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ORIGINAL RESEARCH

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Clinical evaluation versus magnetic resonance imaging findings in patients with radicular arm pain—A pragmatic study

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Abstract

Objectives: Cervical nerve root compression can lead to radiculopathy in the arm. Some studies have reported low accuracy in determining the responsible nerve root in both cervical and lumbar regions. This prospective, observational, pragmatic study aimed to determine the accuracy of the clinical evaluation relative to magnetic resonance imaging (MRI) findings in patients with arm radiculopathy.

Methods: Patients with neck pain and neck-related arm pain referred to a spine unit underwent a standard clinical neurological examination and cervical spine MRI. The clinical examination required a judgment of the most likely cervical root involved, including the side. The Interobserver reproducibility was tested. Using MRI, the most likely nerve root involved according to radiology was assessed.

Results: Eighty-three patients met the inclusion criteria. The Interobserver reproducibility between clinical evaluators was 58%, with a modest κ coefficient (0.33, 95% confidence interval [CI]: 0.18–0.47) classified only as "fair agreement." Only 31% (95% CI: 22–42) of the 83 patients exhibited full agreement regarding the suspected cervical root as assessed via the clinical evaluation and MRI. In another 28% (95% CI: 18–39), the clinical evaluation identified an adjacent level to that identified on MRI.

Conclusions: In cervical radiculopathy, the clinical-neurological examination diagnosed the same in 31% or an adjacent cervical root in 28% of the patients in relation to the most affected cervical root on MRI.

KEYWORDS

adjacent level, dermatome, MRI, nerve-root compression, patient report, radicular

1 | INTRODUCTION

Cervical spine symptoms are the fourth most disabling medical condition in people of all ages, surpassed only by low back pain, major depressive disorders, and, in most European countries, trauma due to falls.[1] In the adult population, 10% suffered from neck pain for at least 30 days during the previous year. The 1-year prevalence estimate of pain in the radiating arm was 16%.[2]

Radiating arm pain is mainly caused by a degenerative neck pathology or may be referred pain from other inner organs, such as heart diseases. Degenerative neck pathology is caused by root compression from either a herniated disc, spondylotic foraminal stenosis, or both.[3] Less frequently, radiculopathy is observed as a result of other medical conditions affecting the root, such as diabetic neuropathy, vitamin B_{12} deficiency, or borreliosis.[4]

The pathology behind the irritation of a certain root resulting in radiculopathy is not quite evident. In the lumbar spine, MRI-demonstrated disc prolapse is much more frequent than radiculopathy symptoms related to prolapse.[5] Moreover, in the cervical spine, disc protrusion without associated clinical symptoms is highly common and increases with age.[6] Additional inflammatory changes are likely important parts of herniation radiculopathy.[7]

Cervical radiculopathy can be diagnosed with a thorough history and physical examination in many cases, but MRI should be used to confirm the diagnosis.[8] The affected dermatomes can both overlap and vary for a certain nerve root in cervical radiculopathy.[9]

According to a recent systematic review, with the goal to determine the reliability and validity of clinical tests in the assessment of the anatomical integrity of the cervical spine in adults with neck pain and its associated disorders, "little evidence exists to support the use of clinical tests to evaluate the anatomical integrity of the cervical spine in adults with neck pain and its associated disorders."[10]

Neurological signs, as presented in textbooks, have been tested in patients with a single-level pathology undergoing anterior cervical discectomy and fusion.[11] Only patients with at least 75% improvement were included, and among these, the pattern of pain and numbness followed traditional textbooks in only 54%. Accuracy did not differ by cervical level.

The evidence for tests conducted during a clinical examination of cervical radiculopathy in relation to imaging or surgical findings was also evaluated in a recent review,[12] wherein none of the five included studies assessed the accuracy of routine clinical tests, such as muscle strength, tendon reflexes, or sensory impairments. In a recent prospective diagnostic accuracy study, Spurling's test and reduced reflexes had a high specificity for defining cervical radiculopathy, whereas the presence of paresthesia showed a high sensitivity,[13] although the interpretation of Spurling's test has also been recently questioned.[14] Indeed, there is no gold standard for testing cervical radiculopathy.[15] Furthermore, even in the lumbar spine, pain distribution and sensory disturbances can be difficult to interpret and were deemed unreliable when distinguishing between subsequent surgery-verified L5 and S1 root involvement.[16]

