

Summer 8-13-2016

Dynamic MRI to Diagnose Spinal Canal Stenosis not Visualized on Standard Static MRI in patients with Cervical Spondylotic Myelopathy

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Dynamic MRI to Diagnose Spinal Canal Stenosis not Visualized on Standard Static MRI in patients with Cervical Spondylotic Myelopathy

Abstract

Background:

Cervical Spondylotic Myelopathy (CSM) is a common disease of the cervical spine that affects people during and after middle age. To date, imaging performed preoperatively consists of MRI of the cervical spine in neutral position. Dynamic factors contribute to canal stenosis and spinal cord compression, and it has been suggested that dynamic MRI may help to identify cervical canal stenosis and cord compression that are not revealed with standard MRI imaging of the neck in neutral position. Observational studies using flexion and extension MRI in addition to neutral position MRI in CSM patients will be reviewed to determine the importance of the addition of dynamic MRI to preoperative evaluation of CSM.

Methods:

An exhaustive medical literature search was performed using MEDLINE-Ovid, MEDLINE-PubMed, Web of Science, and Clinical Key. All searches were conducted using the following search items: dynamic MRI and spinal cord compression. Relevant articles for inclusion were assessed for quality using GRADE.

Results:

The search resulted in 62 articles of which only two studies met inclusion criteria. The results from both the Zeituon et al and Harada et al studies demonstrate that dynamic MRI in the preoperative evaluation of Cervical Spondylotic Myelopathy visualizes more levels of spinal cord compression than neutral position MRI alone. The Zeituon et al showed that stages of canal stenosis were found to be higher in extension than when compared to flexion or neutral position, and also that hyperintense intramedullary lesions (HILs) are better identified in flexion MRI when compared to neutral or extension position. The Harada et al study showed that with the neck extended for MRI, the number of cord compressions in the cervical spine increased for each intervertebral level of the cervical spine.

Conclusion:

Based on the study results, MRI should be done preoperatively in both neutral and extension positions in order to effectively evaluate spinal cord compression in patients with cervical myelopathy undergoing laminoplasty for spinal cord decompression.

Degree Type

Capstone Project

Degree Name

Master of Science in Physician Assistant Studies

First Advisor

Mark Pedemonte, MD

Keywords

Cervical Spondylotic Myelopathy, spinal cord compression, Dynamic MRI, flexion, extension

Subject Categories

Medicine and Health Sciences

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**Dynamic MRI to Diagnose Spinal Canal Stenosis not
Visualized on Standard Static MRI in patients With Cervical
Spondylotic Myelopathy**

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A Clinical Graduate Project Submitted to the Faculty of the

School of Physician Assistant Studies

Pacific University

Hillsboro, OR

For the Masters of Science Degree, August 13th 2016

Faculty Advisor: Mark Pedemonte, MD

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Biography

Gabrielle Engelhard is a native of Washington where she received a Bachelor of Science in Psychology at Washington State University. She worked as a Certified Nursing Assistant at an assisted living facility while volunteering at a local hospital after graduation to gain valuable patient care experience prior to PA school. She is thankful to have gotten into her top preferred PA program at Pacific University and is excited for her future career as a Physician Assistant.

Abstract

Background:

Cervical Spondylotic Myelopathy (CSM) is a common disease of the cervical spine that affects people during and after middle age. To date, imaging performed preoperatively consists of MRI of the cervical spine in neutral position. Dynamic factors contribute to canal stenosis and spinal cord compression, and it has been suggested that dynamic MRI may help to identify cervical canal stenosis and cord compression that are not revealed with standard MRI imaging of the neck in neutral position. Observational studies using flexion and extension MRI in addition to neutral position MRI in CSM patients will be reviewed to determine the importance of the addition of dynamic MRI to preoperative evaluation of CSM.

