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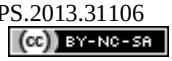
ISSN 2231-3354 

An application of moderately T2-weighted 3D TSE-FS pulse sequence to MRI myelography in investigation of patient with cervical spondylotic radiculopathy

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ABSTRACT

Conventional MRI and MRI-myelography studies were classified as positive when morphological alterations noted correlated with clinical presentations. This study was to analyse the usefulness of MRI myelography of the cervical spine using technique of moderate T2-weighted Three Dimensional Turbo Spin Echo-Fat Sequence pulse sequence in identifying nerve root compression in patients with cervical spondylotic radiculopathy. MRI myelogram detected less nerve root compression 5% but conventional MRI 8%. Clinical findings were significantly associated with imaging findings in both imaging techniques ($p<0.001$). MRI myelogram over-reported 45 and conventional MRI over-reported 80 nerve roots compression when correlated with clinical presentation ($p<0.001$). There was 50% alteration on conventional MRI when viewed together with MRI myelogram. There was significant difference with nerve root compression and clinical findings between MRI myelogram and conventional MRI ($p<0.001$). MRI myelogram underestimated the number of nerve roots compressed but it altered the interpretation of conventional MRI in 5% cases when viewed together. The addition of MRI myelogram increased the number of positive nerve roots. MRI myelogram is a useful adjunct to conventional axial and sagittal imaging in the investigation of cervical spondylotic radiculopathy.

INTRODUCTION

Cervical radiculopathy is a syndrome that arises after the nerve and its roots have been compressed causes irritation to the cervical nerve roots and results in inflammation of the nerve roots (Radhakrishnan *et al*., 1994). The most common causes of nerve root compression are spondylosis of the facet joint and herniation of the intervertebral disc (Benzel, 2012).From a population-based study from 1976 to 1990, done in Rochester, Minnesota, it found that cervical radiculopathy has an annual incidence rate of 107.3 per 100,000 for men and 63.5 per 100,000 for women, with a peak at 50 to 54 years of age (Radhakrishnan *et al*., 1994). There are many approaches to the treatment of cervical radiculopathy from conservative to surgical approach (Sampath *et al*., 1999). Conventional myelogram of the cervical spine previously is the modality of choice in investigating nerve root compression then followed by CT myelography because of its multi-planar capability to diagnose multilevel nerve root compressions (Shafaie *et al*., 1999; Boutin *et al*., 2000; Tsuruda *et al*., 1989). As the emergence of MRI, it has been used as an imaging modality to evaluate nerve root compression due to non-invasiveness and easier to performed. It is reported that 0.6Tesla MRI was equivalent to CT and myelography to diagnose spinal canal stenosis and herniated disc diseases (Modic *et al*., 1986a) and claimed that MRI can be alternative to conventional myelogram to diagnose nerve root compression. Since then, there is steady decline of conventional myelography cases throughout the country.

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The myelography is being thought as a historical investigation for radiculopathy and spinal canal stenosis (Miller and Krauss, 2003). After the emergence of conventional MRI in investigation of radiculopathy, it was found that MR imaging examination is sometimes indeterminate and non-diagnostic and often shows many abnormalities that are difficult to correlate with clinical data (Miller and Krauss, 2003).

Conventional MRI is disappointing because of the lack of resolution and still conventional myelogram or CT myelogram is more diagnostic (Miller and Krauss, 2003). A study reported that conventional MRI underestimated root compression in 28% to 29% of the cases in which root impingement was surgically confirmed. Conventional myelography underestimated root compression in only 5% to 7% of the cases and correctly predicted impingement in 93% to 95%. CT myelography underestimated root compression in 38% of the surgically confirmed cases (Bartynski and Lin, 2003). They found that conventional myelography is still needed to confirm the nerve root compression (Bartynski and Lin, 2003).