In daily practice, spine doctors often agree that a clinical examination, suggesting a symptomatic herniation at one cervical level, but an MRI revealing a herniation at an adjacent level can still serve as an adequate explanation for the patient's complaints. Surgical decisions in patients with suspected cervical radiculopathy are based on a combination of patient history, clinical examination, MRI findings, and sometimes diagnostic nerve root blocks. Surgical outcome depends on several factors, mental impairment being an important one, influencing results of surgery for cervical spondylosis negatively.[17]

As a standard routine work-up regarding possible surgery and adequate level to operate upon, the agreement between clinical neurological examination and MRI findings is evaluated. Further, in nonsurgical candidates, this evaluation is also important, since poor agreement could indicate the need to pursue a selective nerve root block, or also raise suspicions that other pain generators are involved, such as peripheral nerve compression, shoulder pain, and muscle pain.

The actual study is pragmatic. There are important differences between pragmatic and traditional method studies. Pragmatic studies test real-life situations and optimize their applicability. Conversely, traditional method studies, often named"explanatory" studies, aimed to provide knowledge regarding precisely defined biologic mechanisms, are most accurately performed in a selected group of patients under optimal conditions.[18] Such studies, however, are rarely applicable to most patients. Examples of heavy selection bias that can be introduced using protocols in randomized controlled trials can be observed in different fields.[19,20] One study[20] stated that less than 10% of patients in a daily clinic could fit into the frames that were used in an explanatory study of asthmatic disease.

We wanted to test to coherence between results from imaging versus clinical evaluations, since, from a clinical point of view, we experience that there is quite a large proportion of patients where the cervical levels and roots do not seem to agree.

The specific aims were:

1. In a pragmatic study, focusing on the first consultation at a specialized spine center, to test the agreement between the clinical assessment to identify a radiculopathy-affected cervical nerve root, compared to that of an MRI-selected root compression, caused by prolapse and/or recess stenosis (primary purpose).
2. How far a clinical selection of a certain level could be elucidated by a lesion identified at an adjacent level via an MRI (secondary purpose)?
3. Interobserver compliance regarding the selection of clinically suspected cervical roots (secondary purpose).

2 | MATERIALS AND METHODS

2.1 | Design

A pragmatic diagnostic study exploring the clinical examinations in relation to MRI findings in patients with cervical radiculopathy. It was carried out in two specialized spine centers.

2.2 | Inclusion criteria

We performed this pragmatic study including two spinal centers to explore the clinical examinations in relation to MRI findings in patients with cervical radiculopathy recruited from a daily practice setting. We analyzed the ratio of patients with a clinical evaluation, including pain distribution, that agreed with MRI findings regarding pain-responsible root at the same and adjacent levels.

The following inclusion criteria were applied: patients aged >18 years who were referred to a spinal outpatient clinic (Center for

Rheumatology and Spinal Diseases, Copenhagen, Denmark and Division of Neurosurgery, Lund, Sweden, both of which are specialized centers evaluating and operating patients with cervical radiculopathy) for evaluation of suspected cervical degenerative radiculopathy. All patients underwent MRI, which was considered acceptable in terms of quality and age to attain a routine clinical evaluation.

2.3 | Exclusion criteria

The following exclusion criteria were applied: diabetes mellitus or B_{12} deficiency with diffuse symptoms and severe neuropathy; borreliosis or herpes zoster[4]; carpal tunnel syndrome or ulnar nerve entrapment; previous cervical spinal surgery; serious pathologies such as tumors, fractures, spinal cord injuries; missing clinical information in the patient forms and the complete absence of radiculopathy on clinical examination.

2.4 | Definitions

The clinical evaluations and MRI assessments made judgments regarding both:

1. SIDE, which was either left-sided (sin), right-sided (dx), or bilateral, and
2. ROOT, which was C4, C5, C6, C7, C8, or unclear.

