# Cervical myelopathy and radiculopathy

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## INTRODUCTION

Cervical/neck pain is a common musculoskeletal complaint affecting 66–70% of individuals within their lifetime (Anderson et al 1993) with 54% having experienced symptoms within the previous 6 months (Cote et al 1998). Cervical pain can significantly affect both physical and social functions (Bovim et al 1994, Brown et al 2009), with correspondingly high levels of healthcare use and costs (Brattberg et al 1989) and up to 5%
of individuals indicating high disability (Cote et al 1998). Cervical spine pain is more prevalent in individuals who are educated, who have a history of injury or trauma, and who suffer from consistent headaches (Brown et al 1991, 2009).

Cervical pain can originate from a tumour, injurious event, infection, inflammatory disorder, metabolic condition, and/or degeneration (Ahn et al 2007, Binder 2007). The most common cause is degeneration (called cervical spondylosis). Cervical spondylosis is caused by degeneration of tissues such as the cervical disc and cartilaginous end plates, osteophytes along the vertebral body, facets, and unco-vertebral joints, and ossification or thickening of the ligamentum flavum or posterior longitudinal ligament (Rao & Fehlings 1999, McCormick et al 2003).

Two specific diagnoses associated with degenerative changes in the cervical area are cervical myelopathy and cervical radiculopathy. Both conditions involve debilitating neurological symptoms that may progress toward disability if inadequately treated (Muller & Dvorak 2001, McCormick et al 2003). In severe cases, radiculopathic and myelopathic changes can occur simultaneously resulting in myeloradiculopathy. Cervical myeloradiculopathy is a major management challenge and often leads to significant movement disorders (Wong et al 2004).

It has been purported that myelopathy is present in 90% of individuals by the seventh decade of life (Dvorak 1998) and is recognized as the most common form of spinal cord dysfunction in an individual over the age of 55 (Brown et al 2009). Cervical myelopathy most commonly affects males (Montgomery & Brower 1992) and those of Asian descent (Jayakumar et al 1996). It is believed that a large percentage of elderly patients have mild cervical myelopathy that often goes unnoticed, as signs and symptoms are frequently attributed to a normal ageing process (Brown et al 1991, 2009).

Cervical radiculopathy is defined simply as an abnormality of a nerve root, which originates in the cervical spine (Polston 2007). Cervical radiculopathy has a purported prevalence of 3.3 cases per 1000 people (Wainner et al 2003) to 83.2 per 100,000 (Polston 2007), affecting men more frequently than women (Radhakrishnan et al 1994). The condition has a peak annual incidence of 2.1 cases per 1000, and occurs most commonly in the fourth and fifth decades of life (Wainner & Gill 2000). The seventh (60%) and the sixth (25%) cervical nerve roots are the most common regions affected (Malanga 1997).

The natural history of myeloradiculopathy is unclear, the signs and symptoms are inconsistent, and the pathophysiological mechanisms are multifactorial in nature. The prevalence of myeloradiculopathy is unknown, although patients with movement disorders, e.g. cerebral palsy, torticollis and Tourette syndrome, demonstrate accelerated propensity for either spondylosis or myeloradiculopathy (Wong et al 2004). Infectious conditions such as schistosomiasis are the most investigated disease processes associated with myeloradiculopathy in the literature. Schistosomal myeloradiculopathy is a japonicum infection with trematodes of the spinal cord and is usually associated with acute transverse myelitis involving the lower portions of the spinal cord (Lambertucci et al 2008).

Cervical myelopathy, cervical radiculopathy, and cervical myeloradiculopathy may cause significant pain and debilitation and are the focus of this chapter. In particular, we plan to focus on correct diagnosis, prognosis, and treatment of each condition.

## REVIEW OF ANATOMY SPECIFIC TO THE PATHOLOGY

Anatomical knowledge of the cervical spinal is necessary for an understanding of the patho-biomechanics of cervical myelopathy, radiculopathy, and myeloradiculopathy. A single spinal segment is identified by two contiguous vertebral units (e.g. C4 and C5). There are five primary articulations between adjacent vertebrae. The first is the intervertebral disc which cushions and controls movement between two vertebral bodies. Two uncinate processes articulate laterally and provide control of side flexion-based movements, and two zygapophyseal joints guide movements such as rotation. The intervertebral discs allow movement in all three planes, plus torsion. The zygapophyseal joints are considered translational joints and allow sliding motions that depend on the orientation of the joint plane. The uncinate processes allow sliding movements as well but are thought to be limited to those associated with convex and concave movements such as side flexion and sagittal movements (Cook 2006).

