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Positional Cervical Spinal Cord Compression and Fibromyalgia: A Novel Comorbidity With Important Diagnostic and Treatment Implications

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Abstract: The variable presentation and treatment response of fibromyalgia (FM) may be related to comorbidities, including positional cervical cord compression (PC3). Prevalence of PC3 among routine referrals for rheumatology consultation was assessed over 2 random months (January and February 2006) from a 4-year experience of 1100 patients. PC3 was defined as cord abutment, compression or flattening with a spinal canal diameter of <10 mm by magnetic resonance sagittal flexion, neutral, and extension images. Of 107 referrals, 53 had FM, 32 had a connective tissue disease (CTD) without FM, and 22 had chronic widespread pain (CWP) without FM criteria. The dynamic cervical spine images were obtained in 70 patients: 49 of 53 with FM, 20 of 22 with CWP and 1 of 32 with CTD, based on history and examination. Among those who received magnetic resonance imaging [MRI], 52 patients met PC3 criteria (71% of FM group [35/49], 85% of CWP group [17/20]). Two patients had a Chiari malformation (FM), 1 had multiple sclerosis (CWP), and 1 had multiple myeloma (CWP). Extension views were required for diagnosis for 37 of these 52 (71%) subjects, as well as for 8 patients who also had cervical spinal cord flattening. The pilot data suggest that further evaluation of PC3 in a controlled trial is warranted among patients with FM and CWP.

***Perspective:** Fibromyalgia is complex and poorly understood. Recognition of unsuspected, comorbid cervical cord compression may provide new insight into its variable presentation, leading to novel treatment considerations. Also, dissemination of this dynamic MRI protocol may promote further study of this emerging concept of cervical cord irritation.*

***Key words:** Cervical myelopathy, fibromyalgia, pain, magnetic resonance imaging.*

Fibromyalgia (FM) is defined clinically as a condition of chronic widespread pain and tenderness for more than 3 months.[45] Its etiology remains an important and controversial research topic directed at a variety of pathways, including central pain amplification,[2] peripheral pain generators,[41] dopaminergic limbic system dysregulation,[46,47,48,49] autonomic nervous system dysregulation,[8,20,21,33,35,37,43] and fragmentation of deep, restorative sleep stage architecture.[5,17,18,19,25,30,36] To add complexity, fundamental concerns about defining FM as a single entity abound, but little consideration has been apportioned to the concept that variability in patient presentation and treatment response may be related to unsuspected comorbidities.

Recognition of cervical comorbidity with FM was described by Rosner and Heffez when decompression of Chiari I deformity was found to reduce fatigue and global pain in some patients with both conditions.[3,10] Identification of compression of the upper cervical spinal cord and brainstem was considered vital for accurate diagnosis before successful surgical reduction. Understandably, promotion of surgical intervention for patients with FM has raised concern,[44] and Chiari is not common in the general population (0.78%).[23] Clauw et al[6] reported 47% prevalence of cervical canal compromise by either spinal stenosis or Chiari in FM patients (specific Chiari percentage not reported) compared with 50% in asymptomatic control subjects. However, he did not use dynamic flexion-extension imaging to further detail the cervical spinal cord findings. Notwithstanding, these observations have led to consideration of whether

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Table 1. Magnetic Resonance Imaging Specifications for the Flexion-Extension Cervical Spine Protocol

Sequence Description		1 Sag Restor Ext	2 Sag Restor Flex	3 Sag Restor Neu	4 Sag ts T1	5 Axial tse T1
PT position	Landmark	Sternal notch	Sternal notch	Sternal notch	Sternal notch	From C7-T1
	Coil	Spine array/ant.		Spine array/ant.	Spine array/ant.	Spine array/ant.
	Scan plane	Sagittal		Sagittal	Sagittal	
Routine	Slice group	1	1	1	1	1
	No. of slices	11	11	11	11	11
	Dist. factor	25%	25%	25%	0	10%
	Slice thickness	4	4	4	4	4
	FOV	260	260	260	260	200
	TE	109	109	105	12	
	Phase enc.	H/F	H/F	H/F	A/P	A/P
	Phase	55%	55%	55%	0	
	Averages	1	1	2	4	
	Concat.	1	1	1	1	
Contrast	TR	2600	2600	2810	543	500
	Flip angle	180	180	180	180	
Resolution	Base resolution	256	256	512	512	256
	Phase resolution	75%	75%	45%	51%	75%
Geo Sat	Sat region ±				Anterior	Anterior
Seq. Part 1	Bandwidth	130	130	130	150	167
	Flow comp	Read	Read	Read	No	No
	Echospacing	12.1	12.1	13.2	11.7	10.6
Seq. Part 2	Turbo factor	17	17	17	3	3
	RF pulse type	Normal	Normal	Normal	Normal	Normal
	Gradient mode	Fast	Fast	Fast	Fast	Fast

NOTE. For sagittal flexion and extension views: Begin with extension.

distal compression of the cervical spinal cord through post-traumatic, degenerative mechanisms might also be found among patients with FM with dynamic imaging and thereby influence their presentation and treatment response. Such evidence may also be relevant to interest in increased rates of fibromyalgia after cervical spine injury.[4]

What began as an attempt to document spinal cord compression from a congenital abnormality, Chiari I, has developed into an initiative to recognize cord compression and abutment related to cervical position. The position of the cervical spinal cord, its diameter, and surrounding structures change with movement.[9,15,16,26,29,31,50] In a neurosurgical clinic setting, Heffez et al[11] evaluated 270 patients with FM and identified a plethora of neurological signs and symptoms clinically and radiographically compatible with cervical myelopathy and Chiari I malformation. Chiari can be visualized by usual C-spine magnetic resonance imaging [MRI] views, but intermittent, positional, cervical spinal cord compression requires dynamic assessment, including a flexion and an extension sagittal view.