2.5 | Clinical evaluation

Initially, the patients completed an evaluation form with a standard clinical examination for radicular neck arm pain (Supporting Information File 1), with reported pain averaged over 2 weeks. They were asked to mark the distribution of pain on a preprinted schematic outline of a human figure without any usual root-distribution fields and to complete two numeric rating scales (NRS) from 1 to 10 regarding pain in the neck and arm. Additional information regarding pain duration, medication, and patient characteristics were gathered. Subsequently, the doctor evaluated sensory deficits with watt surface and needle; muscle strength; and upper limb reflexes (biceps, triceps, and brachioradial reflexes) with the patient in sitting position, and registered it on the doctor's part of the form. The examiner was unaware of the MRI findings. The forms used by the patients and doctors were in Danish or Swedish. The examining doctors were specialists, all working with patients with cervical radiculopathy., that is, a professor, two senior consultants, and a junior consultant.

An Interobserver test was performed to examine doctors' interpretation of the cervical root most and second-most likely causing radiculopathy, all based on the filled-in forms. One evaluator was a joint evaluation by HNR + TB, called Evaluator (Eval) I, the other CB alone, Eval-II. The evaluators included a specialist, professor, and consultant, all with several years of experience in spine diseases.

The results were predominantly based on the patients' schematic drawings, which we compared to Figure 1, as well as objective neurology which was compared to Table 1. The patients had no access to Figure 1 or Table 1. We chose to give patient-reported pain distribution the highest significance if sensory disturbance, reduced muscle strength, or reflexes did not show a uniform picture. If there was a disagreement between sensory disturbance, muscle strength, or reflexes, reflexes were given highest importance, followed by muscle strength and finally sensory disturbance. If clinical evaluations showed that any of the roots C6, C7, and C8 could equally be suspected primary pathology, we chose C7. If no suspected clinical root could be considered responsible, this was also noted.

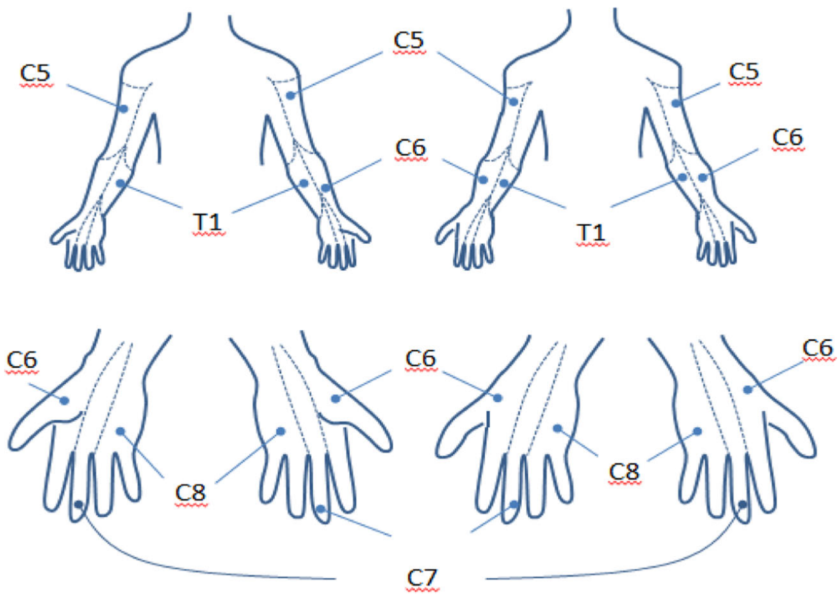

FIGURE 1 Dermatomes for subjective pain description as well as hypo-sensory findings. We denoted hand areas as having the highest priority in cases of discrepancy between dermatome areas in the hand and arm. We chose these distributions as an average of several textbooks' indications.

2.6 | MRI assessment

Patients' MRI scans could stem from several scanners at their local radiological department, in accordance with the pragmatic setup. All were 1.5 Tesla. Sagittal and axial scans with running inclination adjustments according to each end-plate surface were evaluated. T2-weighted MRI scans were evaluated as long as the nerve roots could be readily identified, and the images were not compromised with severe artifacts.

MRI scans were assessed by Eval-I (according to Supporting Information File 3), time wise far from the clinical exam, and thus without actual knowledge of the clinical data. The assessments were cross-checked, *after* noting a conclusion, with the initial report of the examining radiologist.

All cervical nerve roots were considered in a patient's evaluation, and the root interpreted most severely affected was defined as the primary MRI root, defined by level and side; correspondingly regarding a secondary root. If the two roots could not be prioritized, we noticed them to be equal. In case of equality between more secondary roots, they were all designated as such.

