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Research Reviews Involving Neurological Conditions of the Cervical Spine

Instructor: Shawn Thistle, DC

Section One: Pathophysiology of cervical myelopathy

Study Title:	Pathophysiology of cervical myelopathy
Authors:	Baptiste DC & Fehlings MG
Publication Information:	The Spine Journal 2006; 6: S190-S197.
Summary:	<p>Cervical myelopathy is the most common acquired case of spinal cord dysfunction in patients over 55. Cervical Spondylotic Myelopathy (CSM) is the diagnostic interpretation most familiar to manual therapists, while cervical myelopathy is a broad term encompassing a number of distinct pathologies in the cervical spine which lead to compression of the spinal cord. Clinically, these pathologies can be difficult to differentiate, often requiring advanced imaging to identify the exact cause.</p> <p>Further, the signs and symptoms experienced by the patient can be extremely variable, depending on which specific area of the spinal cord is affected. Posterior, dorsolateral and ventrolateral columns, ventral horns, and the cervical nerve roots can all be involved, and patients often have more than one area of involvement. The specific pathophysiology of cervical myelopathy is still uncertain, however it is generally accepted that the disorder involves narrowing of the spinal canal secondary to anatomical</p>

degeneration of discs, facet joints, ligaments and connective tissue. This is often in conjunction with an already narrow spinal canal. As the canal space narrows, the risk of symptoms increases.

This disorder is influenced by static factors, referring to anatomical causes, and dynamic factors, referring to repetitive injury to the cervical cord related to movement abnormalities. The combination of these two factors can cause a cascade of inflammation, degeneration, and altered movement which leads to neuronal and glial injury, ischemia, excitotoxicity, and apoptosis (cell death). The purpose of this review article was to summarize the pathophysiological processes associated with cervical myelopathy.

The authors reviewed human studies and relevant animal studies to create this review, which will be summarized below. Additional information regarding clinical presentation and examination was adapted from the additional paper referenced below.

CLINICAL PRESENTATION OF CERVICAL MYELOPATHY

- the typical patient is male (by a ratio of 2.4:1) and over 50
- C5-6 is the most frequently involved level, followed by C6-7 and C4-5 (see below why C3-4 is then the most common hypermobile segment)
- typical symptoms include: pain, neck stiffness, upper limb paresthesia, weakness, clumsiness, gait disturbance, disequilibrium/dizziness, bladder dysfunction
- typical signs include: decreased cervical ROM, sensory abnormality (touch, vibration, joint position sense etc.), weakness on manual muscle testing, muscle wasting, increased tendon reflexes below the level of compromise, spasticity, gait disturbance, coordination deficits, and long tract neurological signs (ex. Oppenheim's and Babinski's responses)
- early presentation can be vague which often leads to delayed diagnosis

ASSESSMENT OF CERVICAL MYELOPATHY

- a full neurological examination should be completed, starting with cranial nerves and progressing to upper and lower limb examinations (including long tract tests)

- include additional sensory tests - vibration, position sense etc., cerebellar function tests (ex. Rhomberg's)
- special signs can include: shoulder girdle wasting, fasciculations, atrophy of hand intrinsics, diminished grip/release test (patient smoothly opens and closes hand 20 times in 10 seconds), inability to perform heel-toe gait
- IMAGING: x-ray studies should be ordered if significant neurological deficit is present, there is a history of trauma, or if the patient fails to respond to conservative care - CT or MRI can also be utilized
- DIAGNOSTICS: somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) may assist in more specific neurological diagnosis

FACTORS CONTRIBUTING TO CERVICAL MYELOPATHY

Spondylosis and Disc Degeneration (static/dynamic)

- cervical discs are vulnerable to the same pathological processes as lumbar discs
- with age, disc dehydration occurs accompanied by medial annular splitting and disappearance of the nucleus pulposis
- this results in increased load on the uncovertebral processes, which become flattened, thus altering the load-bearing characteristics of the cervical motion segment
- this process can result in an unstable motion segment secondary to disc degeneration
- articular cartilage and endplates of the vertebral bodies respond to this by developing osteophytic spurs at the vertebral margins in an attempt to stabilize the adjacent segment
- the intervertebral discs themselves can calcify to further stabilize the segment
- diminished disc height and osteophytic overgrowth can lead to compression on the spinal cord, cervical nerve roots, or vertebral artery
- C3-4 is thought to be the most common level of instability in the elderly, normally due to excessive degeneration and lack of motion at lower cervical segments

