Original Study

Static and dynamic cervical MRI: two useful exams in cervical myelopathy

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Background: Cervical magnetic resonance imaging (MRI) is the gold standard exam in the assessment of patients affected by cervical myelopathy and is very useful in planning the operation. Herein we present a series of patients affected by long tract symptoms who underwent dynamic MRI in addition to the static exam.
Methods: In the period between March 2010 and March 2012, three-hundred-ten patients referred to our department since affected by neck/arm pain or symptoms related to cervical myelopathy. Thirty-eight patients complained "long-tract symptoms" related to cervical myelopathy. This series of patients was enrolled in the study. All patients underwent clinical and neurological exam. In all the cases, a static and dynamic cervical MRI was executed using a 3.0-T superconducting MR unit (Intera, Philips, Eindhoven, Netherlands). The dynamic exam was performed with as much neck flexion and extension the patient could achieve alone. On T2-weigthed MRI each level was assessed independently by two neuroradiologists and Muhle scale was applied.
Results: According to Muhle's classification of spinal cord compressions, static MRI demonstrated 156 findings: 96 (61.54%) anterior and 60 (38.46%) posterior. Dynamic MRI showed 186 spinal cord compressions: 81 (43.5%) anterior and 105 (56.5%) posterior. The anterior compressions were: grade 1 in 23 cases (28.4%), grade 2 in 52 cases (64.2%), grade 3 in 6 cases (7.4%). The posterior compressions were: 32 (30.48%) of grade 1, 60 (57.14%) of grade 2, 13 (12.38%) of grade 3.
Conclusions: The dynamic MRI demonstrated a major number of findings and spinal cord compressions compared to the static exam. Finally, we consider the dynamic exam able to provide useful information in these patients, but we suggest a careful evaluation of the findings in the extension exam since they are probably over-expressed.

Keywords: Dynamic cervical MRI; extension cervical MRI; cervical myelopathy

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Introduction

Magnetic resonance imaging (MRI) of the cervical spine is extremely useful in assessing pathological changes at the spinal cord, vertebrae, discs, ligaments and facet joints (1).

It provides excellent anatomical information about the spinal cord macrostructure and its histopathological changes (2). Nevertheless, in patients affected by symptoms due to cervical spondylosis, multiple findings with spinal cord compression are usually demonstrated with MRI and different surgical options are available.

In this study, we evaluate the findings at the static and dynamic (flexion-extension) cervical MRI in a series of patients affected by "long-tract symptoms".

Methods

In the period between March 2010 and March 2012, three-hundred-ten patients referred to our department since

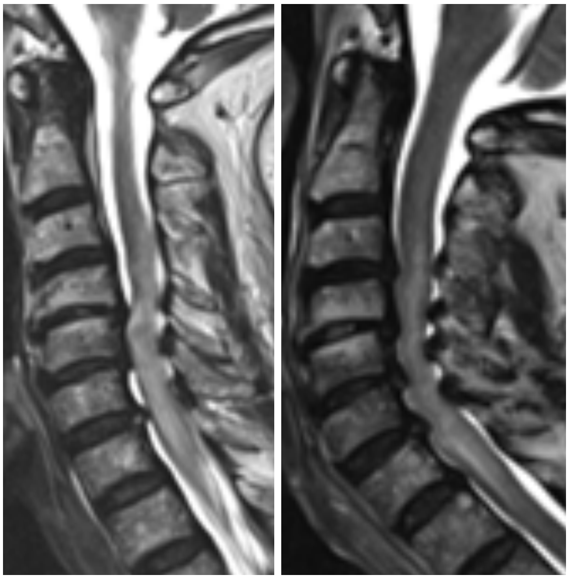

Figure 1 Case #12: static MRI was classified as C4-C5 2ap, C5-C6 2ap, C6-C7 2ap. Extension MRI showed C3-C4 2ap, C4-C5 3ap, C5-C6 3ap, C6-C7 3ap, C7-T1 1a.

affected by neck/arm pain or symptoms related to cervical myelopathy. Fifty-eight patients were excluded since affected by tumors, spondylodiscitis, deformity or trauma. Two-hundred-fourteen patients complained neck pain or symptoms related to cervical radiculopathy and were excluded from the study. Thirty-eight patients complained "long-tract symptoms" related to cervical myelopathy. This series of patients was enrolled in the study. All patients underwent clinical and neurological exam. In all the cases, a static and dynamic cervical MRI was executed using a 3.0-T superconducting MR unit (Intera, Philips, Eindhoven, Netherlands). The dynamic exam was performed with as much neck flexion and extension the patient could achieve alone. Custom-built positioning sponges were positioned under the head for flexion and under the shoulder for extension. T1- and T2-weighted sequences were obtained in sagittal and axial plane for the static exam, only T2-weighted images were executed for the dynamic exam. On T2-weigthed MRI each level was assessed independently by two neuroradiologists (example in *Figure 1*) and Muhle scale was applied (3).