Agreement between clinically and MRI designated roots were performed, calculated as % agreement. Cases were accepted if the side selected in the clinical examination was bilateral, and the MRI showed either left- or right-sided pathology. Correspondingly, when the primary MRI pathology was bilateral, the left- or right-sided clinical side was accepted.

For comparison between radiologists' and clinicians' MRI interpretations, a simplified system was used, illustrated in Table 4. The clinician was unbiased regarding the actual patient history, whereas the radiologist was informed about that.

TABLE 1 Nerve root innervations used in the clinical evaluation, which is also in accordance with the international spinal cord society (ISCoS) score (https://www.iscos.org.uk/international-standards-for-neurological-classification-of-spinal-cord-injury-isncsci).

Nerve root	Muscle	Reflex
C5	Elbow flexors	Biceps
C6	Wrist extensors	Brachioradialis
C7	Elbow extensors	Triceps
C8	Finger flexors	

2.7 | Statistical methods

Statistical evaluations were performed using SPSS® version 25.0 (IBM Corp). Interobserver agreement was analyzed using the Kappa test and %agreement. Landis and Koch's[21] five kappa intervals of 0.2 between $\kappa = 0 \geq$ "no agreement" and $\kappa = 1 \geq$ "full agreement" were used ("slight," "fair," "moderate", "substantial," and "almost perfect").

The Shapiro–Wilks test and visual inspection of normality plots were used to evaluate whether data were normally distributed. To compare data not normally distributed, Mann–Whitney *U* tests were performed. Statistical significance was set at $p < 0.05$.

3 | RESULTS

3.1 | Included patients

Initially, 112 patients were included in the study. Based on our exclusion criteria, 83 patients were included in further analyses (Figure 2). The general features of the included patients are presented in Table 2a–c.

3.2 | General MRI results

In all cases, the root we deemed most severely affected according to MRI for each patient was identified. In four cases, the description

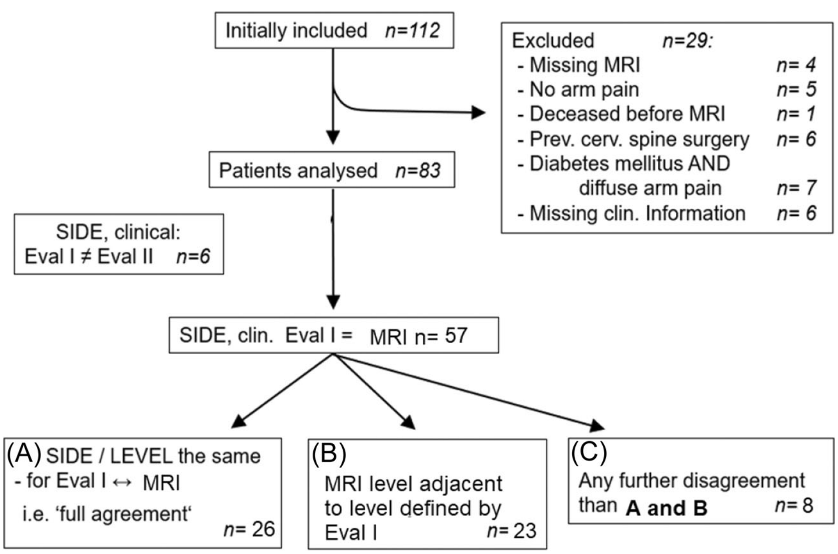

FIGURE 2 Flow chart of inclusion, selection, and results. Eval, evaluator.

TABLE 2a Clinical findings in the total study cohort ($n = 83$)

Sex, Female (%)	53 (64%)
Age (years) (range, mean ± SD)	23–73, 48 ± 11
Neck pain (NRS) (interval scale 1–10) (mean)	6 (range 0–10)
Arm pain (NRS) (interval scale 1–10) (mean)	6 (range 0–10)
Reflexes	Cases (number)
Normal biceps reflex (three cases missing)	66
Normal triceps reflex (four cases missing)	66
Normal brachioradial reflex (four cases missing)	70
Hyperactive biceps reflex (three cases missing)	3
Hyperactive triceps reflex (four cases missing)	2
Hyperactive brachioradial reflex (three cases missing)	1
Muscle strength (scale graded from 0 to 5, 5 = full muscle strength, number of patients with full muscle strength)	Cases (number)
Shoulder elevation (one case missing)	69
Shoulder abduction (one case missing)	64
Shoulder adduction (one case missing)	66
Shoulder flexion (one case missing)	66
Shoulder extension (seven cases missing)	60
Elbow flexion (one case missing)	61
Elbow extension (one case missing)	59
Wrist flexion (two cases missing)	67
Wrist extension (one case missing)	65
Finger flexion (one case missing)	61
Finger extension (one case missing)	58
Finger abduction (one case missing)	62
Finger adduction (one case missing)	58

