Cervical radiculopathy: diagnostic aspects and non-surgical treatment
Kuijper, B.

Citation for published version (APA):

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CHAPTER 3

Interobserver agreement on MRI evaluation of patients with cervical radiculopathy

Barbara Kuijper, Anita Beelen, Bas F W van der Kallen, Frans Nollet, Geert J Lycklama a Nijeholt, Marianne de Visser, Jos Th J Tans

Clinical Radiology 2011
Abstract

Objectives
To evaluate the interobserver agreement on magnetic resonance imaging (MRI) evaluation of herniated discs, spondylotic neuroforaminal stenosis and root compression in patients with recent onset cervical radiculopathy. In addition, to assess the added value of disclosure of clinical information to interobserver agreement.

Participants
82 patients with less than one month of symptoms and signs of cervical radiculopathy.

Methods
MRIs were evaluated independently by two neuroradiologists who were unaware of clinical findings. MRI analysis was repeated after disclosure of clinical information. Interobserver agreement was calculated using kappa statistics.

Results
The kappa score for evaluation of herniated discs and of spondylotic foramen stenosis was 0.59 and 0.63, respectively. A kappa score of 0.67 was found for the presence of root compression. After disclosure of clinical information kappa scores increased slightly; for detection of herniated discs from 0.59 to 0.62, for spondylotic foramen stenosis from 0.63 to 0.66 and for root compression from 0.67 to 0.76.

Conclusion
Interobserver reliability of MRI evaluation in patients with cervical radiculopathy was substantial for root compression, with or without clinical information. Agreement on the cause of the compression, i.e., herniated disc or spondylotic foraminal stenosis, was lower.
Introduction

In patients with cervical radiculopathy, magnetic resonance imaging (MRI) is the imaging technique of choice for the detection of root compression by disc herniation and osteophytes. However, no data are available about the interobserver variability of the interpretation of cervical spine MRI in patients with clinical signs of root compression. Further, it is unknown whether the availability of clinical information diminishes interobserver variation. In daily practice clinical information is usually considered instrumental in assessing radiological examinations. However, there are studies showing no significant increase in interobserver agreement after disclosure of clinical information. In the present study we evaluated interobserver reliability of MRI evaluation of herniated discs, spondylotic neuroforaminal stenosis and root compression in patients with cervical radiculopathy. In addition, we assessed the effect of disclosure of clinical information on interobserver variability.

Materials and methods

Subjects
This prospective study comprised a cohort of 82 patients with a clinical diagnosis of cervical radiculopathy with an onset of less than 1 month in whom the efficacy of either a cervical collar or physiotherapy was compared with a wait and see policy. The diagnosis cervical radiculopathy was made by a neurologist according to the following inclusion criteria: radiation of arm pain distal to the elbow, and at least one of the following: (1) worsening of the arm pain by neck movements, (2) sensory symptoms in one or more adjacent dermatomes, (3) diminished deep tendon reflexes in the affected arm, or (4) muscle weakness in one or more adjacent myotomes. The medical ethics committees of the participating hospitals approved the protocol. Written informed consent was obtained from all patients.

MRI protocol
MRI was performed at 1.5 Tesla, and included sagittal proton density (PD) and T2 weighted turbo spin-echo imaging (TSE; TR/TE: 2900/23/182; echo train length (ETL): 5) and T1 weighted TSE (TR/TE 664/13; ETL: 3), using 3 mm thick slices and pixels of 1 mm². Axial imaging consisted of a T2 weighted flow-compensated gradient echo sequence (TR/TE 1140/27) and T1 TSE (TR/TE 538/13, ETL: 3) using 3 mm thick slices.
and 1 mm$^2$ pixels. Axial slices were placed perpendicular to the vertebral bodies and were angulated in the same way. Axial imaging covered intervertebral spaces C4 to Th1.

**MRI evaluation protocol**

MRI examinations were evaluated independently by two neuroradiologists who were unaware of clinical findings. The presence or absence of a herniated disc or bony foraminal stenosis by spondylarthrosis was evaluated at each cervical level on the right and left side. Differentiation between bony foraminal stenosis and herniated disc was made based on appearance on axial T2$^*$ weighted flow-compensated gradient echo sequence images. On these images, disc material shows relatively high signal intensity compared to adjacent bony structures (figure 1). Also, on sagittal PD weighted images, herniated disc often has a slightly different signal intensity compared to bone. Examples of disc herniations and foraminal stenosis are shown in figures 1 and 2.