Ossification of the Posterior Longitudinal Ligament (OPLL) (static)

- OPLL is a multifactorial disease, and is most prevalent in Japanese people (~2-4%) as well as other ethnic groups
- involves ossification of the PLL which can span the entire length of the spine
- normally presents as progressive myelopathy, and can even result in quadriplegia
- thought to have a strong genetic component but the exact cause or mutation is not known

Ossification of the Ligamentum Flavum (OLF) (static)

- OLF is most common in the thoracic and lumbar spines, but can occur in the neck
- the most common symptoms associated with OLF are arm pain and weakness
- as with OPLL, it tends to affect Japanese people most often, to the point where it is considered rare in other ethnic groups
- the major diagnostic difference between OPLL and OLF is the anatomical location of the two structures
- genetic similarities are thought to exist in the pathology of OPLL and OLF

Calcification of the Ligamentum Flavum (static)

- another rare disorder primarily occurring in Japanese people
- the most common presentation is subacute myelopathy in the absence of precipitating factors, sensory disturbance in the upper limb, clumsiness, difficulty walking, and urinary dysfunction
- neck pain and low grade fever can also occur - thought to originate from inflammation at the calcified sites
- some authors suggest that this condition could be due to an overlying calcium deposition disorder (such as calcium pyrophosphate deposition disease or pseudogout)

Congenital Canal Stenosis (static/dynamic)

	<ul style="list-style-type: none"> • the presence of canal stenosis (< 13mm sagittal) is highly correlated with later development of cervical myelopathy, however this relationship is not always consistent • normal canal diameter is thought to be 17-18mm between C3 and C7 • a narrow spinal canal is thought to lead to local spinal cord tissue damage and ischemia, further exacerbated by repetitive movement problems, and all conditions discussed above • dynamically, neck hyperextension narrows the canal by shingling the laminae and buckling the ligamentum flavum • normal flexion of the neck can also result in cord injury via axial strain to the cord - normal spinal cords are resilient to such forces but over time with associated anatomical problems, the tissue can surpass its threshold and become symptomatic <p>The Role of Ischemia</p> <ul style="list-style-type: none"> • considerable evidence (animal and human) supports ischemia as a major underlying event in the etiology of myelopathy • the neural cell type thought to be most susceptible to ischemia is the oligodendrocyte (responsible for insulating myelin sheaths, and also known to undergo apoptosis after acute traumatic injury) • anterior cord compression compromises the anterior sulcal arteries, while posterior compression reduces perfusion of the intramedullary branches of the central gray matter <p>DIFFERENTIAL DIAGNOSIS</p> <p>Reasonable differentials for cervical myelopathy include: Multiple Sclerosis, shoulder amyotrophy, syringomyelia, rheumatoid arthritis affecting the upper cervical spine, post-polio syndrome, spinal cord tumour, psychogenic disorders, and pernicious anemia.</p>
<p>Conclusions & Practical Application:</p>	<p>Cervical myelopathy is a complex disorder with many contributing factors. It can be a difficult condition to assess and diagnose, but should remain in the astute clinician's mind when patients present with vague neurological symptoms.</p> <p>Additional information for this review was adapted from the</p>

	<p>following paper, also contained in the supplemental issue on the topic from The Spine Journal in December, 2006:</p> <p>Salvi FJ, Jones JC & Weigert BJ. The assessment of cervical myelopathy. The Spine Journal 2006; 6: S182-S198.</p>
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Section Two: Cervical Collar or Physiotherapy versus Wait and See Policy for Recent Onset Cervical Radiculopathy: Randomised Trial

Study Title:	Cervical Collar or Physiotherapy versus Wait and See Policy for Recent Onset Cervical Radiculopathy: Randomised Trial
Authors:	Kuijper B. et al.
Author's Affiliations:	Department of Neurology, Medical Center Haaglanden, Netherlands
Publication Information:	British Medical Journal 2009; 339.b3883.
Background Information:	<p>Cervical radiculopathy is a common disorder that has a favorable prognosis. Typically resolving within 6 weeks, symptoms include neck pain and radiating pain into the arm and possibly the hand as well. Symptoms can be excruciating and therapeutic modalities that accelerate the improvement of pain and function are of value.</p> <p>Several therapeutic modalities exist for the treatment of cervical radiculopathy. However, evidence is lacking for the effectiveness of any non-surgical treatment. This study attempted to assess the effectiveness of a semi-hard cervical collar with rest or physiotherapy versus a traditional wait and see policy on the rate of improvement of recent onset cervical radiculopathy.</p>
Pertinent Results:	<p>205 patients were randomly allocated to 3 groups; cervical collar and rest for 3-6 weeks, physiotherapy (12 treatments over 6 weeks) and control. 12 patients required surgery and were equally distributed among the 3 cohorts.</p> <p>Main Findings:</p> <ul style="list-style-type: none"> The average Visual Analogue Scale scores at