TABLE 2b Radiological findings in the study population

MRI findings	%
Spinal stenosis (two cases missing, % of $n = 81$ with complete information)	
Significant spinal stenosis	12
Narrow canal	31
None	57

made by the radiologist or a competent surgeon was available at the time of evaluation, but the images were not. In all other cases, images were evaluated as described in Section 2.6.

In 12% of the patients, central spinal stenosis could be radiologically observed (Table 2b).

TABLE 2c Duration of pain.

Time with pain	Duration of arm pain number of patients (%)	Duration of neck pain number of patients (%)
<3 months	15 (18.1)	13 (15.7)
3–12 months	31 (37.3)	29 (34.9)
1–2 years	19 (22.9)	15 (18.1)
>2 years	14 (16.8)	19 (22.9)
Not reported/ unknown	4 (4.8)	7 (8.4)

Note: >75% of the patients had the duration of the neck and arm pain >3 months.

In 79 (95.2% of all 83) cases, a primary level was identified on MRI, whereas 4 cases (4.8%) had no affected level. The affected nerves were C4 ($n = 1$; 1.2% of all 83 cases), C5 ($n = 9$; 10.8%), C6 ($n = 44$; 53.0%), and C7 ($n = 25$; 30.1%).

In 50 cases, both primary and secondary MRI roots were identified. In 50% of these 50 cases, this secondary level was C6, the most common, and in 18% of the cases, it was C5 on MRI images.

3.3 | Interobserver clinical agreement

The two evaluators (Eval-I and Eval-II) independently decided which side and root level they considered being the most involved.

In six cases, the clinical side was judged differently by Eval-I and Eval-II: five of these were disagreement regarding if there was bilateral or unilateral affection, whereas one represented right–left disagreement of a unilateral root. We performed an analysis of the interobserver agreement of the clinical evaluation of the cervical root level in all 83 cases. In 48 (58%, 95% CI: 46–69) cases, the same root level was identified (Supporting Information File 2). The interobserver reproducibility showed a Kappa value of 0.33 (95% CI: 0.18–0.47, which is classified only as "fair agreement" by the Landis and Koch thresholds.

3.4 | Agreement between clinician's and MRI-based affected cervical nerve root

In 58 cases, 70% (95% CI: 59–79) of all 83 patients, the side defined by clinical evaluation, fulfilled the criteria regarding side agreement in relation to MRI. In 26 of these patients, 31% (95% CI: 22–42) of all patients, the same level was also identified, and these cases were defined as having a full agreement between clinical examination and MRI (Table 3). The agreement was tested in relation to neck pain (NRS) and arm pain (NRS). Neck pain and arm pain were not normally distributed (Shapiro–Wilk and visual inspection of normality plots), and nonparametric tests were used. There was no significant difference in the patients who reported neck or arm pain between patients with or without full agreement (Mann–Whitney U test: n.s.).

TABLE 3 Cases with a full agreement regarding root level and side according to clinical evaluation and magnetic resonance imaging (MRI, $n = 26$), compared to those with the adjacent level agreement ($n = 23$) and those with no agreement ($n = 34$).

	Full agreement number (%)	Adjacent level agreement number (%)	No agreement number (%)
No of patients	26 (31)	23 (28)	34 (41)
Sex			
Female	15 (58)	15 (65)	23 (68)
Mean age (years)	47	47	50
Arm pain (NRS) (median±SD)	6 ± 2	6 ± 2	7 ± 3
Neck pain (NRS) (median ± SD)	7 ± 2	5 ± 3	7 ± 3
Duration of arm pain (4 not reported)			
<3 months	3 (12)	5 (22)	7 (21)
3–12 months	11 (42)	8 (35)	12 (35)
>1 year	11 (42)	8 (35)	14 (41)
Primary root—MRI			
C4	0	0 ()	0
C5	0	4 (17)	1 (3)
C6	20 (77)	5 (22)	5 (15)
C7	6 (23)	14 (61)	19 (56)
C8	0	0	5 (15)
No affected root	0	0	4 (12)