Within this boundary are two foramen, the spinal canal, which houses the spinal cord and the intervertebral foramen, in which the cervical spine roots exit. For the spinal canal, the lateral and posterior aspects are bordered by the superior and inferior lamina. The ligamentum flavum provides a dorsal boundary and is attached to two-thirds of the undersurface of the superior lamina. Inferiorly the ligamentum flavum is attached to the superior edge of the lower lamina (Cook 2006). Anteriorly, the spinal canal is bordered by the intervertebral disc and anterior-laterally by the unco-vertebral joints.

Each nerve root exits above the correspondingly numbered vertebral body from C2 to C7 in regions identified as intervertebral foramen. Nerve roots in the cervical spine are identified by the caudal segment of the intervertebral foramen. For example, the C3 nerve root exits above C3 vertebral body, as does the C5 nerve root above the C5 body. The intervertebral foramen is bordered superiorly and inferiorly by the pedicle, posteriorly by the facet joint, posterior-medially by the ligamentum flavum, anteriorly...
by the unco-vertebral joint, and anterior-medially by the intervertebral disc and posterior longitudinal ligament (Cook 2006).

**REVIEW OF PROPOSED PATHOLOGY AND PATHO-BIOMECHANICS**

Myelopathy, radiculopathy, and myeloradiculopathy involve both structural and movement-related abnormalities. Structurally, progressive degenerative changes result in disc height losses and reduction of space in the spinal canal and intervertebral foramina. Structural changes to the intervertebral discs, ligaments, and capsule lead to visco-elastic losses and movement abnormalities (Pope 2001). In particular, flexion-extension movements may cause a variety of neurological symptoms in severe degenerated conditions (Wilson et al 1991). During extension, the spinal canal shortens and narrows because of infolding of ligaments. The ligamentous infolding causes dorsolateral encroachment in the canal. In addition, the disc may bulge posteriorly in selected situations, further reducing space dorsolaterally. These structural changes may lead to kinetic changes such as decreased movement, compression on dorsolateral nerve roots or nerve root ganglia, compression on the spinal cord, and pain (Pope 2001).

Cervical myelopathy is hallmarked by the stenotic encroachment of the cervical spinal cord and subsequent neurological changes (Brown et al 2009). The encroachment may lead to structural and vascular changes and originates from sagittal narrowing of the canal. The narrowing may cause compression of the spinal cord and often originated from (1) osteophytes secondary to degeneration of intervertebral joints, (2) stiffening of connective tissues such as the ligamentum flavum at the dorsal aspect of the spinal canal which can impinge on the cord by buckling when the spine is extended, (3) degeneration of intervertebral disc together with subsequent bony changes, and (4) other degenerative connective tissue changes (Wong et al 2004). Non-degenerative, structural-based conditions may be associated with syringomyelia, an arachnoid cyst, a tumour, or epidural lipomatosis (Durrant & True 2002).

Dynamic movements of the spinal cord are regulated by the spinal column and the anchoring elements of the spinal cord. The primary anchoring elements are the dentate ligaments and the filum terminale (Durrant & True 2002). In normal subjects, length changes of the spinal cord are from 4.5 to 7.5 cm, with flexion increasing tension in the spinal cord and with extension decreasing tension (Breig 1978). Spinal cord compression occurs from a number of mechanisms, most notably from the friction that is present from degenerative changes during movements of extension and flexion. Ventral osteophytes can prevent upward and downward movement of the spinal cord during physiological motions (Bartels et al 2007). Furthermore, thickening of tissues and bony changes called a spondylitic bar increases the friction placed upon the spinal cord during movements and causes permanent damage (Bartels et al 2007).

Cervical radiculopathy is caused by a cascade of events that lead to nerve root distortion, intraneural edema, impaired circulation and focal nerve ischaemia, a localized inflammatory response and altered nerve conduction (Truumees & Herkowitz 2000). The localized inflammatory response is stimulated by chemical mediators within the disc, which may incite the production of inflammatory cytokines, substance P, bradykinin, tumour necrosis factor α, and prostaglandins (Albert & Murrell 1999, Rhee et al 2007). These chemical pain mediators are not typically present in chronic disc lesions (Durrant & True 2002). Along with the production of chemicals, the membrane surrounding the dorsal root ganglion, which is more permeable allowing a local inflammatory response, may contribute to cervical radiculopathy (Rao & Fehlings 1999).

The most common compressive causes of cervical radiculopathy are disc herniation and degenerative spine components, e.g. osteophytes, facet joint hypertrophy, and ligament hypertrophy (Truumees & Herkowitz 2000). Disc herniation occurs when nuclear material from the acute soft disc herniation impinges on a nerve root either posterolaterally or intraforaminally (Rhee et al 2007). The degenerative causes are associated with a loss of disc height and a ‘hard disc’ bulging with resultant compressive elements such as the ligaments (Albert & Murrell 1999) and osteophytes (Rhee et al 2007). Location-wise, anterior causes (soft or hard disc herniation and osteophytes from the uncinate processes) are the most common cause of radicular symptoms (Rhee et al 2007). Other causes include ischaemia, trauma, neoplastic infiltration, spinal infections, post-radiation, immune-mediated diseases, lipoma, and congenital disorders (Truumees & Herkowitz 2000).