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Keywords:

Cervical Spondylotic Myelopathy, spinal cord compression, Dynamic MRI, flexion, extension

Acknowledgements

To *my parents*: Thank you for supporting me through all of my personal and career endeavors. You have instilled in me the desire to pursue my every goal and dream, to help and empathize with others, and to explore life to its fullest extent.

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Table I: Quality Assessment of Reviewed Articles

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List of Abbreviations

CSM.....Cervical Spondylotic Myelopathy
HIL.....Hyperintense Intramedullary Lesion
MRI.....Magnetic Resonance Imaging
GRADE.....Grading of Recommendations, Assessment, Development and Evaluations

Dynamic MRI to Diagnose Spinal Canal Stenosis not Visualized on Standard Static MRI in patients With Cervical Spondylotic Myelopathy

BACKGROUND

Cervical spondylotic myelopathy (CSM) is one of the most common diseases of the cervical spine that occurs during and after middle age.¹⁻³ Cervical spondylosis is a chronic degenerative condition of the cervical spine that is caused by combinations of the following: vertebral disc protrusion, osteophyte formation, facet joint degeneration, and hypertrophy of the ligamentum flavum. It has been reported that there are dynamic factors that also contribute to canal stenosis, such as infolding of the ligamentum flavum with extension of the neck.^{4,5} Both mechanical and dynamic factors play a role in the pathophysiology of myelopathy.⁴

Cervical spinal cord compression, or cervical myelopathy, is a serious condition that requires prompt surgical intervention to minimize damage to the spinal cord and preserve its function, and to prevent further progression of the disease and its associated symptoms. In patients with cervical myelopathy, a surgical decompressive laminoplasty is commonly performed to decompress the spinal cord.¹ Preoperatively, magnetic resonance imaging (MRI) of the cervical spine can be used to determine the levels of the cervical spine that require decompression. To date, imaging performed preoperatively consists of MRI of the cervical spine in neutral position only, while dynamic MRI of the cervical spine in flexion and extension positions is not routine in evaluating CSM.⁵ If dynamic MRI can visualize levels of spinal cord compression that

are not visualized on standard neutral MRI, it could lead to the potential modification of surgical preoperative imaging, which in turn could influence surgical technique.

Dynamic MRI studies^{5,6} have been performed recently to define changes that occur in the spinal cord during flexion and extension of the cervical spine, as well as the subarachnoid space. Based on the findings, it has been suggested that dynamic MRI may help to identify significant cervical canal stenosis and spinal cord compression that are not revealed with standard MRI imaging of the neck in neutral position. Although it has been determined in studies^{5,6} that changes in the spinal canal occur during flexion and extension positions of the neck, there is a lack of evidence to support the implementation of dynamic MRI into routine preoperative procedure. This systematic review is to determine the effectiveness of dynamic MRI in diagnosing spinal cord stenosis and compression in the assessment of CSM preoperatively, when compared to static or neutral MRI alone.

METHODS

An exhaustive search of available medical literature was performed using MEDLINE-Ovid, MEDLINE-PubMed, Web of Science, and Clinical Key. All searches were conducted using the following search items: dynamic MRI and spinal cord compression. Inclusion criteria consisted of the evaluation of patients with a diagnosis of cervical spondylotic myelopathy, and the use of dynamic MRI with flexion and extension views compared to MRI in neutral position to diagnose cervical stenosis and myelopathy. The search was then narrowed to include only studies written in the English language and studies involving humans. Relevant articles' bibliographies were

reviewed to expand the search. Studies were evaluated for quality using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE).⁷

RESULTS

The initial result of the search yielded 62 articles. After screening for relevancy, three articles^{1,5,8} remained, and two^{1,8} met all eligibility criteria. One article⁵ evaluated the same group of subjects that were evaluated in a more recent article,⁸ and was therefore excluded to avoid duplication of findings.