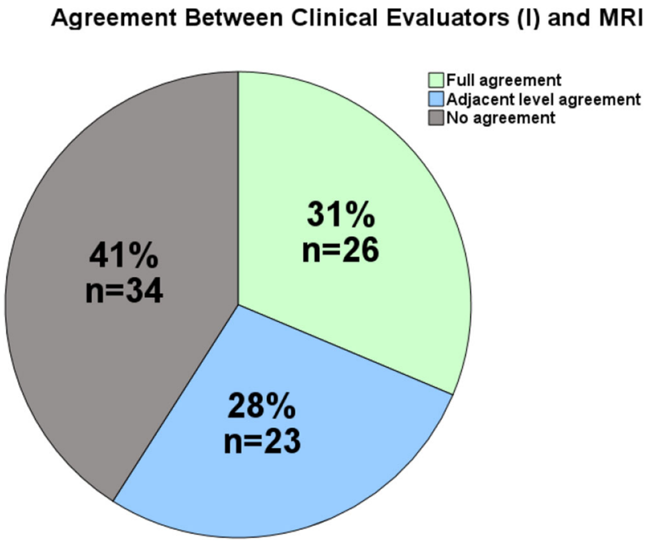

FIGURE 3 Results of agreement analysis between clinical examinations and magnetic resonance imaging (MRI).

TABLE 4 Agreement analysis between the Eval-I's and the radiologist's MRI assessments, where Eval-I did the decision blinded to the clinical presentation.

Agreement: clinician versus radiologist		
Agreement	**Primary root**	**Secondary root**
1 = Strong	Agree	+/− Agree or absent
2 = Partial	Disagree, but one agrees with secondary root	Disagree
	Disagree	Secondary agree
	Canal agree, according to radiologist: narrow canal, no neural affection	
3 = None	Disagree	Disagree

3.5 | Cases with an agreement with an adjacent MRI level

In 31 cases (37% of all 83) with an agreement regarding the side between clinical evaluation and MRI as described in Section 3.4, full agreement regarding the level was not present. However, in 23 out of these 31 patients (28% of all; 95% CI: 18–39) had an agreement with one of the adjacent MRI levels, defined as one MRI level above or below the one indicated by clinical examination. The overall results of our study are shown in Figure 3.

3.6 | Agreement between radiologists' and clinicians' MRI assignment

A post hoc analysis was performed comparing the root selected by clinicians Eval I from the MRI findings, compared to the radiologists' reports (Table 4). The implication of being blinded to clinical data or