![Figure 1](image)

**Figure 1**

Sagittal T1 (A) and proton-density (B) weighted, and corresponding axial T2 weighted flow-compensated gradient echo sequence images (C) and T1 (D) weighted MR images showing a lateral disc herniation at level C5-C6 on the left, best appreciated on axial T2 weighted image (C, arrow), due to relatively high signal of herniated disc.

The probability of root compression, either caused by herniated disc or spondylotic neuroforamen stenosis, was scored on a five-point scale: ‘definitely no root compression’, ‘possibly no root compression’, ‘indeterminate’, ‘possibly root compression’ and ‘definitely root compression’. Presence of other abnormalities like spinal canal stenosis with or without cord compression, tumors etc. was recorded, but was not included in the analysis.
Disclosure of clinical information

Directly after the blinded evaluation, the complete MRI analysis was repeated with disclosure of clinical information including side of arm pain and suspected level of root compression. This clinically affected level was determined by a neurologist, based on the pattern of irradiating pain, sensory changes, diminished deep tendon reflexes or muscle weakness.

Statistical analysis

Data on root compression were dichotomized as either ‘root compression’ (comprising the scores ‘possibly root compression’ and ‘definitely root compression’) or ‘no root compression’ (‘definitely no root compression’, ‘possibly no root compression’ and ‘indeterminate’). Interobserver agreement was calculated using kappa statistics. We calculated overall kappa’s, concerning all levels and both sides. Four levels were investigated separately on both sides (C4-5 to C7-Th1). Kappa values were calculated for the presence of herniated disc, foraminal stenosis and root compression. The kappa values were interpreted as follows: values between 0 and 0.2 represent poor agreement, 0.21 and 0.40 fair agreement, 0.41 and 0.60 moderate agreement, and 0.61 and 0.80 substantial agreement. A value above 0.80 is considered excellent agreement. 8-10
Results

In 4 of the 82 patients reliable MRI-data could not be obtained due to artifacts by pain (n=2) and claustrophobia (n=2). For the remaining 78 MRI examinations interobserver agreement and kappa scores could be calculated at a total of 624 segments (4 levels on right and left side). The mean age of the patients was 48.8 (SD ±9.9) years. 47.4% was male (n=37).

Agreement without clinical information

All segments
With regard to detection of herniated discs at all segments the neuroradiologists agreed in 80.8% and interobserver agreement was moderate (kappa 0.59, CI 0.40-0.77) (table 1). For evaluation of spondylotic foramen stenosis, the neuroradiologists agreed in 82.1% of the cases with a kappa of 0.63 (CI 0.46-0.81) (table 2). An agreement of 91.0% and a kappa of 0.67 (CI 0.43-0.90) were found for presence or absence of root compression (table 3).

Per segment
Percentages of agreement were high at level C5 with comparatively low kappa values. For presence of herniated discs and spondylotic foramen stenosis agreement percentages and kappa scores were higher at the C7 than at the C6 segments, for

Table 1 – Interobserver agreement on the presence of herniated disc in 78 patients with cervical radiculopathy.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Presence of herniated discs, n (%)</th>
<th>percentage agreement</th>
<th>kappa</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>46 (59.0) 53 (67.9)</td>
<td>80.8</td>
<td>0.59</td>
<td>0.40-0.77</td>
</tr>
<tr>
<td>C5 right</td>
<td>1 (1.28) 2 (2.6)</td>
<td>98.7</td>
<td>0.66</td>
<td>0.00-1.32</td>
</tr>
<tr>
<td>C5 left</td>
<td>0 0</td>
<td>100.0</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>C6 right</td>
<td>14 (17.9) 14 (17.9)</td>
<td>87.2</td>
<td>0.56</td>
<td>0.31-0.82</td>
</tr>
<tr>
<td>C6 left</td>
<td>14 (17.9) 13 (16.7)</td>
<td>91.0</td>
<td>0.69</td>
<td>0.47-0.91</td>
</tr>
<tr>
<td>C7 right</td>
<td>13 (16.7) 13 (16.7)</td>
<td>94.9</td>
<td>0.82</td>
<td>0.64-0.99</td>
</tr>
<tr>
<td>C7 left</td>
<td>22 (28.2) 26 (33.3)</td>
<td>87.2</td>
<td>0.70</td>
<td>0.53-0.87</td>
</tr>
<tr>
<td>C8 right</td>
<td>0 0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>C8 left</td>
<td>0 0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 – Interobserver agreement on the presence of spondylotic foraminal stenosis in 78 patients with cervical radiculopathy.