Patient with highly suspicious of nerve root compression and was negative on conventional MRI of the cervical spine need to undergo conventional myelogram to confirm (Miller and Krauss, 2003). Most surgeons prefer to use CT myelography to visualize bony abnormality causing radiculopathy in cervical and lumbar spine only after conventional MRI finding was negative (Miller and Krauss, 2003). However, MRI is preferable due to less invasive, less expensive and less labor intensive than conventional or CT myelography (Miller and Krauss, 2003). MRI myelography is new techniques that apply the concept of conventional myelogram which is invasive and conventional MRI which is non-invasive. There are sets of pulse sequence that able to generate myelogram-like images on MRI. Early invention of MRI myelogram include utilization of a set of pulse sequence of heavily T2-weighted was reported that produce highly contrasted image like conventional myelogram (Krudy, 1992; El-Gammal *et al*., 1995).

This technique has been applied in imaging lumbar degenerative disease and several authors have reported it to be a valuable supplement for the demonstration of the lumbar thecal sac and dural sleeves (Thornton *et al*., 1999; Pui and Husen, 2000; Kuroki *et al*., 1998; Hergan *et al*., 1996; Jenis and An, 2000). However, the diagnostic accuracy of MRI in cervical spondylotic radiculopathy is still limited (has false negative rate), especially in the assessment of foraminal nerve root impingement because of suboptimal demonstration of foraminal disc and osteophyte (Modic *et al*., 1986b; Bartlett *et al*., 1996) and the susceptibility artifact. One study to evaluate the use of MR myelography in the cervical area (Birchall *et al*., 2003) done with 1.5 T Intera scanner (Philips Medical Systems, Best, Netherlands) using a phased array spine coil and using pulse sequence technique of single shot TSE, TR 8000 ms, TE 1000 ms, TSE factor 256, acquisition time 3:36 to produce MRI myelographic image at the cervical area to see the nerve root compression in cervical spondylotic radiculopathy. The disadvantage of heavily T2-weighted images is the background signals were fully suppressed thus the differentiation between disc and osteophyte cannot be made and causing false positive result. In this study, a set of pulse sequence consists of moderately T2-weighted Turbo Spin Echo Fat Saturation was applied to cervical area to produce an excellent three dimensional images MRI myelogram. This technique had been applied for clinical application of brain, spine, pelvic and liver. However this pulse sequence has not yet established in the cervical area. Thus the objective of this study is to investigate the usefulness of this set of pulse sequence in the cervical region mainly in evaluating the nerve roots compression in patient with cervical spondylotic radiculopathy.

The findings were correlated with clinical findings of the patient and look into the agreement of findings in MRI myelogram with the conventional MRI in depicting nerve root impingement. At the same time, we look into the inter-observer variability between the radiologists in interpreting MRI myelogram.

METHODS AND MATERIAL

A total of 30 patients with signs and symptoms of cervical spondylotic radiculopathy were recruited in a cross sectional study. The patients underwent conventional MRI investigation followed by generation of MRI myelogram images using a set of MRI pulse sequence (moderately T2 weighted 3D Turbo Spin Echo-Fat Saturation) without the patient need to change the position or come out from MRI room. The MRI investigation was done in Hospital Sultanah Nur Zahirah (HSNZ), Kuala Terengganu from May 2009 to November 2010. Both images were analysed independently by two experienced radiologists. The findings were compared to clinical presentation. This research has been approved by the ethical committee of HSNZ and Hospital Universiti Sains Malaysia (HUSM) as a part of Master's degree programme.

Signs and symptoms of cervical spondylotic radiculopathy

The symptoms include neck pain, shoulder pain or arm pain distal to the elbow associated with worsening of the pain by neck movements of any duration. Upon physical examination, there is reduced in sensation in one or more adjacent dermatomes, reduced deep tendon reflexes in the affected arm and reduced power /muscle weakness in one or more adjacent myotomes. This has been approved by HSNZ medical ethics committee. The signs of cervical spondylotic radiculopathy include motor deficit which was defined when the motor power is less than 5 and sensory deficit which was defined as reduced sensation to touch (MRC, 2009).