	<p>baseline were ~70mm for arm pain and ~60mm for neck pain (NP)</p> <ul style="list-style-type: none"> • At 6 weeks, VAS values reflected significant reductions in arm pain (average value 33 mm - hence a reduction of ~37mm) and neck pain (average 31mm - hence a reduction of ~29mm) for the collar group and physiotherapy group (both averaged 31mm - hence reductions of ~40mm and 30mm respectively) were observed vs. the control group (reductions were only 19mm and 5mm respectively) • Neck Disability Index (NDI) improvements were statistically significant for the collar group and not for the physiotherapy group (despite both groups showing an improvement) • No difference was noted between groups at 6 months in NDI or VAS for cervical/arm pain - reflecting the natural history of this condition that was mentioned above • No significant difference was noted between groups in secondary outcomes at 3 and 6 weeks: satisfaction, use of opiates/NSAIDS, working status (non-significant pattern for PT group for partial or complete sick leave vs. collar and control group)
<p>Clinical Application & Conclusions:</p>	<p>Traditionally it has been understood that immobilization is contraindicated for stable cervical spine conditions, as a lack of movement is believed to lead to disuse atrophy, deconditioning and increased likelihood of disability and chronicity (1). The authors, however, have found that a short course (3-6 weeks) of immobilization and rest for acute onset cervical radiculopathy may be a viable treatment option and may be equally as effective as strengthening exercises.</p> <p>Past studies have attempted to answer the same question, however, they have looked at a different patient population, namely those with chronic radiculopathy. These previous studies failed to show any benefit with a cervical collar or strengthening exercises (2). This may indicate that cervical</p>

	<p>radiculopathy is a heterogenous condition, requiring specific management based on acuity.</p> <p>It is also important to realize that the changes in VAS scores in this study were deemed significant with a change 3 cm for arm pain and 1.7/1.4 cm (collar/PT) for NP. The patients in this study had a mean VAS of > 70mm at intake. The Minimal Clinically Important Difference (MCID) for VAS of that magnitude is > 20 mm, indicating that the change in neck pain may have been clinically significant but not statistically significant (3).</p> <p>This paper provides the framework for future studies, including a comparison of immobilization to cervical traction and spinal manipulation for acute cervical radiculopathy. It also provides a possible option for patient self management. Patients can utilize a cervical collar when not receiving treatment which may speed recovery and possibly empower the patient to achieve independence from care.</p>
<p>Study Methods:</p>	<p>This was a prospective randomized trial of acute cervical radiculopathy (onset < 1 month). 210 patients were randomized into 3 groups: semi-hard cervical collar, physiotherapy with home exercise, and a control group.</p> <p>Inclusion Criteria:</p> <ul style="list-style-type: none"> • age 18-75 years • symptoms for less than one month • arm pain on a visual analogue scale of 40mm or more • radiation of arm pain distal to the elbow • provocation of arm pain by neck movements <p>...and one of the following:</p> <ul style="list-style-type: none"> • sensory changes in one or more adjacent dermatomes • diminished deep tendon reflexes in the affected arm

	<ul style="list-style-type: none"> • muscle weakness in one or more adjacent myotomes <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • clinical signs of spinal cord compression • previous treatment with physiotherapy or a cervical collar • insufficient understanding of the Dutch or English language <p>The collar group was required to wear the brace daily for the first 3 weeks of care, minimize activity and take as much rest as possible. At week 4 they were to "wean" off of the brace and discontinue use by week 6. Each patient was also required to keep a daily journal recording time of brace use and medication use.</p> <p>The physiotherapy group was treated 2x/week for 6 weeks. No passive care was provided. Instead, therapy was supervised active strengthening of the superficial and deep cervical musculature. Patients were given home exercises to compliment the in-office care.</p> <p>The control group was instructed to continue with their activities of daily living.</p> <p>Outcomes Measures:</p> <ul style="list-style-type: none"> • Cervical spine and arm VAS, NDI, self reported opiate use, working status and satisfaction • Outcomes were assessed at baseline, 3 weeks, 6 weeks and 6 months
<p>Study Strengths/Weaknesses:</p>	<p>Weaknesses of this study:</p> <ul style="list-style-type: none"> • Both patients and examiners were not blinded • The calculated sample size of 240 patients was not reached, therefore power was not achieved. • All patients presented with sensory disturbance which is subjective and has been previously shown