Since January 2003, these 2 views have been added to a traditional C-spine MRI protocol to identify the presence of positional cervical spinal cord compression among patients referred for rheumatology consultation. Given that the presence of this cervical finding influences treatment and that cervical pain has been an exclusion criterion in some FM trials,[12,13,38] obtaining these images was considered usual clinical practice. This pilot study was undertaken to evaluate this concept in a nonsurgical clinic population, promote discussion of its possible relevance, and consider future research initiatives related to this potential comorbidity with FM.

Materials and Methods

This retrospective chart review was approved by the Western Institutional Review Board (Olympia, WA) and examined a random 2-month subset of a 4-year experience evaluating an enhanced cervical spine MRI protocol. Because of the retrospective nature of the study, informed consent of study subjects was not required. The flexion-extension C-spine protocol was established in January 2003, using a Siemens Magnetome Symphony 1.5-Tesla MRI with a Syngo software platform (Siemens Corp., New York, NY) (Table 1), as described by Heffez et al.[11] The protocol included a standard C-spine MRI with addition of flexion and extension midline sagittal views with transaxial measurement of spinal canal diameter at each disc level in flexion, neutral, and extension (Fig 1).

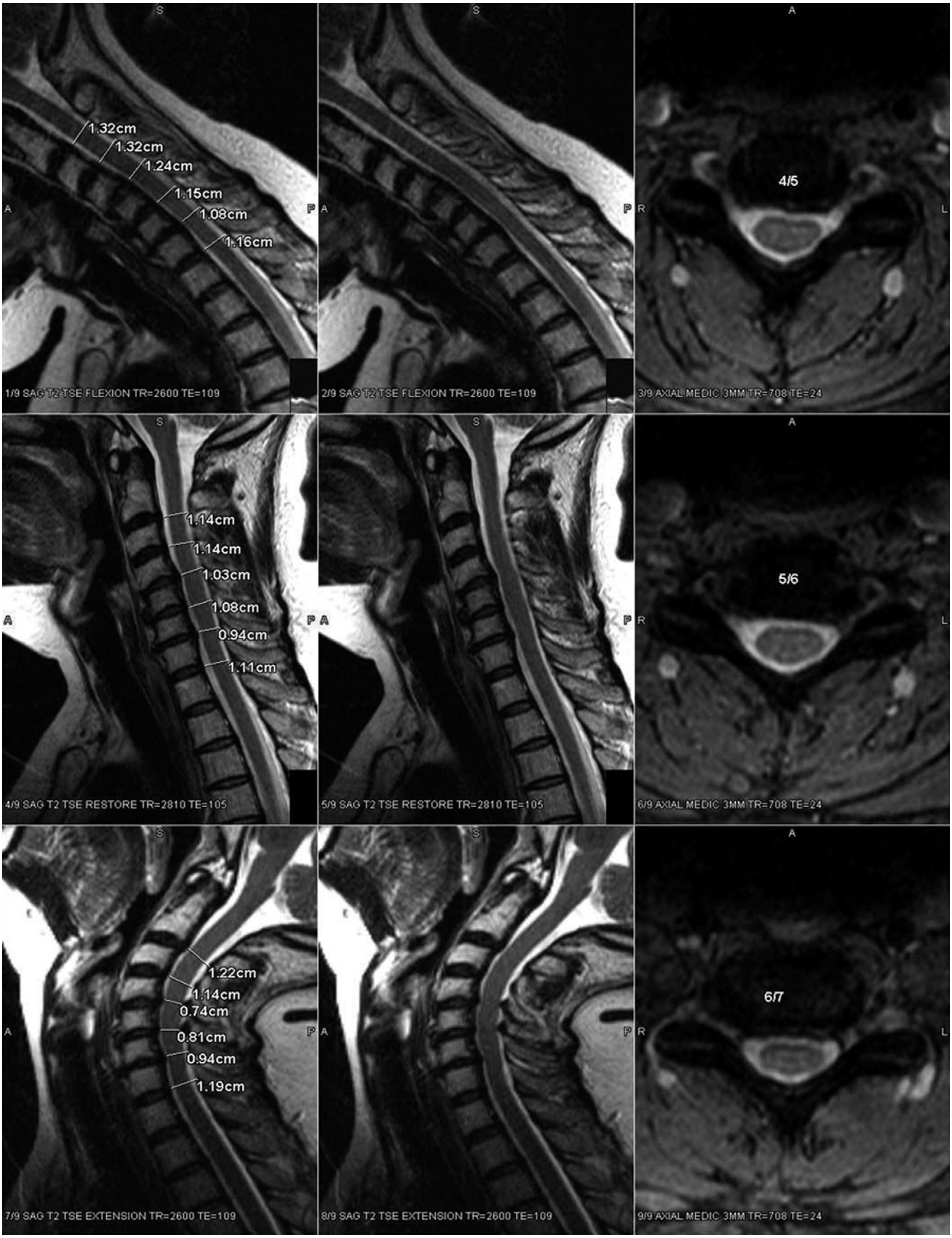

Figure 1. Typical image montage used to evaluate each patient, including flexion, neutral, and extension sagittal images, with and without transaxial measurement of the cervical canal at each disc level. Note cord abutment at C4-5 only in extension.