Cervical myeloradiculopathy is believed to occur during chronic spondylosis and repetitive compressive damage to the cervical spinal cord and roots, but may also occur acutely upon a flexion/extension injury (Ito et al 2004, Lewis et al 2008). Compression may result from anterior spondylotic spurs, posterior infolding of ligaments, or both (Frank 1993). Changes involve demyelination, vascular compromise and inflammation of the nerve roots.

**CLINICAL SIGNS AND SYMPTOMS**

**Myelopathy**

Myelopathy is characterized by a variable distribution pattern (Brown et al 2009) and may involve clinical findings in the lower extremities first, with subsequent gait related changes, weaknesses of the legs and spasticity (Bartels et al 2007, Harrop et al 2007). Gait disturbances are associated with...
upper motor neuron changes involving corticospinal tracts and spinocerebellar tracts dysfunction. Later, lower motor neuron findings in the upper extremities such as loss of strength, atrophy, and difficulty in fine finger movements may present (Cook et al 2007, Harrop et al 2007, Cook et al 2009).

Additional signs and symptoms of cervical myelopathy manifest as pain in the cervical, upper quarter region or shoulder, widespread numbness, paraesthesia and sensory and ataxic changes of the lower extremities (Polston 2007). Findings may include tetraspasticity (Dvorak 1998), gait-related clumsiness (Dvorak 1998), spasticity, hyper-reflexia (Crandall & Batzdorf 1966), and the presence of primitive reflexes (Hawkes 2002). Other clinical findings indicative of progressive decline include acquired spastic paraparesis (Hawkes 2002), tetraparesis, or paraparesis (Montgomery & Brower 1992). Because the signs and symptoms are often sequential, weakness and stiffness of the legs (Adams & Victor 1999) typically precedes pain and the occasional findings of bowel and bladder changes (Thongtrangan et al 2004).

There is a distinct possibility of mixed presentation of signs and symptoms with myelopathy. Reflexes and sensibility changes may actually be depressed at the level of compression (C5–C8) with hyper-reflexia at the levels below the lesion (Brown et al 2009). Since myelopathy can involve a number of cervical levels, most commonly, C5–C8, changes below the affected level may manifest as hyper-reflexia, whereas problems above the level are generally hyporeflexic (Brown et al 2009). In addition, uncommon symptoms may be present with myelopathic conditions, including restless legs secondary to loss of descending inhibition of the corticospinal tract, nausea, dizziness and dysphagia which can occur from compression of vertebral artery (Brown et al 2009).

Radiculopathy

For cervical radiculopathy, neurological symptoms may lead to pain, motor weakness or sensory deficits along the affected nerve root (Rao & Fehlings 1999, Polston 2007, Rhee et al 2007). Depending on the nerve root affected, symptoms may exist concurrently in the neck, shoulder, upper arm or forearm (Polston 2007). Often, pain and sensibility changes are not consistent and may result in a dull ache to a severe burning pain in the neck and arm. Pain is typically noted in the medial border of the scapula and shoulder, which can progress down the ipsilateral arm and hand along the sensory distribution of the involved nerve root (Wolff & Levine 2002). The pain may not be localized because multiple nerve roots can cause similar distribution patterns (Ellenberg et al 1994).

Motor weakness associated with radiculopathy may provide a variety of clinical scenarios and is associated with specific nerve root levels (Polston 2007, Rao & Fehlings 1999). Specific nerve root weakness typically presents in the following patterns: scapular weakness with C4; shoulder abduction or forearm flexion weakness with C5; wrist extension/supination with C6; triceps, wrist flexion/pronation with C7; and finger flexors/interossei with C8 (Tsao et al 2003). Others have noted (Tsao et al 2003) that motor weakness often with fasciculations is present in 61–68% of patients. Advanced cervical radiculopathy cases may present with muscle wasting and fasciculations (Polston 2007). In a study of 846 patients, Henderson et al (1983) noted triceps weakness due to C7 radiculopathy was present in 37% of the subjects and biceps weakness was present in 28%.

Sensibility changes (sensation variations) of the affected nerve roots may help localize the level of the lesion. C4 nerve root distribution tends to affect the shoulder and upper arm, C5 nerve root distribution the lateral aspect of the arm, C6 nerve root affects the lateral aspect of the forearm, hand, and thumb, the C7 nerve root the dorsal lateral forearm and 3rd digit, and the C8 nerve root the medial forearm, hand and 4th and 5th digits (Chien et al 2008).