<table>
<thead>
<tr>
<th>presence of spondylotic stenosis, n (%)</th>
<th>radiologist #1</th>
<th>radiologist #2</th>
<th>agreement %</th>
<th>kappa</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>43 (55.1)</td>
<td>49 (62.8)</td>
<td>82.1</td>
<td>0.63</td>
<td>0.46-0.81</td>
</tr>
<tr>
<td>C5 right</td>
<td>6 (7.7)</td>
<td>8 (10.3)</td>
<td>92.3</td>
<td>0.53</td>
<td>0.17-0.89</td>
</tr>
<tr>
<td>C5 left</td>
<td>5 (6.4)</td>
<td>8 (10.3)</td>
<td>91.0</td>
<td>0.42</td>
<td>0.00-0.83</td>
</tr>
<tr>
<td>C6 right</td>
<td>29 (37.2)</td>
<td>33 (42.3)</td>
<td>84.6</td>
<td>0.68</td>
<td>0.51-0.85</td>
</tr>
<tr>
<td>C6 left</td>
<td>23 (29.5)</td>
<td>30 (38.5)</td>
<td>78.2</td>
<td>0.52</td>
<td>0.32-0.72</td>
</tr>
<tr>
<td>C7 right</td>
<td>23 (29.5)</td>
<td>26 (33.3)</td>
<td>91.0</td>
<td>0.79</td>
<td>0.65-0.94</td>
</tr>
<tr>
<td>C7 left</td>
<td>24 (30.8)</td>
<td>26 (33.3)</td>
<td>89.7</td>
<td>0.77</td>
<td>0.61-0.92</td>
</tr>
<tr>
<td>C8 right</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>C8 left</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
* kappa statistics could not be calculated

### Table 3 – Interobserver agreement on the presence of root compression in 78 patients with cervical radiculopathy.

<table>
<thead>
<tr>
<th>presence of root compression, n (%)</th>
<th>radiologist #1</th>
<th>radiologist #2</th>
<th>agreement %</th>
<th>kappa</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>67 (85.9)</td>
<td>64 (80.8)</td>
<td>91.0</td>
<td>0.67</td>
<td>0.43-0.90</td>
</tr>
<tr>
<td>C5 right</td>
<td>1 (1.3)</td>
<td>5 (6.4)</td>
<td>94.9</td>
<td>0.32</td>
<td>-0.33-0.97</td>
</tr>
<tr>
<td>C5 left</td>
<td>1 (1.3)</td>
<td>2 (2.6)</td>
<td>96.2</td>
<td>-0.17</td>
<td>-1.00-1.00</td>
</tr>
<tr>
<td>C6 right</td>
<td>27 (34.6)</td>
<td>28 (35.9)</td>
<td>85.9</td>
<td>0.69</td>
<td>0.52-0.86</td>
</tr>
<tr>
<td>C6 left</td>
<td>25 (32.1)</td>
<td>25 (32.1)</td>
<td>87.2</td>
<td>0.71</td>
<td>0.54-0.88</td>
</tr>
<tr>
<td>C7 right</td>
<td>24 (30.8)</td>
<td>20 (25.6)</td>
<td>82.1</td>
<td>0.56</td>
<td>0.35-0.77</td>
</tr>
<tr>
<td>C7 left</td>
<td>35 (44.9)</td>
<td>32 (41.0)</td>
<td>85.9</td>
<td>0.71</td>
<td>0.56-0.87</td>
</tr>
<tr>
<td>C8 right</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>C8 left</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
* kappa statistics could not be calculated
root compression these were almost equal (tables 1, 2, 3). Kappa scores could not be calculated for the C8 segments due to the absence of abnormalities.

**Agreement after disclosure of clinical information**

After disclosure of the side and clinical expected level of root compression, the neuroradiologists re-evaluated all MRI images. One neuroradiologist changed his assessment once: ‘indeterminate’ root compression was altered in ‘possibly’ root compression. The other neuroradiologist changed four assessments of three separate MRI examinations. The degree of root compression was altered in two patients: in one of these two cases a herniated disc that was seen before disclosure was now not observed, in another case foraminal stenosis on top of an already detected herniated disc was noted.