Table 2. Patient Demographics for Connective Tissue Disease Group, Fibromyalgia Group, and Unexplained Widespread Pain Group

Variable	CTD (n = 32) Mean (±SD)	FM (n = 53) Mean (±SD)	CWP (n = 22) Mean (±SD)	P Value*
Age (y)	50.0 ± 15	48.7 ± 9.0	51.9 ± 15.4	.59
Female (%)	18 (56)	49 (92)	19 (86)	< .001
FM duration (y)		10.3 ± 8.2		
Disabled (%)	0 (0)	18 (34)	1 (5)	< .001
Trauma (%)	0 (0)	18 (34)	4 (18)	.051
Sink pain (%)	1 (3)	36 (68)	3 (59)	< .001
Dentist chair pain (%)	2 (6)	34 (64)	8 (36)	< .001
Dizziness (%)	0 (0)	16 (30)	5 (23)	< .001
Abnormal gait (%)	0 (0)	6 (11)	1 (5)	.119
Poor dominant grip (%)	0 (0)	14 (26)	7 (32)	.007
Exam pain w/ extension	3 (9)	36 (68)	15 (68)	< .001
Pos. 7 sec. Romberg (%)	3 (9)	37 (70)	14 (64)	< .001
MHAQ Function†	2.0 ± 1.6	2.9 ± 1.7	2.3 ± 1.4	.050
MHAQ Psychiatric†	2.4 ± 2.3	5.2 ± 2.1	3.7 ± 2.9	< .001
MHAQ VAS pain (0–10)†	4.2 ± 2.8	6.1 ± 2.5	5.2 ± 2.8	.011
MHAQ stiffness (min)	33.1 ± 48.4	88.0 ± 62.3	79.2 ± 67.5	< .001
MHAQ fatigue (0–10)†	3.5 ± 3.1	7.5 ± 2.3	5.7 ± 2.8	< .001
MHAQ VAS global (0–10)†	4.3 ± 2.6	6.4 ± 2.3	6.0 ± 2.4	< .001

Abbreviations: CTD, connective tissue disease group; FMS, fibromyalgia group; CWP, unexplained widespread pain group; MHAQ, Multidimensional Health Assessment Questionnaire; VAS, visual analog scale.

*Statistical significance tested by *F* test for continuous variables and by χ^2 test for categorical variables.

†Function range (0–10 worst), psychiatric (0–10 worst), VAS pain (0–10 worst), VAS fatigue (0–10 worst), VAS global (0–10 worst).

These additional views were obtained without additional cost to the patients, who had been referred to a suburban clinic for routine rheumatology consultation. More than 1100 of these imaging protocols have been obtained between January 2003 and January 2007 in patients with FM or chronic widespread pain (CWP) in the course of routine rheumatology care. Diagnostic and treatment decisions were made based on this enhanced imaging. No patients received imaging simply for research purposes.

All referred consultations to a single rheumatologist during this random 2-month period (January and February 2006) were reviewed, including history, physical examination, Multi-dimensional Health Assessment Questionnaire (MHAQ),[34] and MRI findings. Imaging was ordered when patients noted a recent or prolonged history of positional cervical pain in prolonged extension, such as in a hairdresser's sink or dentist chair. Abnormal grip (weak or relative dominant vs nondominant weakness), positive Romberg test (7 seconds), gait, and complaints of dizziness and unsteadiness with normal gait also led to ordering this unique MRI evaluation. Although these criteria had been used for 4 years at this institution, they have not been validated, otherwise studied, or even reported previously. Also, no control subjects were assessed for this exploratory pilot report.

Prospectively, the imaging study was considered to be positive only when cervical spinal cord abutment, flattening, and/or compression was visualized on midline sagittal views with cervical canal narrowing below 10 mm. Abnormal cervical spinal cord signal was not required for a positive study because cord irritation and compression were being studied rather than evidence of cord damage, edema, demyelination, or atrophy.

Statistical Analysis

Patient demographics were evaluated by *F* test and χ^2 test for continuous and categorical variables, respectively. Missing data were not imput, and statistical significance was defined as $P < .05$. The relationship between patient characteristics and abnormal MRI results were evaluated with Fisher's exact test for binary variables (eg, sink pain). Spearman correlation was used to evaluate correlation between number of abnormal cervical canal levels and MHAQ scores. Assessment of MHAQ variables comparing positive and negative MRI studies within the FM and CWP groups as well as comparison of flexion, neutral, and extension image findings used the Wilcoxon rank-sum test as a nonparametric test without distributional assumptions.