Statistical analysis

All statistical analyses were performed using the PASW Statistics 18 Version 18 (SPSS, Inc., 2009, Chicago, IL, USA).

Results

A total of 38 patients were definitively enrolled in the study (*Table 1*). They were 16 males (42.1%) and 22 females (57.9%), mean age 62.26 (SD =8.72). The symptoms referred were: generalized gait disturbances in 14 cases (36.8%), paresthesia in 7 cases (18.4%), hypoesthesia in 7 cases (18.4%), weakness in 4 cases (10.5%), stiffness in 4 cases (10.5%) and urinary disturbances in 2 cases (5.3%). According to Muhle's classification of spinal cord compressions static MRI demonstrated 156 findings (*Figure 2*): 96 (61.54%) anterior and 60 (38.46%) posterior. The anterior compressions were: grade 1 in 41 cases (42.7%), grade 2 in 51 cases (53.12%), grade 3 in 4 cases (4.18%). The posterior compressions were: 42 (70%) of grade 1, 14 (23.3%) of grade 2 and 4 (6.7%) of grade 3.

Dynamic MRI showed 186 spinal cord compressions (*Figure 3*): 81 (43.5%) anterior and 105 (56.5%) posterior. The anterior compressions were: grade 1 in 23 cases (28.4%), grade 2 in 52 cases (64.2%), grade 3 in 6 cases (7.4%). The posterior compressions were: 32 (30.48%) of grade 1, 60 (57.14%) of grade 2, 13 (12.38%) of grade 3.

Discussion

In this study, we report our experience in using the dynamic cervical MRI in addition to the static exam. The dynamic exam was executed in a series of patients affected by long tract symptoms in which there was not a clear surgical plan. The findings at the static and dynamic exam with the relative grade of spinal cord compression are reported.

Muhle proposed a new classification system analysing eighty-one patients with different stages (I–IV) of degenerative disease of the cervical spine examined with MRI. He classified each segment as: 0= normal, 1= partial obliteration of the anterior or posterior subarachnoid space, 2= complete obliteration of subarachnoid space and 3= cervical cord compression or displacement.

The antero-posterior diameter of the spinal canal has been reported to be increased in flexion and decreased in extension (4).

Sayit *et al.* (5) investigated the dynamic change of the ligamentum flavum in the cervical spine using dynamic MRI. They reported that ligamentum flavum at C7-T1 was significantly thicker than C2-3 to C6-C7. It was significantly thicker in extension than flexion at C3-C4 to C6-C7.

Somatosensory evoked potentials (SSEPs) during dynamic motion of the cervical spine and the efficacy of

Table 1 Shows age/sex, symptoms, static and dynamic MRI findings for each patient