After disclosure of clinical information the interobserver agreement and kappa scores did increase, but not significantly; the kappa of overall herniated discs changed from 0.59 (CI 0.40-0.77) to 0.62 (CI 0.43-0.80) and that of spondylotic foramen stenosis from 0.63 (CI 0.46-0.81) to 0.66 (CI 0.49-0.83). For blinded MRI evaluation the kappa of root compression was 0.67 (CI 0.43-0.90) and after disclosure 0.76 (CI 0.57-0.96).

**Discussion**

Our study showed an overall kappa of 0.67 for the detection of root compression on MRI in a series of patients with well defined subacute onset cervical radiculopathy. This can be interpreted as substantial agreement. In 9% of the 624 examined segments no agreement was found on the clinically most important question, whether root compression was present or not. These results allow neuroradiologists to report on this condition with confidence. Although cervical spine MRI is routinely used as a diagnostic tool in patients with cervical radiculopathy, in particular in those who fail conservative treatment and are candidates for surgery, the interobserver variability of neuroradiological interpretation has, surprisingly, never been studied to our knowledge.

Several studies assessed interobserver agreement in evaluation of cervical MRI examinations, but patients with clinically well-defined cervical radiculopathy were not included in any of those studies. The kappa value in our study is slightly lower than that found in a study where a grading system for cervical disc degeneration was evaluated in
Interobserver agreement on MRI evaluation

patients with unspecified cervicobrachial pain. This grading system, based on nucleus signal intensity and structural homogenity yielded a kappa of 0.73 to 0.83. 11 Others have used grading systems for cervical disc MRI properties as well, 12 13 but none focused on the presence of root compression making a direct comparison of the results of these studies with ours less relevant. Apart from the fact that no grading systems for cervical root compression are available we prefer to stay close to the clinical practice in which grading systems are not used on a routine basis.

In earlier studies on cervical spine MRI a wide range of kappa scores was reported. In a study assessing 10 patients with cervical myelopathy high agreement, but low kappa scores ranging from -0.12 to 0.51 were found, mainly due to methodological choices. 14 Another study investigated interobserver agreement on cervical spine MRIs in patients complaining of dizziness, without neck or arm pain. This study showed a moderate agreement on spinal cord compression (kappa 0.53), but did not include herniated discs or root compression. 15 Therefore, these studies can not be compared with our cohort encompassing patients with cervical radiculopathy.

In a study on interobserver agreement on the evaluation of disc herniation and root compression in patients with lumbar radiculopathy, kappa scores of 0.63 and 0.77, respectively, were found. 5 The methodology of this study is comparable with that of ours and the kappa values are within the same range.

We found a strikingly low prevalence of root compression at level C5 and C8 compared to C6 and C7 which has also been shown in other studies. Reported percentages of compression of root C5 range from 2-7% and of root C8 from 6-12%, compared to 18-19% at C6 and 46-69% at C7. 16-18 The low prevalence of abnormalities at levels C4-5 and C7-Th1 in our study can probably be explained by a selection bias since we only included patients with pain radiating below the elbow whereas in C5 radiculopathy pain is mostly perceived in the upper arm. We cannot explain why our series did not encompass patients with C8 radiculopathy. At levels C5 and C8 agreement was high, but due to low prevalence of abnormalities kappa scores were low 10 19 20 : a kappa score at C8 could even not be calculated due to the complete agreement on the absence of herniated discs, spondylotic foramen stenosis and root compression.

A difference was found between percentages of agreement for the assessment of disc herniation and spondylotic foramen stenosis (80.8% and 82.1%, respectively) and that of
root compression (91.0%). Also kappa scores were higher for the latter. In other words, the presence of root compression itself is more reliably detected than the cause of root compression.

After disclosure of the level and side of the radiculopathy by the neurologist the neuroradiologists reported root compression more frequently, but interobserver agreement did not increase significantly. The same results were observed in a study assessing kappa scores in lumbar herniated discs, which did not change significantly after unblinding. More bulging discs without root compression were seen but interobserver agreement remained unaltered. A limitation of the present study is that the evaluation with clinical information occurred directly after the blinded evaluation possibly leading to underestimation of the differences between the two evaluations. In addition, all our patients had a cervical radiculopathy on clinical grounds and, therefore, the initial radiological evaluation was only partly blind. Therefore we still are of the opinion that clinical information is a useful adjunct to the radiological evaluation.

Conclusion

There is substantial interobserver agreement between neuroradiologists for the detection of root compression on MRI in a series of patients with well-defined recent onset cervical radiculopathy, with or without clinical information. Agreement on the cause of root compression i.e., disc herniation and spondylotic foraminal stenosis is less robust.


Chapter 3