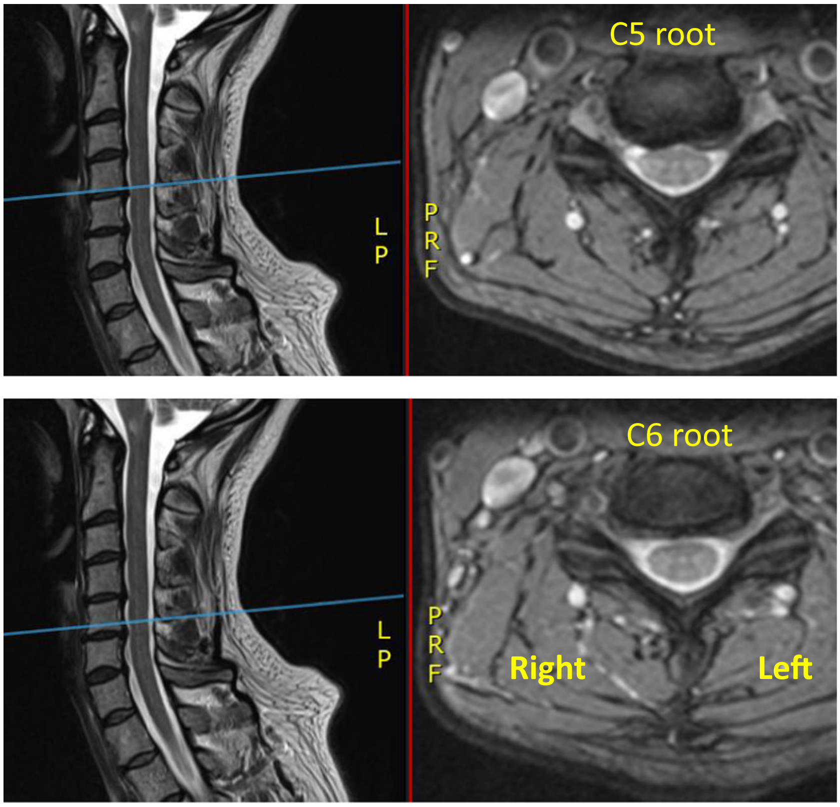

FIGURE 4 The radiologist, who knew that the clinical symptoms were left-sided, selected the "C5 left" root (above) as the primary root affection, whereas evaluators blinded to the clinic defined both the "C5 left" (above) and "C6 right" (below) as equally compressed roots according to MRI. The clinical symptoms pointed towards C6 root, left, which was much less compressed.

not is illustratively shown in Figure 4. Only cases in which the full radiological report was available were included ($n = 67$). In 54 (84%) cases, there was a full agreement between roots assigned by Eval I and radiologists; four (6%) cases had a partial agreement and in six (9%) cases there was no agreement.

4 | DISCUSSION

This study primarily aimed to explore the agreement between traditional clinical evaluation and MRI in a pragmatic setting in patients with cervical radiculopathy. Our overall findings were that the accuracy of diagnosing an impaired cervical nerve root is rather poor compared to MRI and what our anatomical learning would suggest. Diagnostics in cervical radiculopathy based on routine neurological examination combined with pain patterns generates an ambiguous picture in many patients. This was verified with an only fair agreement between clinical examiners. Furthermore, agreement between clinical evaluations and MRI findings was present in around one-third of all cases, only. Surgeons often accept agreement between clinically- and MRI-based diagnostics at adjacent root levels. In the present study, 28% of the patients had such an adjacent level agreement. Accepting the involvement of the same or adjacent root on MRI compared to clinical evaluation, a useful agreement could be reached in 59% of the cases. Providing data on this adjacent-level issue contributes to further discussions on that subject.

Even though different clinical evaluators used the same information when asked to define the most likely affected cervical root from a clinical point of view, including patterns of pain distribution, sensory disturbance, muscle strength, and reflexes, there was only a fair agreement regarding the selection of the most likely affected nerve root. A full agreement between clinical evaluation and MRI was observed in only approximately one-third of the included patients.

We could not define any distinct pattern separating patients with agreement between clinical evaluation and MRI findings, from those with adjacent level agreement or no agreement, when it came to age or duration of neck pain. In the present study, most of the patients had suffered from pain >3 months, which is often the case in our healthcare systems, where initial conservative management before the patient is referred to a spinal department. The mean age in our study was 48 years, which is well in line with previous reports defining cervical radiculopathy to be most prevalent in persons aged 50–54 years.[22]

Low agreement has been observed in other studies, even though they might have used a more explanatory and less pragmatic setup.[3] In the study by Kuijper et al., the agreement between clinical and MRI evaluations was only 35%, which is similar to 31% found in our study. Only patients with cervical radiculopathy lasting less than 1 month were included in the study by Kuijper et al. This could be discussed from a pragmatic point of view since 80% of patients already improve, predominantly due to natural history, within 1 month of the onset of cervical radiculopathy.[23]

The aim of the present study was not to provide a strict interobserver reliability assessment of MRI. The clinical evaluators of our study were blinded to the background history once assessing the MRI, whereas the radiologists used the referral history in accordance to clinical routine. However, in another study interobserver tests obtained inter-and intra-observer agreement which was almost perfect when it came to assessing the presence of foraminal stenosis.[24]

Patients with multilevel degenerative cervical spinal pathologies on MRI are common. If surgery is chosen, selective diagnostic nerve root blocks may be valuable in increasing the accuracy of predicting the nerve root responsible for the clinical symptoms. In a relatively small study of patients with the multilevel disease, the agreement between nerve root blocks and the most severely affected spinal level according to MRI was 60%.[25] The agreement was reduced to 28% if nerve root blocks were tested against only neurological deficits/dermatome radicular pain distribution.[25] It has also been shown that the diagnostic value of selective cervical nerve root bocks is limited to patients with severe foraminal stenosis and is less useful in those with moderate stenosis.[26]