Results

Over the 2-month period, 107 patients were referred for rheumatology consultation by primary care clinicians. Demographics reflected a typical patient population referred for rheumatology consultation (Table 2). On presentation, 53 had FM by the American College of Rheumatology (ACR) criteria,[45] 22 had CWP without FM criteria, and 32 had a specific inflammatory connective tissue disease (CTD) without evidence of comorbid FM. CTD patients were less often female and not disabled. They also failed to report pain with extension (sink, den-

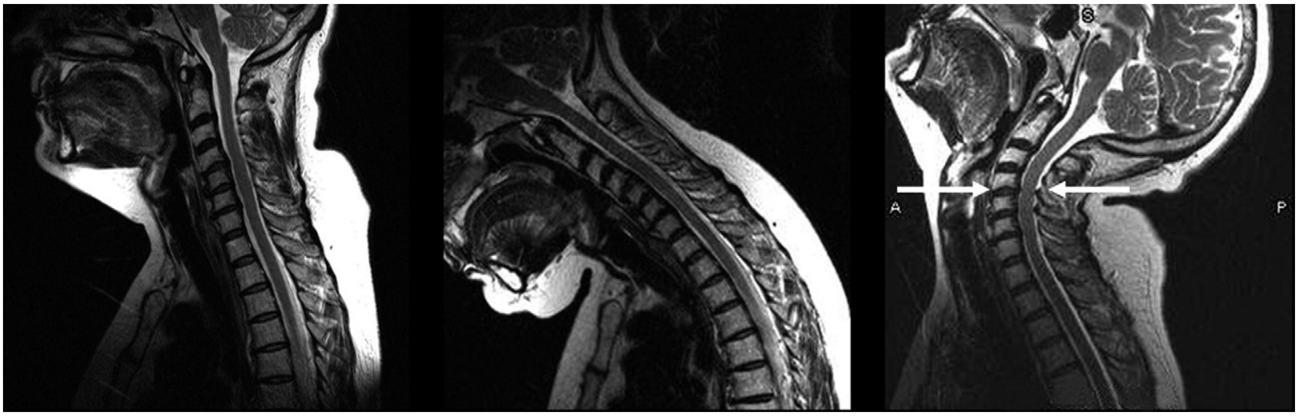

Figure 2. Sagittal neutral, flexion, and extension MR cervical spine images of the same patient demonstrating cervical cord abutment at C4-5 only in extension. Note obliteration of the CSF space around the cord by positional distortion of the C4-5 disc and ligamentum flavum.

tist chair, on examination), dizziness, or positive Romberg as often as patients with FM or CWP. MHAQ function, psychiatric, stiffness, fatigue, and global scores were higher (greater impairment) for the FM and CWP groups than for those with CTD.

Based on history and physical examination during routine clinical care, 70 patients obtained the flexion-extension C-spine MRI, of which 2 patients were found to have a Chiari I malformation (both in the FM group), 1 had multiple myeloma (CWP group), 1 had multiple sclerosis (CWP group), and 52 had demonstrable evidence of cervical spinal cord abutment or compression, usually in extension. Of those assessed by dynamic C-spine MRI, 71% in the FM group (35 of 49 patients) and 85% in the CWP group (17 of 20 patients) had visual evidence of intermittent cervical spinal cord compression, usually only in extension. Of these 52 positive cases, only 15 (29%) had visual evidence of abutment or compression in the neutral view (Fig 2). Eight subjects had evidence of spinal cord flattening, but, again, without visual evidence of spinal cord abutment or compression in the standard neutral sagittal view. Cervical spinal canal compromise was generally caused by disk protrusion, and ligamentum flavum buckling accentuated in the extension position.

Segments involved with abutment or compression were: C2-3 [1], C3-4 [17], C4-5 [25], C5-6 [33], C6-7 [30], and C7-T1[4]. Some patients had more than 1 affected disk level. Change in cervical spinal canal diameter from flexion to extension was considerable and greatest at C6-7 (mean, 1.78 mm; range, −1.0–4.0 mm) (Table 3). The mean number of cervical canal levels <10 mm [SD] was greater in the extension view (FM 1.5 [1.4], CWP 1.7 [1.3]) than in the flexion (FM 0.6 [1.0], CWP 0.5 [1.0], $P <$ .01) or neural views (FM 0.6 [1.1], CWP 0.3 [0.4], $P < .01$). Neither the number of abnormal canal levels (<10 mm) nor the mean or maximal change in canal diameters from flexion to extension or neutral to extension correlated with MHAQ scores with one exception. The number of abnormal disk levels in flexion (−0.329, $P < .05$), neutral (−0.318, $P <$. 5), and extension (−.0312, $P < .05$) mildly correlated inversely with MHAQ psychiatric score (Spearman correlation).

No specific question, examination finding, or MHAQ score significantly differentiated a patient with a positive from a negative study (Tables 4 and 5), except for the presence of pain positioned in a hairdresser's sink (sink pain) among subjects with CWP ($P = .009$). Although not statistically significant, an inverse correlation with MHAQ psychiatric subscore was suggested in FM patients with a positive MRI study ($P = .085$). Also, patients with CWP and an abnormal MRI had lower visual analog scale (VAS) pain scores ($P = .081$) than those with a negative MRI study.