	to have a high false positive rate. Few patients presented with motor deficit or hyporeflexia which are objective and more indicative of a neurocompression lesion.
Additional References:	<ol style="list-style-type: none"> 1. Polston DW. Cervical radiculopathy. <i>Neurol Clin</i> 2007; 25:373. 2. Persson LC, Carlsson CA, Carlsson JY. Long-lasting cervical radicular pain managed with surgery, physiotherapy, or a cervical collar: a prospective, randomized study. <i>Spine</i> 1997; 22: 751-8. 3. Bird SB, Dickson EW. Clinically significant changes in pain along the visual analog scale. <i>Ann Emerg Med</i> 2001; 38: 639-43.

Section Three: A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy

Study Title:	A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy
Authors:	Rubinstein SM et al.
Publication Information:	European Spine Journal 2006; DOI 10.1007/s00586-006-0225-6
Summary:	<p>Cervical radiculopathy can be a substantial cause of pain, morbidity, and disability. It is a common condition that affects both men and women, mainly around middle age. Despite its prevalence, the gold standard for diagnosis of this condition is unclear. Traditionally, clinical history and examination findings are confirmed with advanced imaging or electrodiagnostic testing. As with many other clinical conditions, all of these diagnostic methods have inherent limitations. In addition, the expense and lack of availability of these tests limits their application, emphasizing the necessity for simple, clinical tests to identify this condition.</p> <p>The purpose of this systematic review was to evaluate diagnostic accuracy for clinical tests commonly used in the evaluation of cervical radiculopathy. For this review, cervical</p>

radiculopathy refers to signs and symptoms related to dysfunction of a spinal nerve of the neck. These can include pain, myotomal weakness, and sensory or reflex neurological deficit.

The optimal reference standard defined for and utilized in this review when selecting studies included both: a) electrodiagnostic evidence or acute denervation in cervical paraspinal muscles and/or a specific myotome, and b) demonstrated abnormalities on advanced imaging (myelography, CT, MRI) that correlated with the site and corresponding signs and symptoms of the patient.

This study began with a hand search of relevant orthopedic texts to identify tests commonly used to evaluate cervical radiculopathy. A comprehensive literature search was then conducted, including all relevant databases, to identify studies which met the following criteria:

- any provocative test of the neck for diagnosing cervical radiculopathy was identified
- the diagnostic test was compared to any reference standard (such as EMG, plain film x-ray or advanced imaging)
- sensitivity and specificity were reported and a 2x2 contingency table could be (re)constructed
- the publication was a complete report

Case series, case reports, animal studies, surgical and cadaveric studies were all excluded because diagnostic accuracy cannot be determined from these types of studies. Each potential study was reviewed by two separate reviewers, and reviewed for methodological quality with QUADAS, a previously tested set of 12 criteria. Any disagreement regarding study inclusion was resolved by a third reviewer.

Pertinent results of this review include:

- 6 studies met the inclusion criteria (all of which were found on MEDLINE) - 3 were published in the 1980s, and the other three after 2000
- no single study used the optimal reference standard described above - 2 used EMG, 3 used advanced

	<p>imaging, and 1 used operative findings</p> <ul style="list-style-type: none"> • multiple studies evaluated the following tests: upper limb tension test (ULTT), shoulder abduction test, traction/neck distraction, Spurling's test, and only one study evaluated Valsalva's maneuver • no studies were found which examined the axial compression test or the shoulder depression test • the most striking finding was the variability among results for the various studies - this was most pronounced for the shoulder abduction test, which had reported sensitivities ranging from 0.17-0.78 • Spurling's test was shown to have low to moderate sensitivity and high specificity, as did individual studies for traction/neck distraction and Valsalva's maneuver • the ULTT demonstrated high sensitivity and low specificity while the shoulder abduction test demonstrated low to moderate sensitivity and moderate to high specificity • in general, no test demonstrated high sensitivity and specificity, and the methodological quality of the studies (except for one) was "meager"
<p>Conclusions & Practical Application:</p>	<p>This review was limited by three major shortcomings:</p> <ol style="list-style-type: none"> 1. only six studies were identified that met inclusion criteria (and only one of those included patients in a primary care setting) 2. no study used the optimal reference standard (even though this optimal standard was defined for this review by these authors - it seems reasonable) 3. the studies included were not standardized in terms of test performance (this seemed most prevalent for Spurling's test, which was performed in slightly different ways in each study) <p>Despite these drawbacks, I feel this study underlines a critical point. During our education, we were exposed to many clinical tests from various orthopedic textbooks without (in many cases) ever critically examining the literature to support their accuracy. This is one example where these familiar tests don't seem to hold up to critical review. That being said, determining</p>