Zietuon et al

This is a retrospective case series study⁸ of 51 patients who underwent dynamic and neutral cervical MRI preoperatively during October 2005 through February 2007 at Pitie-Salpetriere Hospital in Paris, France. The mean age of patients was 60.3 (range, 36-89 years old), and consisted of 33 males and 18 females. Patients were selected if they had clinical signs of myelopathy and cervical canal spondylosis signs on X-ray and MRI, with no other cause of cervical myelopathy found. Patients diagnosed with cervical spondylotic myelopathy had cervical MRI performed in neutral, flexion, and extension positions of the cervical spine as part of their preoperative evaluation for cervical decompressive surgery.⁸

A 1.5 T MR unit was used to examine the patients. Imaging in the neutral position consisted of sagittal T1-weighted and sagittal T2-weighted sequences. Sandbags were used during the MRI in extension and placed under the patient's shoulders. The extension MRI consisted of sagittal T2-weighted sequence and axial sequences from C3-T1. The flexion MRI consisted of sagittal T2-weighted sequence. Axial T2-weighted

sequence was performed in the flexion position only if a hyperintense intramedullary lesion (HIL) was noted, whose significance with regards to prognostic outcome of CSM is still controversial in literature⁹ at this time.⁸

An experienced radiologist evaluated the images. The angles at which flexion and extension images were performed were not fixed, in order to prevent potential neurological decline during the imaging process. Patients put themselves in comfortable flexion and extension positions, causing angles to not be consistent across patients in the study group.⁸

The study measured cervical canal stenosis using Muhle classification⁶ (see Table II) with each position of the cervical spine between C3 and T1 on the sagittal T2-weighted sequence passing through the spinous processes in each of the three positions, and further assessed the presence or absence of HILs on T2 weighted images. Means of stages at each level and at each position were analyzed as a quantitative variable, and significant results were assumed on the 5% level ($p < 0.05$). Analysis showed that 6 levels were graded as stage 3 in the flexion position, 16 in the neutral, and 68 in extension. From C3 to C6, around 22.5% of stage 3 levels in the extension were stage 1 in the neutral position, which implies that those lesions would not be identified if using standard neutral MRI alone. At every level evaluated in the study, higher stages of canal stenosis were found in the extension position compared to the stages found in the neutral and flexion positions ($p < 0.05$), with the only exception being at the C7-T1 level. Higher stages were also found in the neutral position compared with stages in the flexion position in the C4-C5 and C5-C6 levels ($p < 0.05$). With regards to HILs, 22 patients did not have any HILs on images in all three positions,

29 patients had HILs on flexion sequences, and 5 patients had HILs visualized only in flexion.⁸

Harada et al

This is a prospective study¹ of 54 patients with CSM who underwent a selective laminoplasty surgical procedure with dynamic MRI imaging preoperatively. The study was completed by the Orthopaedic Department of the Graduate School of Medical Science in Kyoto, Japan. The study was conducted to evaluate the clinical usefulness of dynamic MRI to select levels for decompression of the spinal cord. Current practice utilizes preoperative MRI completed in the neutral position to select levels of the spine to be surgically decompressed. This study added dynamic MRI in flexion and extension views to visualize levels of stenosis that may not be visible in the neutral position.¹

The mean age of patients was 65.4 years (range 48-89), and consisted of 33 males and 21 females. Patients were selected with inclusion criteria of having been diagnosed with CSM. Patients were excluded if found to have ossification of the posterior longitudinal ligament, rheumatoid arthritis and developmental canal stenosis, cervical instability, or abnormalities in alignment on flexion-extension X-rays. A selective laminoplasty was performed, with preoperative evaluation consisting of cervical dynamic MRI in flexion, neutral, and extension views. These images were used to select levels requiring decompression using surgery.¹

Each level of the cervical spine was evaluated from C2/3 to C6/7 for any spinal cord compression that occurred during each of the three positions, with cervical cord compression defined as a complete obliteration of both the anterior and posterior subarachnoid space in any position of the cervical spine. Patients were divided into two

groups, in order to further evaluate clinical outcomes postoperatively: all patients under 65 years old and patients 65 and older. ¹