Conventional MRI

Patient underwent conventional MRI as part of the investigation in cervical spondylotic radiculopathy. Patient was lying supine within the MRI room and a set of pulse sequence applied to produce conventional MRI images. The parameters used

include TR T1WI:397ms, TR T2WI 2500 ms,, AT T1WI 3:18, AT T2WI 3:07, TSE factor T1WI:3, TSE T2WI 34, ET T1WI:14ms, ET T2WI: 115ms and using Phased array body coil. All conventional MRI images were reviewed by radiologists from HSNZ. They were from different background experience in radiology. The definition of nerve root compression on conventional MRI includes diminished size of exit foramina, paucity of peri-neural fat surrounding the nerve root (Jenis and An, 2000), indistinct of the nerve root in exit foramina (Lee *et al*., 2009) and epidural fat obliteration surrounding the nerve root (Lee *et al*., 2009). Exit foramen is defined as foraminal segment of the radicular canal (Alfieri *et al*., 1997).

It is measured between the medial and lateral borders of pedicle (Lee *et al*., 2009). Normal measurement is 4mm or more (Ferrer *et al*., 2004).

Fig. 1: MRI myelogram using Moderately T2 weighted 3D TSE-FS pulse sequence.

MRI myelogram of the cervical spine

A set of pulse sequence with parameters TR (Repetition Time): 6000ms, TE (Echo Time): 249ms, TSE (Turbo Spin Echo) factor:256, AT (Acquisition Time) 3:26, Half Fourier Acquisition Single Shot Turbo Spin Echo was applied to the magnetic field to generate a specific contrast and producing high resolution three dimensional MRI myelogram images. The technique used Phased array body coil.

The MRI myelogram images were obtained in coronal plane. Two radiologists of more than 10 years-experience reviewed the MRI myelogram images independently without knowing the clinical presentation. Radiologist A reviewed the MRI myelogram images at MRI workstation in HSNZ, Kuala Terengganu, Malaysia and Radiologist B reviewed the MRI myelogram images at HUSM Kubang Kerian, Kota Bharu, Kelantan, Malaysia using computer.

The findings were then correlated with the clinical presentation and were compared with the conventional MRI findings.

The findings between two radiologists were also compared to see inter-observer variability. The definition of nerve root compression (Figure 1 and figure 2) on MRI myelogram is presence or absence of thecal sac or nerve root encroachment, alteration of dural sac and distortion of intra-dural nerve roots or emergent nerve roots or intra-dural lesion (El-Gammal *et al*.,1995).

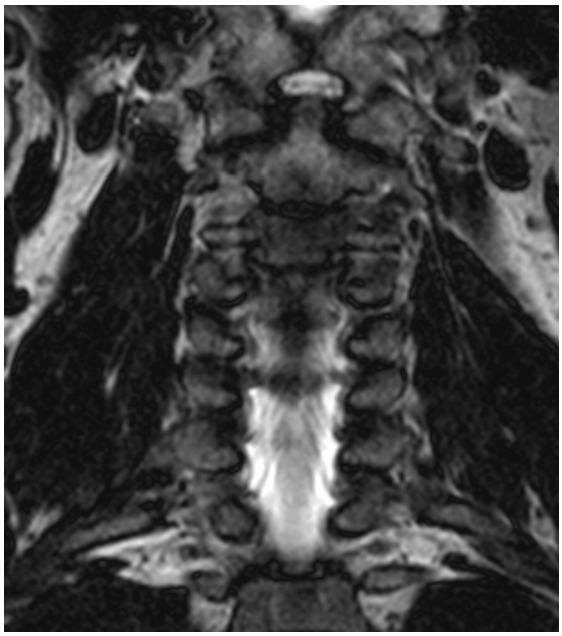

Fig. 2: MRI myelogram using same sequence show marginal osteophyte at both right and left C5/C6.

Imaging procedure

The procedure was done using 1.5 Tesla Avanto scanner (Siemens) machine. All patients had initial imaging with conventional MRI where images obtained were sagittal T1WI and T2WI, axial T2WI and proton density weighted images. It took about 30 minutes to complete.