	<p>accuracy for tests like these is difficult because there is no universally accepted gold standard for diagnosis, and what these tests are actually testing (in terms of tissue stress etc.) has not been elucidated. The problem is further clouded by the difficulty in distinguishing cervical radiculopathy (spinal nerve involvement) from brachial plexopathy or peripheral nerve entrapment.</p> <p>So what is the take home message from this systematic review? First, I feel that it emphasizes our immediate need to clarify our clinical testing abilities for this, and other clinical conditions. We have inherently trusted orthopedic textbooks for too long.</p> <p>Second (and on a more positive note), the authors propose the following as a practical application of the existing data: "When consistent with the history and other physical findings, a positive Spurling's test, as well as positive findings for traction/neck distraction [i.e. symptom reduction], and the Valsalva's maneuver might be suggestive of a cervical radiculopathy (i.e. given their high specificity), while a negative ULTT might be used to rule it out (i.e. given its high sensitivity)."</p> <p>I think this recommendation is reasonable, but it must be understood that the combination of these tests mentioned by the authors is an extrapolation based on the limited existing data.</p>
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Section Four: Cervical roots as origin of pain in the neck or scapular regions

Study Title:	Cervical roots as origin of pain in the neck or scapular regions
Authors:	Tanaka Y et al.
Publication Information:	Journal of Clinical Neuroscience 2006; 13: 578-581.
Summary:	Neck, scapular, and arm pain are symptoms potentially resulting from cervical radiculopathy. Patients commonly describe pain in the neck or scapular region prior to the onset of neurological symptoms such as numbness and tingling or motor weakness in the arm and fingers. Often, a

diagnosis of mechanical neck pain is modified to a radiculopathy as the arm and finger symptoms appear. The time interval that normally exists between the onset of pain and the onset of radicular symptoms has led some to believe that the pain is not caused by nerve root compression, but by mechanical stress secondary to instability in the neck caused by arthritic changes to the disc and facet joints.

The authors of this study aimed to determine whether pain in the neck and scapular regions in patients with cervical radiculopathy originates from a compressed nerve root, and if the site of pain is helpful in determining the level of involvement. This study had an interesting way to test this idea. Basically, if pain originates from the disc or facet joint, then surgical decompression of a nerve root would not relieve the pain - implicating a mechanical cause.

Conversely, if pain was originating from a compressed nerve root, then surgical decompression would relieve the pain. Further, if pain in a region of the scapula is relieved by nerve root decompression, referred pain patterns could be established.

In this prospective observational study, 50 patients (42 males and 8 females) with pain and arm/finger symptoms underwent single root decompression surgery alone. All patients had been treated conservatively for at least 4 months before undergoing surgery. Symptom duration averaged 7 months, and the involved nerve root levels were C5 in 9 patients, C6 in 14, C7 in 14, and C8 in 13. Nerve root levels were determined by classic arm/finger symptoms patterns, and associated pain was also recorded immediately before, and 1 month and 1 year after surgery. Five regions were demarcated around the scapula - nuchal, suprascapular, interscapular, scapular, and superior scapular angle. Patients identified the location of pain during single-finger palpation by one examiner.

Pertinent findings of this study include:

- the neck or scapular pain and the arm/finger symptoms occurred on the same day in only 30% of the patients
- pain preceded arm/finger symptoms in the remaining 70% (35 patients)

	<ul style="list-style-type: none"> • in these 35 patients - 33 described the interval between the pain and arm/finger symptoms - <1 week (15 pts) or 1 month or longer (7 pts) [other patients somewhere between] • within one month of surgery, 92% of patients were not experiencing pain in the original location • when painful site was suprascapular, C5-6 radiculopathy was frequent (p<0.01) • when the painful site was interscapular, C7 or C8 radiculopathy was frequent (p<0.001) • when the painful site was scapular (directly over the scapula), C8 radiculopathy was frequent (p<0.01)
Conclusions & Practical Application:	<p>This study raises a couple of relevant points for consideration:</p> <ol style="list-style-type: none"> 1. pain in the scapular region is a common precursor to radicular symptoms in the arm/fingers 2. the location of pain in the scapular region can be helpful in determining the involved nerve root level <p>If patients are not responding to conservative care of scapular region pain, a closer investigation for possible cervical radiculopathy is warranted. The associations delineated in this study between nerve root levels and pain locations in the scapular region could prove useful in this process.</p>