Case	Age/sex	Symptoms	Static cervical MRI findings	Dynamic cervical MRI findings
1	54/M	Gait disturbances	C3-C4 1ap; C4-C5 1ap; C5-C6 1ap	C3-C4 2p; C4-C5 2p; C5-C6 2p
2	53/F	Gait disturbances	C5-C6 2a; C6-C7 2a	C3-C4 2p; C4-C5 2p; C5-C6 2a3p
3	57/F	Lower limb paresthesia	C3-C4 1p; C4-C5 1ap; C6-C7 2a	C3-C4 1p; C4-C5 1ap; C6-C7 2a
4	73/F	Lower limb hypoesthesia	C3-C4 1p; C4-C5 1p; C5-C6 3a	C3-C4 2ap; C4-C5 2ap; C5-C6 3ap
5	62/M	Lower limb weakness	C6-C7 3a1p	C6-C7 3a2p
6	55/M	Gait disturbances	C4-C5 2a1p; C5-C6 2a1p; C6-C7 2a1p; C7-T1 1a	C4-C5 2ap; C5-C6 2ap; C6-C7 2ap; C7-T1 1ap
7	48/F	Gait disturbances and urinary incontinence	C4-C5 2a1p; C5-C6 2a; C6-C7 1ap	C3-C4 1p; C4-C5 2a1p; C5-C6 2a1p; C6-C7 1ap
8	63/F	Lower limb weakness	C5-C6 2a1p; C6-C7 2a1p	C5-C6 2a; C6-C7 2a1p
9	72/M	Lower limb paresthesia	C4-C5 1ap; C5-C6 1ap; C6-C7 2a	C3-C4 1p; C4-C5 2p; C5-C6 2p
10	63/F	Left side paresthesia	C3-C4 2a; C4-C52a; C5-C6 2a	C3-C42a1p; C4-C52a1p; C5-C6 2a1p
11	55/M	Gait disturbances	C4-C5 2a; C5-C6 1a; C6-C7 1a	C4-C5 1a3p; C5-C6 1a3p
12	49/F	Lower limb stiffness	C4-C5 2ap; C5-C6 2ap; C6-C7 1ap	C3-C4 2ap; C4-C5 3ap; C5-C6 3ap; C6-C7 3ap; C7-T1 1a
13	71/F	Gait disturbances	C5-C6 2a; C6-C7 2a; C7-T1 1a	C5-C6 2ap; C6-C7 2ap; C7-T1 1a
14	55/M	Lower limb paresthesia	C4-C5 1ap; C5-C6 1ap; C6-C7 1ap	C4-C5 1a2p; C5-C6 1a2p; C6-C7 1a2p
15	74/F	Lower limb hypoesthesia	C3-C4 2a; C4-C5 2a; C5-C6 2a	C3-C4 2a1p; C4-C5 2a1p; C5-C6 2a1p
16	52/M	Left side weakness	C4-C5 1ap; C5-C6 2ap	C4-C5 2ap; C5-C6 2a3p
17	76/F	Gait disturbances	C5-C6 2ap; C6-C7 2ap	C5-C6 2ap; C6-C7 2ap
18	63/F	Left side paresthesia	C5-C6 2a; C6-C7 1p	C4-C5 1p; C5-C6 1p; C6-C7 2p
19	69/F	Lower limb hypoesthesia	C2-C3 1a; C3-C4 2a; C4-C5 2a1p; C5-C6 1p	C2-C3 1a; C3-C4 2a; C4-C5 2a3p; C5-C6 3p
20	57/M	Lower limb stiffness	C4-C5 1ap; C5-C6 2ap; C6-C7 1p	C4-C5 2ap; C5-C6 2ap; C6-C7 2p
21	78/F	Gait disturbances	C5-C6 2a; C6-C7 2a	C4-C5 2p; C5-C6 2ap; C6-C7 2ap
22	70/F	Lower limb hypoesthesia	C3-C4 1ap; C4-C5 1ap; C5-C6 1ap; C6-C7 2a	C3-C41a2p; C4-C51a2p; C5-C61a2p; C6-C7 2a2p
23	60/M	Right side weakness	C5-C6 2a; C6-C7 1a	C4-C5 1p; C5-C6 2a1p; C6-C7 2p
24	52/F	Gait disturbances	C4-C5 2a; C5-C6 2a	C4-C5 2a3p; C5-C6 2a3p
25	58/M	Gait disturbances	C4-C5 1ap; C5-C6 2ap	C4-C5 3p; C5-C6 2ap; C6-C7 2p
26	65/F	Lower limb hypoesthesia	C4-C5 1a; C5-C6 1ap; C6-C7 1ap	C4-C5 2p; C5-C6 2p; C6-C7 2p
27	75/F	Lower limb hypoesthesia	C3-C4 1ap; C4-C5 1ap; C5-C6 2ap	C3-C4 2p; C4-C5 2p; C5-C6 2p
28	64/M	Left side paresthesia	C4-C5 2p; C5-C6 2p; C6-C7 2p	C4-C5 2p ; C5-C6 2p; C6-C7 2p
29	50/M	Lower limb stiffness	C4-C5 2ap; C5-C6 1ap; C6-C7 1ap	C4-C5 1a2p; C5-C6 1a2p; C6-C7 1a2p
30	66/F	Lower limb stiffness	C4-C5 1a; C5-C6 2a	C5-C6 2ap; C6-C7 2p
31	59/M	Left side paresthesia	C5-C6 2a; C6-C7 1a	C5-C6 2p; C6-C7 2ap
32	52/M	Gait disturbances	C3-C4 1ap; C4-C5 1ap; C5-C6 1ap	C3-C4 1a2p; C4-C5 12p; C5-C6 1a2p
33	74/F	Lower limb hypoesthesia and increase in urinary frequency	C2-C3 1a; C3-C4 2a; C4-C5 2a; C5-C6 2a	C2-C3 1ap; C3-C4 2a1p; C4-C5 2a1p; C5-C6 2a1p
34	57/M	Gait disturbances	C4-C5 1ap; C5-C6 1ap	C4-C5 2ap; C5-C6 2ap
35	69/F	Gait disturbances	C5-C6 1ap; C6-C7 1ap	C4-C5 1p; C5-C6 2a1p; C6-C7 2a1p
36	58/M	Right side hypoesthesia	C3-C4 1ap; C4-C5 1ap; C5-C6 2a	C4-C5 1a2p; C5-C6 1a2p
37	62/F	Gait disturbances	C4-C5 1ap; C5-C6 2ap	C5-C6 2ap; C6-C7 3a2p
38	76/F	Gait disturbances	C5-C6 2a; C6-C7 2a	C4-C5 1p; C5-C6 2a1p; C6-C7 2a1p