Discussion

Since publication of specific criteria by the American College of Rheumatology in 1990, FM has been characterized as chronic widespread pain and tenderness involving at least 11 of 18 specific tender points for greater than 3 months.[45] Related features of significant fatigue, nonrestorative sleep, and autonomic dysregulation expand our appreciation for this disorder, but many authors continue to question the veracity of FM as a single entity. In fact, reconstructing FM as one of many related central sensory sensitivity syndromes has become increasingly popular and has prompted a lack of confidence in the original ACR diagnostic criteria. Ineffective

Table 3. Change in Cervical Spinal Canal Diameter From Flexion to Extension at Each Disk Level (mm)

Disk Level	N	Mean (SD)	Minimum	Maximum
C23	68	0.044 (0.98)	−3.00	3.00
C34	68	0.59 (1.21)	−2.00	4.00
C45	68	0.97 (1.24)	−3.00	3.00
C56	68	1.18 (1.31)	−3.00	4.00
C67	68	1.78 (1.33)	−1.00	4.00
C7T1	66	0.50 (1.50)	−4.00	5.00

Table 4. Summary of Abnormal MRI Studies by Patient Characteristics

*Variable**	*CTD (%)*	*FM (%)*	*CWP (%)*
Sink pain			
No	0/29 (0)	8/14 (57)	3/7 (43)
Yes	0/1 (0)	25/34 (74)	12/12 (100)
P value†	NA	.315	.009
Dentist chair pain			
No	0/26 (0)	10/18 (56)	9/13 (69)
Yes	0/2 (0)	25/33 (76)	7/7 (100)
P value†	NA	.207	.249
Dizziness			
No	0/26 (0)	13/19 (68)	9/13 (69)
Yes		12/14 (86)	4/4 (100)
P value†	NA	.416	.519
Abnormal gait			
No	0/30 (0)	29/45 (64)	13/17 (76)
Yes		6/6 (100)	1/1 (100)
P value†	NA	.159	1.000
Poor grip			
No	0/26 (0)	23/37 (62)	11/13 (85)
Yes		6/6 (100)	5/7 (71)
P value†	NA	.176	.587
Exam pain w/extension			
No	0/27 (0)	8/11 (73)	2/4 (50)
Yes	0/3 (0)	24/35 (69)	13/15 (87)
P value†	NA	1.000	.178
Positive Romberg			
No	0/28 (0)	8/15 (53)	4/7 (57)
Yes	0/3 (0)	24/35 (69)	12/13 (92)
P value†	NA	.187	.101

*For each patient characteristic summary, the entry represents the number and percentage of patients with abnormal magnetic resonance imaging (MRI) among the patients who have known characteristic and MRI result.

†Fisher's exact test.

treatment and an inability to substantiate the pathophysiology of FM have fueled this controversy suggesting that it may not be a single entity.

In animal models, intermittent compression or irritation of the cervical spinal cord activates autonomic brainstem arousal.[14,22] In humans, intermittent cervical compression from whiplash injury induces spinal cord hypersensitivity.[1] This leads to concern that cervical spinal cord irritation from intermittent abutment or compression could be a particularly challenging comorbidity with FM. It may influence FM presentation and treatment response,[40] possibly by affecting autonomic tone, altering descending inhibition or promotion of referred pain. Cervical spinal cord compression adversely affects sleep efficiency and melatonin secretion[39] and also affects dopamine and restless legs syndrome (RLS),[7,32] which are already common concerns among patients with FM.[51] Indeed, it may be difficult to assess how much autonomic dysregulation, global pain, RLS, and dopaminergic dysregulation stems from the cervical spinal cord, FM or both until either condition is identified and effectively addressed.

This pilot study has only begun to explore the potential impact of positional cervical spinal cord compression. Among those who were imaged on the basis of their history and examination (70 of 75 patients), the flexion-extension C-spine MRI revealed abutment and/or compression of the cervical spinal cord in 71% of patients with documented FM and in 85% of patients with CWP. Of note, the standard, neutral sagittal view only documented visual evidence of the cervical spinal cord abutment in 29%, leading to concern that traditional neutral sagittal C-spine MR images may be surprisingly insensitive.

Previous studies of cervical radiculopathy and spondylosis in patients without FM have provided similar evidence for insensitivity of standard MR images. In healthy patients, flexion views expand neuroformina by 31%, whereas extension with ipsilateral rotation reduces neuroforaminal diameter by 15% to 23%, compared with neutral position.[27] In patients with cervical radiculopathy, spinal cord displacement or rotation was confirmed in patients with spondylosis in an extended position, whereas herniated disc size remained unchanged.[28] These findings were not consistent with this study, which demonstrated variable disc protrusion into the canal for many patients, but radiculopathy was also not a common clinical feature of our patients. Notwithstanding, one might opine that dynamic structures are best evaluated dynamically, and our current static MRI standards for evaluation of the cervical spinal cord are insufficient in some patients.

Historically, cervical spinal cord compression has been associated with a host of symptoms similar to that iden-

Table 5. **Comparison Multidimensional Health Assessment Questionnaire Variables Among Patients With Fibromyalgia and Chronic Widespread Pain With and Without a Positive MRI Study**

		FMS Group		CWP Group	
MHAQ score	Statistic	Negative MRI	Positive MRI	Negative MRI	Positive MRI
Function	n	16	35	4	17
	Mean (SD)	3.1 (1.8)	2.8 (1.8)	2.8 (1.5)	2.1 (1.4)
	Median	2.9	2.7	3.3	1.7
	P value*		.618		.368
Psychiatric	n	16	35	4	17
	Mean (SD)	5.9 (1.9)	4.7 (2.1)	4.7 (2.3)	3.2 (2.9)
	Median	5.5	4.4	4.4	2.2
	P value*		.085		.298
VAS Pain	n	16	34	3	17
	Mean (SD)	6.4 (2.2)	5.8 (2.7)	7.4 (1.1)	4.7 (2.9)
	Median	6.7	6.7	7.9	5.1
	P value*		.640		.081
Stiffness (min)	n	14	33	4	15
	Mean (SD)	102.9 (66.3)	83.5 (60.7)	115.5 (84.5)	64.8 (60.8)
	Median	120.0	60.0	140.0	60.0
	P value*		.372		.269
VAS Fatigue	n	16	35	4	16
	Mean (SD)	7.3 (1.7)	7.5 (2.6)	7.4 (2.0)	5.2 (2.9)
	Median	7.2	8.3	7.2	5.6
	P value*		.230		.186
VAS Global	n	15	35	4	16
	Mean (SD)	6.4 (1.8)	6.3 (2.5)	6.7 (3.2)	5.6 (2.3)
	Median	6.7	6.7	7.0	5.8
	P value*		.865		.449