The results of the study found that the number of cord compressions for each intervertebral level in the flexion position were 1 at C2/3, 6 at C3/4, 5 at C4/5, 10 at C5/6, and 5 at C6/7. In the neutral position, there were 1 at C2/3, 10 at C3/4, 28 at C4/5, 40 at C5/6, and 23 at C6/7. In the extension position, 4 at C2/3, 30 at C3/4, 44 at C4/5, 52 at C5/6, and 41 at C6/7. There was no case in the flexion position compared to neutral and extension positions where the number of cord compressions increased. Appearance ratios of cord compression were evaluated to compare the two groups (under 65 and 65 and over), which found that the ratios were high in the 65 and over group compared to the under 65 group, and especially high for the C2/3, C3/4 and C4/5 intervertebral levels. ¹

DISCUSSION

The data in the studies reviewed ^{1,8} suggest that a preoperative MRI in neutral position alone is potentially missing levels of spinal cord compression in the cervical spine that may benefit from surgical decompression. As demonstrated by the two studies, ^{1,8} the addition of flexion and extension MRI of the cervical spine allows more levels of spinal canal stenosis to be identified compared to neutral position alone during the preoperative evaluation of patients with cervical myelopathy. This data has the potential to modify future preoperative evaluation of cervical myelopathy, which may also impact initial surgical technique and strategy. Worth noting is that there are significantly more levels of spinal canal stenosis and compression seen in extension when compared to neutral position as shown in both studies. ^{1,8}

Although there are not significantly more levels of spinal cord compression seen in flexion when compared to neutral, hyperintense intermedullary lesions are visualized more often in flexion than compared to neutral or extension positions.⁸ HILs visualized on MRI can suggest various changes in the spinal cord, including gliosis, demyelination, ischemia, and edema. HILs importance in the literature varies, with some authors suggesting that they are an indicator of poorer surgical prognosis.¹⁰ Zeituon et al⁸ suggested that HILs are important to be discovered before surgery, as the visualization of a lesion post-operatively might be attributed to a surgical incident or error.

Prior to the two studies reviewed, several studies^{2,6} attempted to evaluate and quantify dynamic changes of the cervical spine, but most were researching dynamic changes in the healthy patient. The Zeituon et al⁸ and Harada et al¹ studies help to emphasize that dynamic factors are of much importance in the evaluation of the cervical spine in patients with CSM, and that MRI in extension can visualize significantly more levels of spinal stenosis and compression in the preoperative assessment. Zeituon et al⁸ further found that HILs are visualized most often in flexion. There are a few limitations to these studies however. Neither study had predetermined angles set for the extension and flexion MRI of the cervical spine, which could be an issue of consistency. This caused variation in the angles across the patients groups while preventing any neurological deterioration during the time while performing the imaging. Another limitation of both studies are the smaller sample sizes of 51 and 54.

Further research should be conducted using larger sample sizes to study the use of dynamic MRI to select decompression levels for surgical intervention of CSM, with attention to the modification of the surgical plan based on the results of the imaging.

Studies to further research the importance and prognostic impact of hyperintense intramedullary lesions found with dynamic MRI should also be conducted.

CONCLUSION

Dynamic MRI with extension views is an effective and non-invasive imaging study for the diagnosis of spinal stenosis and compression used preoperatively, and should be utilized in addition to neutral position MRI as it is able to visualize more levels of cord compression. MRI with flexion views is effective in visualizing hyperintense intramedullary lesions that are not visualized on neutral MRI. Although the importance of these lesions are uncertain at this time, there may be prognostic significance associated. This information has significance in the evaluation of patients with CSM and the preoperative evaluation prior to decompression of the spinal cord. Use of dynamic MRI allows more precision, and may impact surgical strategy and modify future standards in the evaluation of cervical myelopathy.