Section Five: Assessment of forearm pronation strength in C6 and C7 radiculopathies

Study Title:	Assessment of forearm pronation strength in C6 and C7 radiculopathies
Authors:	Rainville J et al.
Publication Information:	Spine 2007; 32(1): 72-75.
Summary:	Cervical radiculopathy is a common condition which peaks

in prevalence in patients in their early fifties. Fortunately, the existing literature indicates that 74% of all cervical radiculopathies can be treated conservatively, and that 90% of patients recover fully or have only minor residual disability. Despite the favorable prognosis, the condition itself can be extremely painful and limiting, resulting in lost work time, high medical costs, and medicolegal claims.

Cervical radiculopathy is caused by irritation or mechanical impingement of spinal nerves within the spinal canal or neural foramen. Osteocartilaginous degeneration resulting in deformity of the discs, facet joints, or uncovertebral joints is normally the cause, but symptoms can also result from space occupying lesions, congenital deformity etc. The most common symptom of cervical radiculopathy is radiating pain into the upper extremity. Other neurological symptoms may be present including sensory disturbance (33% of patients), motor weakness (15-34%), and reflex changes (84%). It is important to note that previous studies have indicated that actual weakness on examination is more common than subjective (i.e. patient-reported) weakness - with 64-75% of patients exhibiting weakness on examination.

C6 radiculopathy can present as pain in the neck, shoulder, lateral arm, radial forearm, and even into the thumb and index finger. Reflex changes include diminished or absent biceps, brachioradialis, and pronator teres reflexes. The conventional manual muscle test (MMT) for the C6 myotome is wrist extension, but this has only been studied in one paper (which reported a positive in only 36% of patients with confirmed C6 radiculopathy).

One published EMG study stated that the most consistent finding in C6 radiculopathies is involvement of the pronator teres muscle (they also noted that this was never present with C5 radiculopathy, but was present in 50% of C7 radiculopathies). The goal of this study was to expand on this finding by exploring the clinical utility of forearm pronation MMT in C6 and C7 radiculopathies.

Fifty-five consecutive patients (average age ~45) with imaging-confirmed C6 or C7 radiculopathy were included in the study. Patients had arm pain (with or without neck

pain) in patterns consistent with C6/7 involvement, paresthesia in the involved dermatomes, and complaints of weakness in the upper extremity. Imaging-confirmation had to include findings of cervical disc herniation or stenosis of the neural foramen.

Exclusion criteria included:

- not having a CT or MRI study of the cervical spine
- neurologic or muscular disease of the spinal cord or peripheral nerves
- anatomic compression of more than one nerve root on the symptomatic side
- bilateral radicular symptoms
- known shoulder, elbow, wrist or hand arthritis that may interfere with MMT
- cancer under active treatment
- severe psychiatric disorders

Each patient underwent a standard series of MMTs on the following muscles: pronator teres, wrist extensors, biceps, and triceps. Forearm pronation was tested with the patient's arm at their side, with the elbow at 90° and the forearm in a neutral position. Each patient was completely examined by two physicians, with the results then compared to determine interrater reliability of the tests.

Pertinent results of this study include:

- 25 patients with C6 involvement and 30 with C7 involvement were included in the study
- for those with C6 radiculopathy, forearm pronation was the only weakness in 5/20 subjects (20%)
- in all subjects with C6 radiculopathy - positive (weak) wrist extension and elbow flexion was always accompanied by weak pronation (overall pronation was weak in 72% of patients)
- for C7 radiculopathies, pronation weakness accompanied weak elbow extension in 7/30 patients (23%)