Abbreviations: MHAQ, Multidimensional Health Assessment Questionnaire; FM, fibromyalgia; CWP, chronic widespread pain; MRI, magnetic resonance imaging; VAS, visual analog scale.

*Wilcoxon rank-sum test.

tified with FM, such as global pain, headaches, nausea, dizziness, autonomic dysregulation, dysesthesias, sleep disturbance, and fatigue.[11,24,42] Its recognition to target therapeutics in patients with FM has already been applied. Dopamine agonists appear less effective in FM patients with comorbid cervical pain, hence the specific exclusion of positional cervical pain in randomized, controlled trials for pramipexole and ropinirole.[12,13]

Based on its mechanism of action and its European approval for treatment of central, spinal cord neuropathic pain, one might also hypothesize that an $\alpha_2\delta$-ligand, such as pregabalin, might be a superior choice in a patient with FM and comorbid cervical spinal cord compression than for FM alone. Pregabalin has been approved by the FDA for treatment of FM, but no pregabalin trials included cervical imaging. It would be interesting to know whether pregabalin responders in FM trials were more likely to have also had comorbid positional cervical spinal cord compression. Unfortunately, these concerns remain conjectural, because dynamic cervical spinal cord imaging is currently only an exploratory concept.

As with any exploratory study, analysis of pilot data is encumbered by significant limitations. This preliminary study attempted to consider common characteristics in patients with intermittent cervical spinal cord compression to differentiate affected patients. Although not supported by statistical significance, cervical pain with prolonged extension in a hairdresser's sink, dentist chair, or on examination all favored a positive study. Abnormal grip strength, poor balance, and borderline and positive Romberg tests were also suggestive. Among patients with FM, 100% with poor grip or abnormal gait as well as 100% of patients with CWP with abnormal gait, cervical pain in a dentist chair or hairdresser's sink, or dizziness had a positive dynamic MRI result (Table 4).

Interestingly, MHAQ scores did not appear predictive except possibly the psychiatric score, which was lower in CWP patients with positional cervical spinal cord compression. Indeed, the MHAQ was a particularly poor tool to predict a positive MRI. Although it clearly differentiated patients with FM or CWP from those with CTD, severity of cervical spinal cord narrowing did not correlate with symptoms. This may result from limitations of the MHAQ tool, excessive symptom overlap between positional cervical spinal cord compression, FM, and CWP compared with CTD or other factors. Decreased VAS pain among CWP patients with a positive MRI also seems counterintuitive, unexpected, and enigmatic. Detailed neurologic findings may be more discriminative. But, because there were no control subjects, predictive strength of patient history and examination were impossible to judge. Perhaps specific questions and examination findings may be validated in a future controlled study to improve judicious use of this dynamic imaging technology.

Our understanding of whether positional cervical spinal cord compression is an important medical concern is also preliminary. A few studies have begun to describe changes in cervical spinal cord and spine anatomy with position, but the prevalence and impact of spinal cord abutment and intermittent compression in normal control subjects is unknown. Radiographic studies of the cervical spine have demonstrated that even severe boney abnormalities correlate poorly with symptomatology. Similarly, how the severity of cervical spinal cord impingement correlates with clinical significance remains to be determined.

Fiscal consequences of obtaining dynamic C-spine images for 10 million patients in the US patients and many more with FM and CWP worldwide may also raise concern. A high prevalence would require considerable resources. However, resources currently delegated to evaluating and treating patients with chronic FM and CWP over many years already represent a daunting challenge. Conceivably, accurate diagnosis and focus on cervical spinal cord involvement when present may lead to decreased overall costs and improved patient outcome if these findings are confirmed.

It is not yet clear whether recognition of positional cervical spinal cord compression will be considered as an intriguing source of widespread pain or as an important comorbidity among patients with FM or as a common incidental finding. But, these preliminary data suggest that additional resources should be allocated to evaluate this concept further.

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References

1. Banic B, Petersen-Felix S, Andersen OK, Radanov BP, Villiger PM, Arendt-Nielsen L, Curatolo M: Evidence for spinal cord hypersensitivity in chronic pain after whiplash injury and in fibromyalgia. Pain 107:7-15, 2004

2. Bennett RM: Emerging concepts in the neurobiology of chronic pain: Evidence of abnormal sensory processing in fibromyalgia. Mayo Clin Proc 74:385-398, 1999

3. Burton TM: High hopes: Surgery on the skull for chronic fatigue? Doctors are trying it. This and a related syndrome lead to operation some raise and many decry. Bit more room for the brain. The Wall Street Journal, November 11, 1999, p A8