The sagittal images were included from base of skull down to lower cervical. An axial section was determined after reviewing the sagittal images and the plane for axial sections was through the intervertebral disc. Subsequently, MRI myelogram (MRM) procedure using set of pulse sequence without the patient need to change in position and place. It took another 10 minutes to be completed.

Statistical analysis

The association between clinical symptoms and sign with nerve root impingement in both conventional MRI and MRI myelogram were obtained using McNemar test. The agreement of presence of nerve root compression between both imaging techniques and inter-observer variability were assessed using Kappa statistical analysis.

RESULTS

Patients with signs and symptoms of cervical spondylotic radiculopathy involved in this study were ranged from 20 to 78 years old with a mean age of 46.93 years old. The median age was 49.50 years old and mode age of 38 years old. The productivity of our country is depending on this age group. Thus, early investigation is needed to ensure patient have the best treatment. All patients (100%) came with symptoms of either neck pain, shoulder pain or arm pain. Twenty-three patients had tingling sensation and giddiness (76.7%), twenty-five patients had upper limb weakness (83.3%) and twenty-eight patients had upper limb numbness (93.3%).Both conventional MRI and MRI myelogram able to detect approximately 60% of the nerve root impingement. There is significant association between imaging findings in both MRI myelogram and conventional MRI with clinical findings (*P<0.001*) (Table 1 and Table 2).

Table. 1: Agreement of findings between clinical variables and conventional MRI

Conventional MRI findings Clinical variables	Present of nerve root compression N (%)	Absence nerve root compression N (%)	*p*-value
Sensory deficit			
(Present)	13(13.7)	82(86.3)	**<0.001**
(Absent)	34(8.8)	351(91.2)	
Motor deficit			
(Present)	26(14.8)	150(85.2)	**<0.001**
(Absent)	21(6.9)	283(93.1)	
Upper limb numbness			
(Present)	44(10.3)	50(94.3)	**<0.001**
(Absent)	3(5.7)	383(89.7)	
Upper limb weakness			
(Present)	40(38.8)	77(91.7)	**<0.001**
(Absent)	7(8.3)	356(89.9)	

Table. 2: Agreement of findings between clinical variables and MRI myelogram in observer A.

MRI myelogram findings Clinical variables	Presence of nerve root compression N (%)	Absence nerve root compression N (%)	*p*-value
Sensory deficit			
(Present)	13(13.7)	82(86.3)	**<0.001**
(Absent)	18(4.7)	367(95.3)	
Motor deficit			
(Present)	14(8.0)	162(92.0)	**<0.001**
(Absent)	17(5.6)	287(94.4)	
Upper limb numbness			
(Present)	28(6.6)	50(94.3)	**<0.001**
(Absent)	3(5.7)	399(93.4)	
Upper limb weakness			
(Present)	29(7.3)	82(97.6)	**<0.001**
(Absent)	2(2.4)	367(92.7)	

There is moderate agreement of findings (*kappa value 0.46, p<0.001*) between these two imaging techniques (Table 3). There is moderate agreement of findings between two observers in MRI myelogram (*Kappa value 0.541, p<0.001*) (Table 4).It was found that 85% of patients with clinical symptoms had no nerve root compression on both imaging study. After consensus opinion, MRI myelogram correctly interpreted nerve root impingement in the majority of the cases (37 out of 47 cases of nerve root impingement seen on conventional MRI).Conventional MRI over reported 10 nerve root impingement where there was absent of clinical presentation at that level. Even though MRI myelogram able to detect 37 nerve root compression but there was no false positive findings noted. MRI myelogram detected additional 8 nerve roots impingements which were not detected by conventional MRI of the cervical spine. After evaluation of both conventional and MRI images, out of 47 nerve roots, there were 15 levels of similarities of levels of nerve root compression between these two imaging techniques. Both agreed that 431 nerve roots (94%) were free from compression. However there were 40 levels of difference between these two techniques. There were 10 nerve roots (32%) that appear to be compressed on conventional MRI but when reviewed back the nerve roots on MRI myelogram images, there were indentations on the cerebrospinal fluid (CSF) column which corresponding to the presence of disc complexes indenting ventral CSF spaces which were not consider by radiologists as nerve root compression initially. This factor should be considered in the future for improvement. There were 22 cases out of 47 nerve roots that appear impinged on conventional MRI but after reviewing the MRI myelogram images, there were no significant compression of the nerve root. It was found that MRI myelogram able to exclude 22 cases out of 47 (50%) of nerve root compression on conventional MRI which was a quite high number of nerve root impingement. Both agreed that 431 nerve roots (94%) were free from compression. According to the another study there is substantial inter-observer agreement with the Kappa score of 0.67 to 0.76 in detecting nerve root compression (Brown et al., 1988).