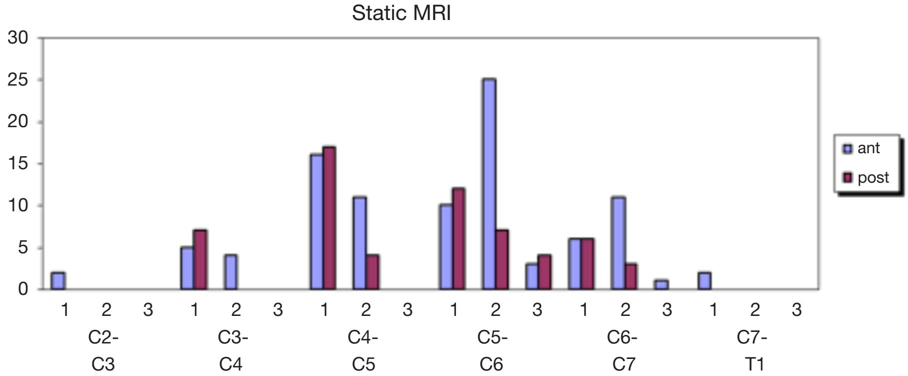

Figure 2 Shows static MRI findings at Muhle grade for each level.

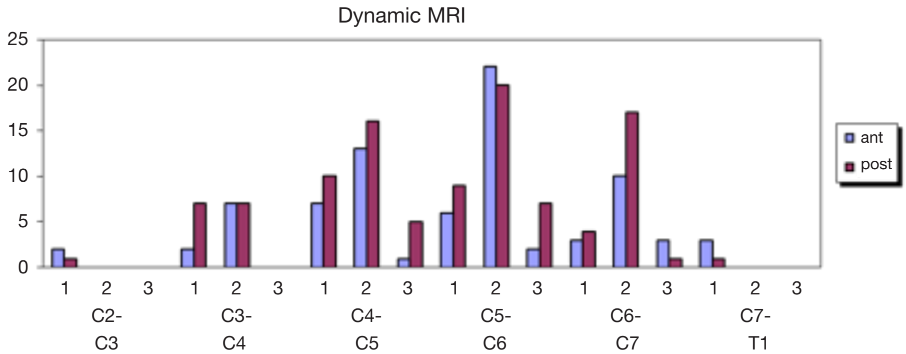

Figure 3 Shows dynamic MRI findings at Muhle grade for each level.

dynamic SSEPs have been evaluated in patients with cervical spondylotic myelopathy. SSEPs tended to deteriorate after cervical spine extension and the percent latency and amplitude progressively increased during cervical spine extension in these patients (6).

Yu *et al.* (7) studied 71 patients affected by cervical myelopathy with and without hyperintensity on T2W MRI and the Cobb angle on cervical flexion-extension radiographs. He concluded that increased segmental hyperextension curvature (≥10°) and range of movement (ROM) are risk factors for high intensity lesions on T2W MRI in these patients.

An analysis of extension MRI found an increased number of compression levels in 72% of patients as compared to the findings of static MRI. The interpretation of asymptomatic spinal compressions based exclusively on extension MRI has been warned to be made with caution (8).

Our study demonstrates that dynamic MRI found more spinal cord compression than static MRI (186 *vs.* 156). The static exam showed a prevalence of anterior compressions (61.54%), while the dynamic one demonstrated prevalence of posterior compressions (56.5%). The posterior compressions in static MRI are in 70% of grade 1, while in dynamic MRI they are in 57.14% of grade 2. Basing on the additional dynamic exams we obtained more radiological information and this helped us in defining the surgical plan. After the acquisition of static T1- and T2-weighted images, only T2-weighted images were performed for the dynamic exam. The positioning of the neck was easily executed using custom-built sponges and the dynamic exam required an acquisition time of a few minutes more (15–20 minutes in total for static and dynamic MRI) with a slightly higher cost. Finally, we consider the dynamic cervical MRI an additional exam with a slightly higher acquisition time and cost, however it adds useful radiological information to the surgical plan. This exam can be particularly useful for the treatment of patients affected by cervical myelopathy, since their neurological exam does not usually give information about the level to operate and many surgical options are available. The high rate of radiological findings in extension images suggests its careful evaluation and integration with flexion images.

Conclusions

Dynamic cervical MRI shows a major number of findings compared to static MRI with a prevalence of posterior ones, which are in 57.14% with complete obliteration of subarachnoid space. Its use in conjunction with static MRI may be useful in patients affected by cervical myelopathy in order to plan the operation, but a careful evaluation of the posterior findings should be done since they are probably overexpressed by dynamic MRI.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by our Institution and written informed consent was obtained from all patients.

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