4. Buskila D, Neumann L, Vaisberg G, Alkalay D, Wolfe F: Increased rates of fibromyalgia following cervical spine injury: A controlled study of 161 cases of traumatic injury. Arthritis Rheum 40:446-452, 1997

5. Carette S, Oakson G, Guimont C, Steriade M: Sleep electroencephalography and the clinical response to amitriptyline in patients with fibromyalgia. Arthritis Rheum 38:1211-1217, 1995

6. Clauw DJ, Bennett RM, Petzke F, Rosner MJ: Prevalence of Chiari malformation and cervical spinal stenosis in fibromyalgia [abstract]. Arthritis Rheum 43(suppl):S173, 2000

7. Clemens S, Rye, Hochman S: Restless legs syndrome: Revisiting the dopamine hypothesis from the spinal cord perspective. Neurology 67:125-130, 2006

8. Cohen H, Neumann L, Shore M, Amir M, Cassuto Y, Buskila D: Abnormal sympathovagal balance in men with fibromyalgia. J Rheum 28:581-589, 2001

9. Condon BR, Hadley DM: Quantification of cord deformation and dynamics during flexion and extension of the cervical spine using MR imaging. J Comput Assist Tomogr 12: 947-955, 1988

10. Heffez DS, Ross RE, Shade-Zeldow Y, Kostas K, Morrissey M, Elias DA, Shepard A: Treatment of cervical myelopathy in patients with the fibromyalgia syndrome: Outcomes and implications. Eur Spine J (E publication) April 11, 2007

11. Heffez DS, Ross RE, Shade-Zeldow Y, Kostas K, Shah S, Gottschalk R, Elias DA, Shepard A, Leurgans SE, Moore CG: Clinical evidence for cervical myelopathy due to Chiari malformation and spinal stenosis in a non-randomized group of patients with the diagnosis of fibromyalgia. Eur Spine J 13: 516-523, 2004

12. Holman AJ: Treatment of fibromyalgia with the dopamine agonist ropinirole: A 14-week double-blind, pilot, randomized controlled trial with 14-week blinded extension [abstract]. Arthritis Rheum 50:S6, 2004

13. Holman AJ, Myers RR: A randomized, double-blind, placebo-controlled trial of pramipexole, a dopamine agonist, in patients with fibromyalgia receiving concomitant medications. Arthritis Rheum 52:2495-2505, 2005

14. Krassioukov AV, Fehlings MG: Effect of graded spinal cord compression on cardiovascular neurons in the rostro-ventro-lateral medulla. Neuroscience 88:959-973, 1999

15. 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. Spinal Disord Tech 19:348-352, 2006

16. Kuwazawa Y, Pope MH, Bashir W, Takahashi K, Smith FW: The length of the cervical cord: Effects of postural

changes in healthy volunteers using positional cervical magnetic resonance imaging. Spine 31:E579-E583, 2006

17. Landis CA, Lentz MJ, Rothermel J, Buchwald D, Shaver JL: Decreased sleep spindles and spindle activity in midlife women with fibromyalgia and pain. Sleep 27:741-750, 2004

18. Lentz MJ, Landis CA, Rothermel J, Shaver JL: Effects of selective slow wave sleep disruption on musculoskeletal pain and fatigue in middle aged women. J Rheumatol 26: 1586-1592, 1999

19. MacFarlane JG, Shahal B, Mously C, Moldofsky H: Periodic K-alpha sleep EEG activity and periodic limb movements during sleep: Comparisons of clinical features and sleep parameters. Sleep 19:200-204, 1996

20. Martinez-Lavin M, Hermosillo AG, Rosas M, Soto M: Circadian studies of autonomic nervous balance in patients with fibromyalgia: A heart variability analysis. Arthritis Rheum 41:1966-1971, 1998

21. Martinez-Lavin M, Hermosillo AG: Autonomic nervous system dysfunction may explain the multisystem features of fibromyalgia. Semin Arthritis Rheum 29:197-199, 2000

22. Mayorov DN, Adams MA, Krassioukov AV: Telemetric blood pressure monitoring in conscious rats before and after compression injury of spinal cord. J Neurotrauma 18:727-736, 2001

23. Meadows J, Kraut M, Guarnieri M, Haroun RI, Carson BS: Asymptomatic Chiari type I malformations identified on magnetic resonance imaging. J Neurosurg 92:920-926, 2000

24. Milhorat TH, Chou MW, Trinidad EM, Kula RW, Mandell M, Wolpert C, Speer MC: Chiari I malformation redefined: Clinical and radiographic findings for 364 symptomatic patients. Neurosurgery 4:1005-1016, 1999

25. Moldofsky H, Scarisbrick P, England R, Smythe H: Musculoskeletal symptoms and non-REM sleep disturbance in patients with 'fibrositis syndrome' and healthy subjects. Psychosom Med 37:341-351, 1975

26. Muhle C, Metzner J, Weinert D, Falliner A, Brinkmann G, Mehdorn MH, Heller M, Resnick D: Classification system based on kinematic MR imaging in cervical spondylitic myelopathy. Am J Neuroradiol 19:1763-1771, 1998

27. Muhle C, Resnick D, Ahn JM, Sudmeyer M, Heller M: In vivo changes in the neuroforaminal size at flexion-extension and axial rotation of the cervical spine in healthy persons examined using kinematic magnetic resonance imaging. Spine 26:E287-E293, 2001