Table. 3: Agreement of findings between conventional MRI and MRI myelogram in observer A.

Conventional MRI MRI Myelogram	Present of nerve root impingement N (%)	Absence nerve root impingement N (%)	Kappa value	P-value
Present of nerve root impingement	18 (58.1)	13(41.9)	**0.416**	**<0.001**
Absence nerve root impingement	29(6.5)	420(93.5)		
Total	47(9.8)	433(90.2)		

Table. 4: Inter-observer variability between two observers.

Observer A / Observer B	Presence of nerve root compression No (%)	Absence of nerve root compression No (%)	Kappa value	p-value
Presence of nerve root compression	15(68.2)	7(31.8)	**0.541**	**<0.001**
Absence of nerve root compression	16(3.5)	442(96.5)		

DISCUSSION

Cervical spondylotic radiculopathy is a common condition worldwide and the diagnosis of the disease needs a diagnostic tool that is non-invasive, easily available and not time

consuming. As time progresses many imaging modalities to diagnose nerve root compression. There is steady decline of the used of conventional myelogram after the introduction of conventional MRI to evaluate nerve root compression (Modic *et al*., 1986a). Some study reported that CT myelogram is better because it correctly predict the surgical findings in 85% in lumbar degenerative disease (Modic *et al*., 1986a). Several papers correlated that conventional MRI able to correctly interpreted 90% of the cases (Brown *et al*., 1988; Van and van, 1994). However, other groups noted that conventional MRI only detected 74% of the cases and CT myelogram is 85% when correlated with surgical findings (Modic *et al*., 1986a). Some study showed that when conventional MRI and CT myelography viewed in combination the diagnostic rate become increasing (Yousem *et al*., 1991). However, CT myelogram is also invasive need injection of contrast media intrathecally same as conventional myelogram. MRI myelography is basically a recent technique used in evaluation of nerve roots at the entrance and proximal canal of exit foramina (Krudy, 1992; El-Gammal *et al*., 1995). It has been used in the evaluation of lumbar degenerative disease (Thornton *et al*., 1999; Hergen *et al*., 1996) and when viewed together had no significant value to conventional MRI. The limited diagnostic efficacy of the technique has been attributed to inconsistent definition of nerve roots and to the observation that lumbar disc protrusions may displace only the epidural fat and not the thecal sac (Thornton *et al*., 1999). It is reported for cervical spondylotic radiculopathy that MRI myelography increased the diagnostic yield to the conventional MRI by increased the number of positive nerve roots compression (Birchall *et al*., 2003) and MRI myelography was able to detect the nerve root compression on the different spinal levels (Kuijper *et al*., 2011). However, it was found that MRI myelography when viewed in isolation had an insufficient diagnostic accuracy to justify its use as an independent imaging technique for the evaluation of cervical foraminal disease (Thornton *et al*., 1999). MRI myelogram uses a set of pulse parameters to produce a three dimensional high resolution images. Hence, enable the radiologist to come to the diagnosis confidently. The adjustment of time to repeat (TR) and time to echo (TE), fat saturation technique and turbo spin echo also part of the parameters that produce high resolution MRI myelogram images. The use of single-shot turbo spin-echo pulse sequences, are faster to complete which is in seconds rather than several minutes. The use of fat suppression technique is effective in reducing the signals from the subcutaneous and adipose tissue.