	<ul style="list-style-type: none"> • in C7 radiculopathy patients, isolated pronation weakness without elbow extension weakness was present in 3 patients (10%)
<p>Conclusions & Practical Application:</p>	<p>Manually testing forearm pronation strength is a simple procedure that may have some value in detecting cervical radiculopathy at C6 or C7. In this small, simple study, forearm pronation weakness was the most consistent motor impairment in patients with C6 radiculopathy, detected in 72% of cases. Further, it was twice as common as wrist extensor weakness, which is the conventional muscle test used to indicate this level of involvement. Pronation weakness was also noted in 23% of patients with C7 radiculopathy, and was the only positive muscle test in 10% of these patients. These findings suggest that pronation weakness may be sensitive to C6 radiculopathies, but not specific, as it can also occur with C7 involvement. The secondary outcome of this study indicated that interrater reliability for pronation was comparable to the other muscle tests performed.</p> <p>I reviewed this study because I felt its simple design and message add to conventional practice. It now seems reasonable to include forearm pronation in our examination of patients with suspected cervical radiculopathy. As a simple addition to a thorough examination, weakness of forearm pronation may indicate C6 or C7 radiculopathy. The most important take home message from this study is that weak pronation may be the ONLY finding from muscle testing, which alone supports its inclusion in the examination of these patients.</p> <p>This study's main drawback is the lack of blinding of the examining physicians, who had already viewed the imaging studies and accompanying reports. This prior knowledge may have influenced the results of this study, and no mention of statistical correction for this influence was mentioned. In addition, the study would have been strengthened by utilizing a larger patient group, and including other cervical levels of involvement to further clarify sensitivity and specificity of this test.</p>

Section Six: Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control

Study Title:	Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control
Authors:	Treleaven J Author Affiliations: Neck Pain and Whiplash Unit, Division of Physiotherapy, University of Queensland, Australia
Publication Information:	Manual Therapy 2008; 13: 2-11.
Summary:	<p>The control of stable, upright posture relies on input from a variety of afferent sources including the vestibular, visual, and proprioceptive systems, all of which converge in the central nervous system. The cervical spine plays a central role in providing proprioceptive information, as evidenced by its abundance of mechanoreceptors and reflex connections to the visual and vestibular systems (outlined below). Dysfunction in the cervical spine can alter afferent input to these systems, subsequently changing the integration, timing, and tuning of neuromuscular and sensorimotor control. This paper reviewed recommendations for the clinical assessment and treatment of sensorimotor control disturbances with a special focus on the cervical spine. An executive summary follows:</p> <p>Introduction and Background:</p> <p>There are 3 main reflexes in the neck that influence head, eye, and postural stability - they should be kept in mind while reading this review:</p> <ol style="list-style-type: none">1. Cervico-Collic Reflex: activates neck muscles in response to mechanical stretch in order to maintain head position2. Cervico-Ocular Reflex: in combination with the vestibulo-ocular reflex (relation between vestibular apparatus and eye positioning via the extraocular muscles), this reflex also affects the extraocular

muscles to assist with clear, smooth vision during neck movement

3. **Tonic Neck Reflex:** is evident in newborns - when the face is turned to one side, the arm and leg on the side to which the face is turned extend and the arm and leg on the opposite side bend - in adults it is integrated with the vestibulospinal reflex to achieve postural stability

It is well known that there are significantly more muscle spindles located in the suboccipital region of the cervical spine (200/gram of muscle compared to only 16/gram in the lumbricals of the thumb). This indicates that the suboccipital muscles relay a significant amount of information to the central nervous system, reflected also by the fact that there are numerous connections between the cervical receptors and the visual/vestibular system, as well as the sympathetic nervous system. Studies that artificially disturb these connections anatomically or through vibration have revealed their potential to alter eye and head positioning, as well as postural sway, and velocity and direction of gait and running. Further, similar effects have been noted after induction of neck muscle fatigue.

It is not surprising then, that patients with neck disorders can have altered cervical joint position sense (JPS), postural stability, and oculomotor control. These patients can have either traumatic or insidious symptoms, which may be associated with complaints of dizziness/unsteadiness, headaches, loss of balance, or visual problems. This obviously necessitates a thorough clinical history and examination to rule out other potential causes such as vertebral artery pathology, central nervous system disease, infection, systemic pathology, tumour/malignancy, medication side effects, and so on. Once these have been sufficiently ruled out, examination for cervical spine causes can be undertaken. The clinician should bear in mind that sensorimotor symptoms can also be influenced by pain levels in general, and psychosocial stressors. Further, although most of the literature to date has examined those with chronic neck pain, there is evidence suggesting that these changes

can occur soon after pain onset.

