early diagnosis remains critical to enable these factors to be considered in a timely manner.

This is a preliminary study and carries limitations for interpretation and generalisability. First, the study was conducted in specialist neurosurgical clinic, where the mJOA is established in practice and familiarity was high. Translation of these findings to a non-specialist setting may be hampered by lack of familiarity, particularly in the context of the myriad possibilities for diagnosis that a primary care clinician must consider and the vast array of tools accompanying each. Second, the patients in this study are a subset of all patients who attend primary care with a neck problem, specifically those for whom the problem was deemed severe enough to warrant referral for a neuro-surgical opinion. They are not representative of the wider population of people with neck problems that present to primary care. It is likely that primary care clinicians differ in their decisions to refer to tertiary care, further limiting generalisability of findings from our cohort. Conversely, it is possible that the mJOA could assist in this decision-making, a point that supports the need for further investigation in a larger-scale feasibility study. Third, the eventual number of participants with the outcome of interest (DCM diagnosis) was just 21 and findings will need replication with a larger sample size, though our study contributes valuable data in this regard for sample size calculation. Finally, although the mJOA was completed before radiological reporting of the MRI, it is possible that the mJOA score contributed to the clinical judgement of the assessor in determining the diagnostic category, as the two (mJOA and diagnostic criteria of DCM) are not entirely independent of one another. We tried to mitigate this by contemporaneous (rather than retrospective) scoring of the mJOA during clinical assessment but they are nonetheless part of the same process. The diagnostic criteria for DCM are not validated and there is room for clinical interpretation of subtle signs and symptoms.

5. Conclusion and implications

In summary, this study found preliminary evidence of potential clinical utility of the mJOA as a tool for early detection of DCM in people with neck pain referred to a neurosurgical service for a specialist opinion. These findings are not definitive in this small, pragmatic, single-site study and need replication in other settings, particularly in primary care at point of first clinical assessment. To do this would first require stakeholder consultation to establish the acceptability and feasibility of implementing the mJOA, or adapting it, in primary care in the routine assessment of people with neck problems, particularly those with upper limb symptoms, neurological symptoms or neurological signs.

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.

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