The parameters within this pulse sequence provide moderately suppression of the background signal and this will help radiologist to differentiate between disc and osteophyte that may cause the false positive of nerve root compression in conventional MRI. Heavily T2-weighted signals in the previous study able to produce a highly contrasted image like conventional myelogram had become an advantage to evaluate nerve root compression (Birchall *et al*., 2003). In this study, MRI myelogram helped detection of nerve root compression due to the differentiation between the disc bulge and marginal osteophytes are clear without fully suppression of the background signals. In case of cervical spondylotic radiculopathy, MRI myelogram had the advantage of able to clearly demonstrate the cervical thecal sac and dural sleeve thus any abnormality will be easily detected. Furthermore, MRI myelogram images were not degraded by the CSF artifact. It also able to provide a rapid survey of potential sites of pathology; this has potential to improve the operator sensitivity at lesion identification. It can also detect multilevel nerve root compression which due to degenerative changes in patient with cervical spondylotic radiculopathy. Thus, MRI myelogram can determine which level most likely to produce the patient's symptom in a fast screening way. MRI myelogram when viewed in isolation had significant correlation with the clinical findings and can be justify its use as a fast screening tool in cervical spondylotic radiculopathy. It also provided additional information and complemented conventional MRI when viewed together. MRI myelogram in this study also provided additional nerve roots compressions which were not detected by conventional MRI. These signify that MRI myelogram altered the interpretation of nerve root compression and can be used as a complementary tool to conventional MRI to confirm the nerve root impingement which can increase the confidence of radiologist in interpreting nerve root compression in cervical spondylotic radiculopathy.

CONCLUSION

This study suggests that MRI myelogram of the cervical spine is a safe, non-invasive and rapid survey technique to evaluate nerve root compression. It is able to exclude compression to the nerve roots in conventional MRI. MRI myelogram also better to conventional MRI in detecting nerve root impingements and provide additional diagnostic value when viewed together. It can detect multilevel nerve root compression which most likely to produce the patient's symptom in a fast screening way. The use of MRI myelography increased the number of nerve roots compression and it significantly correlated with clinical presentation. In the future, its use can be justified to be used as a fast screening tool in patient with cervical spondylotic radiculopathy. This study however needs bigger sampling and another study needed to validate the above results. Further study is also required to define the diagnostic accuracy of this technique by comparison with conventional CT myelography.

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REFERENCES

Alfieri KM, Hesselink JR. MR imaging of spinal stenosis. Applied Radiology, 1997; 26: 18-27.

Bartlett RJ, Hill CA, Devlin R, Gardiner ED. Two-dimensional MRI at 1.5 and 0.5 T versus CT myelography in the diagnosis of cervical radiculopathy. Neuroradiology, 1996; 38(2):142-147.

Bartynski WS, Lin L. Lumbar root compression in the lateral recess: MR imaging, conventional myelography, and CT myelography comparison with surgical confirmation. AJNR Am J Neuroradiol, 2003; 24(3):348-360.

Benzel, EC. 2012. Spine surgery: techniques, complication avoidance, and management (3rd ed.), Elsevier/Saunders, Philadelphia.

Birchall D, Connelly D, Walker L, Hall K. Evaluation of magnetic resonance myelography in the investigation of cervical spondylotic radiculopathy. British Journal of Radiology, 2003; 76 (908): 525-531.

Boutin RD, Steinbach LS, Finnesey K. MRI of degenerative diseases of the cervical spine. Magn Reson Imaging Clin N, 2000;8:471-490.

Brown BM, Schwartz RH, Frank E, Blank NK. Preoperative evaluation of cervical radiculopathy and myelopathy by surface coil MRI. AJR Am J Roentgenol, 1988; 151 (6): 1205–1212.

El-Gammal T, Brooks BS, Freedy RM, Crews CE. MR myelography: imaging findings. AJR Am J Roentgenol, 1995. 164:173–177.

Ferrer P, Martí-Bonmatí L, Mollá E, Arana E. MR Myelography as an adjunct to the MR examination of the degenerative spine. Magnetic Resonance Materials in Physics, Biology and Medicine, 2004; 16 (5): 203-210.