As manual therapists, there are a couple of ways we could potentially intervene to treat sensorimotor disturbances related to cervical spine structures:

1. **Manual Therapies** such as manipulation/mobilization, acupuncture; or
2. **Rehabilitation Programs** focusing on gaze stability, eye/head coordination, or cervical position sense

All of the above-mentioned interventions have at least some degree of evidence supporting their efficacy for treating these types of problems. Therefore, the best current recommendation for these patients is to combine local cervical spine treatment with individualized programs for sensorimotor control (see below).

Clinical Assessment of Sensorimotor Control in Neck Disorders:

Current evidence suggests that assessment of sensorimotor control include investigation for dizziness, cervical joint position sense (JPS), postural stability, and oculomotor control. Regarding dizziness, patients should be questioned regarding the temporal pattern, sensation, and associated symptoms (including visual disturbance, loss of balance/falls, difficulty with ambulation, etc.).

Cervical Joint Position Sense (JPS)::

- refers to a patient's ability to reproduce a specified head/neck position with visual input removed (blindfolded or eyes closed)
- most accurately measured using a head mounted laser pointer or torch on a lightweight headband - patient seated 90cm from a wall, initial position marked via laser, patient then moves head (rotation, flexion, or extension) and attempts to return to initial position which is also marked, allowing measurement of error (this could also be done without a head-mounted laser, but accuracy would obviously suffer)

- previous literature indicates that the laser measurement technique can detect a deficit within 3-4 degrees (4-5cm) which can indicate a deficit in JPS
- clinically, patients may overshoot/undershoot starting position, exhibit jerky motions, or recreate dizziness or other symptoms

Oculomotor Assessment:

- incorporates gaze stability and smooth pursuit
- **Gaze Stability:** tested by having the patient maintain stable gaze as the head moves into flexion, extension, rotation - looking for awkward cervical motion, reproduction of dizziness, nausea, blurred vision, or other symptoms
- **Smooth Pursuit/Eye Follow:** patient maintains a stable head position while the eyes track an object - the literature suggests moving the object 20°/second through a 40° visual angle (this can then be repeated with the trunk rotated up to 45°)
- can be tested with patient seated, or supine if necessary depending on patient presentation

Eye-Head Coordination:

- the patient moves the eyes and the head in the same direction, or opposite directions, or various combinations
- examiner should investigate for symptom reproduction, abnormal eye movements etc.

Postural Stability:

Generally, balance can be assessed in tandem, narrow or wide stance, and uni/bilaterally. Unstable surfaces can be added for to increase difficulty. It is reasonable to expect that a person under the age of 60 can maintain stability for 30 seconds in a comfortable and narrow stance. Subjects under age 45 should also be able to complete 30 seconds in tandem and single leg stance

tests.

Management of Sensorimotor Control Disturbances in Neck Disorders:

In general, treatment should include local treatment to involved cervical spine structures to decrease pain and improve neuromuscular function, as well as individually prescribed sensorimotor exercises to improve identified deficits. The exercises described below should be performed 2-5 times per day. Patients should expect temporary reproduction of dizziness, however exacerbation of neck pain or headache should not occur.

Cervical JPS can be practiced at home, with or without the aid of a head mounted laser. Patients can practice with eyes open and then closed by lining up their target positions with objects on the wall to check their accuracy upon return.

Occulomotor exercises are based on assessment findings, and can be made more challenging by increasing the speed of the motions, changing the patient's position, or altering the visual background.

Examples include:

- **Eye follow with stationary head:** patient follows a target with the eyes with the head stationary - target example could include tossing a tennis ball in the air
- **Gaze stability:** can begin with slow passive neck movements while fixing the eyes on a stationary object, progressing to keeping gaze fixed with the eyes closed (checking gaze maintenance when eyes are opened), or restricting peripheral vision
- **Eye/head coordination:** these begin with rotating the eyes and head to the same side/direction, and progressed to the head and eyes moving in opposite directions, or eyes first - then head, or active neck motion to follow a slowly moving object with peripheral vision restricted. Patients can also use their own thumb as a moving target while they walk and move their neck at the same time - any

	<p>appropriate combinations can be used as progressions.</p> <p>Postural stability and balance can be trained in similar ways as it is assessed, adding unstable surfaces, external perturbations, and so on, as the patient progresses.</p>
Conclusions & Practical Application:	<p>The cervical spine is clearly important in maintaining postural stability. This review has provided the clinician with simple tools that can be used to assess and treat various sensorimotor disturbances that can occur.</p> <p>The assessment and treatment methods described above are based on existing evidence. It should be noted that more extensive research is required to refine and optimize these strategies.</p>