References

1. Harada T, Tsuji Y, Mikami Y, et al. The clinical usefulness of preoperative dynamic MRI to select decompression levels for cervical spondylotic myelopathy. *Magn Reson Imaging*. 2010;28(6):820-825. Accessed 20100712. doi: <http://dx.doi.org/10.1016/j.mri.2010.03.038>.
2. Kuwazawa Y, Bashir W, Pope MH, Takahashi K, Smith FW. Biomechanical aspects of the cervical cord: Effects of postural changes in healthy volunteers using positional magnetic resonance imaging. *J Spinal Disord Tech*. 2006;19(5):348-352. Accessed 20060707.
3. Miura J, Doita M, Miyata K, et al. Dynamic evaluation of the spinal cord in patients with cervical spondylotic myelopathy using a kinematic magnetic resonance imaging technique. *J Spinal Disord Tech*. 2009;22(1):8-13. Accessed 20090204. doi: <http://dx.doi.org/10.1097/BSD.0b013e31815f2556>.
4. Fehlings MG, Skaf G. A review of the pathophysiology of cervical spondylotic myelopathy with insights for potential novel mechanisms drawn from traumatic spinal cord injury. *Spine*. 1998;23(24):2730-2737. Accessed 19990311.
5. Zhang L, Zeitoun D, Rangel A, Lazennec JY, Catonne Y, Pascal-Moussellard H. Preoperative evaluation of the cervical spondylotic myelopathy with flexion-extension magnetic resonance imaging about a prospective study of fifty patients. *Spine*. 2011;36(17):E1134-E1139. doi: 10.1097/BRS.0b013e3181f822c7.

6. Muhle C, Wiskirchen J, Weinert D, et al. Biomechanical aspects of the subarachnoid space and cervical cord in healthy individuals examined with kinematic magnetic resonance imaging. *Spine*. 1998;23(5):556-567. Accessed 19980507.
7. Grade working group. GRADE guidelines. <http://Gradworkinggroup.org>. Accessed 4/19, 2016.
8. Zeitoun D, El Hajj F, Sariali E, Catonne Y, Pascal-Moussellard H. Evaluation of spinal cord compression and hyperintense intramedullary lesions on T2-weighted sequences in patients with cervical spondylotic myelopathy using flexion-extension MRI protocol. *Spine J*. 2015;15(4):668-674. Accessed 20150325. doi: <http://dx.doi.org/10.1016/j.spinee.2014.12.001>.
9. Suri A, Chhabra RPS, Mehta VS, Gaikwad S, Pandey RM. Effect of intramedullary signal changes on the surgical outcome of patients with cervical spondylotic myelopathy. *Spine J*. 2003;3(1):33-45. Accessed 20031031.
10. Wada E, Yonenobu K, Suzuki S, Kanazawa A, Ochi T. Can intramedullary signal change on magnetic resonance imaging predict surgical outcome in cervical spondylotic myelopathy?. *Spine*. 1999;24(5):455-461. Accessed 19990504.

Table I. Quality Assessment of Reviewed Articles

Study	Design	Downgrade Criteria					Upgrade Criteria	Quality
		Limitations	Indirectness	Inconsistency	Imprecision	Publication bias		
Zeituon al ⁸	Observational	Not Serious	Not Serious	Not Serious ^a	Not Serious	Unlikely	None	Low
Harada et al ¹	Retrospective	Not Serious	Not Serious	Not Serious ^a	Not Serious	Unlikely	None	Low

^a Authors did not report angles for flexion and extension positioning

Table II. Muhle Grading System

Stage 0	Normal width of the spinal canal, and no signs of anterior and posterior subarachnoid space narrowing
Stage 1	Partial obliteration of the anterior or posterior subarachnoid space or of both
Stage 2	Complete obliteration of the anterior or posterior subarachnoid space or of both
Stage 3	Anterior or posterior cord impingement or both