Hergan K, Amann T, Vonbank H, Hefel C. MR myelography: a comparison with conventional myelography. Eur J Radiol, 1996; 21(3):196–200.

Jenis LG, An HS. Spine Update, Lumbar Foraminal Stenosis, Spine (Phila Pa 1976), 2000; 25 (3):389-394.

Krudy AG. MR myelography using heavily T2-weighted fast spin-echo pulse sequences with fat pre-saturation. AJR Am J Roentgenol, 1992:1315–1320.

Kuijper B, Tans JT, van der Kallen BF, Nollet F, Lycklama A Nijeholt GJ, de Visser M. Root compression on MRI compared with clinical findings in patients with recent onset cervical radiculopathy. J Neurol Neurosurg Psychiatry, 2011; 82(5):561-563.

Kuroki H, Tajima N, Hirakawa S, Kubo S, Tabe R, Kakitsubata Y. Comparative study of MR myelography and conventional myelography in the diagnosis of lumbar spine diseases. Journal of Spinal Disorder, 1998; 11 (6):487-492.

Lee IS, Kim HJ, Lee JS, Moon TY, Jeon UB. Extra Foraminal With or Without Foraminal Disk Herniation: Reliable MRI Findings. AJR Am J Roentgenol, 2009; 192(5):1392-1396.

Medical Research Council (MRC) Scale for Muscle Strength. 23 March 2009. Available from http://www.medicalcriteria.com/site/index.php?option=com_content&viwn (Accessed on 7 October 2013)

Miller GM, Krauss WE. Myelography: Still the Gold Standard, AJNR Am J Neuroradiology, 2003; 24(3): 298.

Modic MT, Masaryk T, Boumphrey F, Goormastic M, Bell G. Lumbar herniated disk disease and canal stenosis: prospective evaluation by surface coil MR, CT, and myelography. AJR Am J Roentgenol, 1986a;147:757–765

Modic MT, Masaryk TJ, Mulopulos GP, Bundschuh C, Han JS, Bohlman H. Cervical radiculopathy: prospective evaluation with surface coil MRI, CT with metrizamide, and metrizamide myelography. Journal of Radiology, 1986b; 161 (3):753–759.

Pui MH, Husen YA. Value of magnetic resonance myelography in the diagnosis of disc herniation and spinal stenosis. Austral Radiology, 2000; 44:281-284.

Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT. Epidemiology of cervical radiculopathy: a population-based study from Rochester, Minnesota, 1976 through 1990. Brain, 1994;117 (Pt 2):325-335.

Sampath P, Bendebba M, Davis JD, Ducker T. Outcome in patients with cervical radiculopathy: Prospective, multicenter study with independent clinical review; Spine, 1999; l (24): 591–597.

Shafaie FF, Wippold J, Gado M, Pilgram T, Riew KD. Comparison of computed tomography myelographyandmagnetic resonance imaging in the evaluation of cervical spondylotic myelopathy and radiculopathy. Spine (Phila Pa 1976), 1999; 1; 24(17):1781-1785.

Thornton MJ, Lee MJ, Pender S, McGrath FP, Brennan RP, Varghese JC. Evaluation of the role of magnetic resonance myelography in lumbar spine imaging. European Journal of Radiology, 1999; 9:924-929.

Tsuruda JS, Norman D, Dillon W, Newton TH, Mills DG. Three-dimensional gradient-recalled MRI as a screening tool for the diagnosis of cervical radiculopathy. AJNR Am J Neuroradiol, 1989;10 (6):1263-1271.

Van de Kelft E, van Vyve M. Diagnostic imaging algorithm for cervical soft disc herniation. J Neurol Neurosurg Psychiatry, 1994; 57(6):724-728.

Yousem DM, Atlas SW, Goldberg HI, Grossman RI. Degenerative narrowing of the cervical spine neural foramina: evaluation with high-resolution 3DFT gradient-echo MRI. AJNR Am J Neuroradiol, 1991; 12: 229–236.

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