Electrophysiological methods were not included in the present study. However, the literature does not point to the high accuracy of these methods. Electrodiagnostic testing is not considered to be needed if the diagnosis of cervical radiculopathy is clear.[22] Needle electromyography and nerve conduction tests are primarily reported as useful if clinical and MRI examinations cannot differentiate between cervical or other neurologic causes of radiculopathy.[27] Upper limb neurodynamic tests have been tested in comparison to clinical practitioners in ruling out cervical radiculopathy with MRI confirmation. Using a single upper limb neurodynamic test for the median, radial, and ulnar nerves in isolation did not alter the chance of ruling out cervical radiculopathy. Only the combination of three positive tests was useful.[15]

Discrepancies between clinical and MRI findings have also been reported from others.[28] Mostofi and Khouzani retrospectively reviewed the medical records of 102 patients who underwent anterior cervical discectomy and fusion due to cervical radiculopathy. In 10 of these cases, there was a discrepancy between the clinically determined side and MRI findings. Despite this, the patients who underwent surgery were completely relieved of pain at the 3-month follow-up, although this improvement most likely had been attributable to natural history and/or placebo.[28]

Unlike standard textbook pictures,[29] the mixed group of radicular-pain patients does not exclusively present with single-level disease and a clear clinical picture of cervical radiculopathy. Our study focuses on the relationship between clinical evaluation and cervical spine MRI assessment in a mixed patient cohort typically encountered in a spinal outpatient clinic, with or without necessarily being candidates for surgery. It has been insightfully stated that "in patients with chronic pain in general, and cervical radicular pain particularly, it is extremely difficult to determine with certainty which intervertebral disc or nerve root is causing the pain."[27]

4.1 | Strengths and limitations

We selected a pragmatic design, which can be seen as both a strength and a limitation: a *strength* because it optimally reflects everyday clinical practice, as described at the end of our "Introduction"; a probable *limitation*, because a strictly executed classical "explanatory method study," may imply a better agreement between the clinical and the MRI exams, but as argued also less relevant results in relation to the situation encountered in everyday clinical practice. Another strength is that we have provided data on the often-discussed adjacent-level issue.

This study has some further *limitations*. In the clinical exam the "foramen-compression test," Spurling test, and possibly cervical distraction test[30] could have been incorporated in the test battery, as these are tests with reasonable validity,[31] although this has differed in various studies.[13,14]

Spinal cord stenosis was not addressed in relation to radicular findings in our study. However, only 12% of the patients had radiological signs of spinal stenosis, which is only slightly more than 7% reported in asymptomatic patients undergoing MRI for other reasons.[6]

4.2 | Suggested further studies

Randomized clinical trials (RCTs) to elucidate whether adjacent-level agreements have the same positive effect of surgery as those with the total agreement, that is, RCTs with groups of both full-agreement and adjacent-level patients.

Systematic description of the variation in skin areas of pain and objective neurology in cases with the full and adjacent-level agreement between clinical evaluation and MRI.

5 | CONCLUSIONS

In this study of cervical radiculopathy, most of the clinical evaluation was only slightly indicative of involvement of a certain nerve root. Even trained MRI-blinded evaluators often came up with different clinical conclusions. Full agreement of a suspected root between clinical evaluations and MRI assessment was obtained in only 31% (95% CI: 22–42) of the patients. In another 28% (95% CI: 18–39) of the patients, an agreement was obtained between clinical evaluations and an MRI affection on an adjacent spinal level. By accepting agreement on both the same and the adjacent level, clinical and MRI evaluations were agreed in 59% of the cases.

AUTHOR CONTRIBUTIONS

Henrietta N. Redebrandt: conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; validation; writing—original draft; writing—review & editing. **Christian Brandt**: conceptualization; formal analysis; funding acquisition; investigation; methodology;

resources; supervision; validation; writing—original draft; writing—review & editing. **Said Hawran**: conceptualization; data curation; investigation; methodology; project administration; resources; validation; writing—review & editing. **Tom Bendix**: conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing—original draft; writing—review & editing.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICAL APPROVAL

Patients were included in the study in accordance with the permission granted by the regional ethics board in Lund (permission number 2017/715) and Copenhagen (RH-2017-72). Informed consent was obtained from all individual participants included in the study. Patients were informed that participation would not affect clinical decisions or further treatment and that they could withdraw their consent to participate at any time.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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