28. Muhle C, Weinert D, Falliner A, Wiskirchen J, Metzner J, Baumer M, Brinkmann G, Heller M: Dynamic changes of the spinal cord in patients with cervical spondylosis at flexion and extension using magnetic resonance imaging. Invest Radiol 33:444-449, 1998

29. Muhle C, Wiskirchen J, Weinert D, Falliner A, Wesner F, Brinkmann G, Heller M: Biomechanical aspects of the subarachnoid space and cervical cord in healthy individuals examined with kinematic magnetic resonance imaging. Spine 23:556-567, 1998

30. Older SA, Battafarano DF, Danning CL, Ward JA, Grady EP, Derman S, Russell IJ: The effects of delta wave sleep interruption on pain thresholds and fibromyalgia-like symptoms in healthy subjects; correlations with insulin-like growth factor I. J Rheum 25:1180-1186, 1998

31. Ordway NR, Seymour RJ, Donelson RG, Hojnowski LS, Edwards WT: Cervical flexion, extension, protrusion and retraction. Spine 24:240-247, 1999

32. Paulus W, Schomburg ED: Dopamine and the spinal cord in restless legs syndrome: Does spinal cord physiology reveal a basis for augmentation? Sleep Med Rev 10: 185-196, 2006

33. Petzke F, Clauw DJ: Sympathetic nervous system function in fibromyalgia. Curr Rheumatol Rep 2:116-123, 2000

34. Pincus T, Swearingen C, Wolfe F: Toward a multidimensional Health Assessment Questionnaire (MDHAQ): Assessment of advanced activities of daily living and psychological status in the patient-friendly health assessment questionnaire format. Arthritis Rheum 42:2220-2230, 1999

35. Raj SR, Brouillard D, Simpson CS, Hopman WM, Abdollah H: Dysautonomia among patients with fibromyalgia: A noninvasive assessment. J Rheum 27:2660-2665, 2000

36. Roizenblatt S, Moldofsky H, Benedito-Silva AA, Tufik S: Alpha sleep characteristics in fibromyalgia. Arthritis Rheum 44:222-230, 2001

37. Rosner I, Rozenbaum M, Naschitz JE, Sabo E, Yeshurum D: Dysautonomia in chronic fatigue syndrome vs fibromyalgia. Irr Med Assoc J 2(Suppl):23-24, 2000

38. Russell IJ, Bennett RM, Michalek JE: Sodium oxybate relieves pain and improves sleep in fibromyalgia syndrome [FMS]: A randomized, double-blind, placebo-controlled, multi-center clinical trial [abstract]. Arthritis Rheum 52:L30, 2005

39. Sheer FAJL, Zeitzer JM, Brown R, Czeisler CA, Shea SA: Reduced sleep efficiency in cervical spinal cord injury: Association with abolished night time melatonin secretion. Spinal Cord 44:78-81, 2006

40. Staud R: Long-term outcome of fibromyalgia related to cervical spine injury is worse in women than in men. Curr Rheumatol Rep 6:259-260, 2004

41. Staud R, Vierck CJ, Robinson ME, Price DD: Overall fibromyalgia pain is predicted by ratings of local pain and pain-related negative affect: Possible role of peripheral tissues. Rheumatology (Oxford) 45:1409-1415, 2006

42. Thimineur M, Kitaj M, Kravitz E, Kalizewski T, Sood P: Functional abnormalities of the cervical cord and lower medulla and their effect on the brain: Observations in chronic pain patients with incidental mild Chiari I malformation and moderate to severe cervical cord compression. Clin J Pain 18:171-179, 2002

43. Vaeroy H, Qiao ZG, Morkrid L, Forre O: Altered sympathetic nervous system response in patients with fibromyalgia (fibrositis syndrome). J Rheum 16:1460-1465, 1998

44. Wilke WS: Can fibromyalgia and chronic fatigue be cure by surgery? Cleveland Clin Med J 88:277-279, 2001

45. Wolfe F, Smythe HA, Yunus MB, Bennett RM, Bombadier C, Goldenberg DL, Tugwell P, Campbell SM, Abeles M, Clark P, Fam AG, Farber SJ, Fiechtner JJ, Franklin CM, Gatter RA, Hamaty D, Lessad J, Lichtbroun AS, Masi AT, McCain GA, Reynolds WJ, Romano TJ, Russell IJ, Sheon RP: The American College of Rheumatology 1990 criteria for the classification of fibromyalgia: Report of the multicenter criteria committee. Arthritis Rheum 33:160-172, 1990

46. Wood PB: Fibromyalgia syndrome: A central role for the hippocampus: A theoretical construct. J Musculoskel Pain 12:19-26, 2004

47. Wood PB: Stress and dopamine: Implications for the pathophysiology of chronic widespread pain. Med Hypotheses 62:420-424, 2004

48. Wood PB: Mesolimbic dopaminergic mechanisms and pain control. Pain 120:230-234, 2006

49. Wood PB, Patterson JC, Sunderland JJ, Tainter JH, Glabus MF, Lilien DL: Reduced presynaptic dopamine activity in fibromyalgia syndrome demonstrated with positron emission tomography: A pilot study. Pain 8:51-58, 2007

50. Yuan Q, Dougherty L, Marguilies S: In vivo human cervical spinal cord deformation and displacement in flexion. Spine 23:1677-1683, 1998

51. Yunus M, Aldag J: Restless legs syndrome and leg cramps in fibromyalgia syndrome: A controlled study. BMJ 312:1339, 1996