Cervical radiculopathy typically presents with diminished deep tendon reflexes (muscle stretch reflex). Deep tendon reflexes are an involuntary response which offers an objective assessment for neurological impairment (Durrant & True 2002). Loss of deep tendon reflexes is usually said to be the most reliable clinical finding (Marshall & Little 2002) and is noted in 70% of the cases (Tsao et al 2003). Generally, the decline in reflexes follows a predictable radicular pattern.

Myeloradiculopathy

The combination of signs and symptoms of cervical myeloradiculopathy lead to a complex clinical presentation (Baba et al 1998). In most cases, the presentation of myeloradiculopathy involves both the cardinal signs and symptoms of the two separate diseases. For example, a common presentation is radicular symptoms in the arm (pain and weakness) and myelopathic symptoms in the legs (gait disturbances, loss of position and vibratory sense and spasticity) (Frank 1993). The challenges occur when clinical signs and symptoms overlap. In these selected cases, which typically involved highly affected, chronic spondylitic changes, differentiation of the condition is less probable and recognition of the need for decompressive surgery is the key clinical finding.

CURRENT BEST EVIDENCE WITH REGARD TO DIAGNOSIS

Cervical myelopathy

Patient history

In most cases, myelopathic changes are slow and progressive (Masdeu et al 1997). The duration of symptoms often
spans a number of years and is present with concomitant conditions associated with spondylosis such as stiffness and pain. Initial symptoms are typically vague and are often mistaken as changes associated with ‘old age’. Often, patients will indicate problems after or period of rest or inactivity (Masdeu et al 1997, Bednarik et al 2004). Gait problems are the first symptoms associated with myelopathy but it’s often motor changes such as spasticity, weakness, and clumsiness of the arms and hands that warrants the pursuance of work up (Masdeu et al 1997, Bednarik et al 2004).

Myelopathic changes either occur after a prolonged bout of spondylotic changes or after trauma in those patients with relatively recent degenerative changes. Most patients are older, have experienced range of motion limitations, pain with selected positions such as end range rotation and extension, and routinely have had bouts of radiculopathy in the past (Bednarik et al 2004). In fact, the strongest predictor of future myelopathy is a history of radiculopathy (Bednarik et al 2004).

Sensory changes are inconsistent and generally occur later more so than early, and in the upper extremities more than the lower extremities (Masdeu et al 1997). Initial symptoms in milder cases can start with hand clumsiness or numbness, which may be unilateral at first, before gait abnormalities are noted (Masdeu et al 1997, Polston 2007). Hand clumsiness or numbness involves less sensory loss than motor dysfunction and is, in essence, an apraxia of the distal upper extremities and hands (Good et al 1984). Diminished vibration sense is often seen in the lower extremities (Masdeu et al 1997).

Other symptoms may include decreased appreciation of pain, hot, or cold (Brown et al 2009), decreased response to sharp or dull, and restless legs (Brown et al 2009). Long-term cases may involve wasting or fasciculations of the biceps (Harrop et al 2007). In very rare cases, bowel and bladder disturbances may occur. Presence of urinary retention, dribbling incontinence or faecal incontinence should raise concern of a condition outside of myelopathy such as cauda equina syndrome (Masdeu et al 1997).

**Outcomes measures**

There are a number of clinician-scored outcomes for myelopathy represented in the literature. The oldest is the Nurick-score consisting of five definitive explanations of the effects of the condition, and is scored from 0 to 5 (0 representing root involvement but no evidence of spinal cord disease, 5 representing chair bound or bedridden status). The Nurick-score suffers from a lack of responsiveness as each grade reflects substantial jumps in clinical condition (Nurick 1972).

The most used appears to be the Japanese Orthopaedic Association Score (JOA), which is effective at measuring changes in patients’ conditions (Vitzhum & Dalitz 2007). The JOA is a disease-specific, physician-oriented scale designed to assess the neurological status of a patient and allows surgeons to measure pre- and post-intervention changes (Dalitz & Vitzhum 2008). The scale involves a number of constructs including scoring of feeding, upper extremity shoulder and elbow function, lower extremity gait capabilities, sensory involvements, and bowel and bladder control (Dalitz & Vitzhum 2008).

The European Myelopathy Score (EMS) is a diseasespecific, physician oriented scale that involves a number of constructs including gait function, walking dysfunction, climbing stairs, bladder and bowel function, handwriting, eating, and dressing, and activities associated with sensory losses and proprioception (Vitzhum & Dalitz 2007). The scale is more sensitive to change than the JOA and the Nurick but is not routinely used in clinical practice.

**Physical examination**

a) Observation: Diagnosis of myelopathy is challenging, particularly in the early stages of the condition, as symptoms may present as hyper-reflexia (MacFadyen 1984, Polston 2007), clumsiness in gait (Matsuda et al 1991, Bednarik et al 2004), neck stiffness (Montgomery & Brower 1992, Chiles et al 1999), shoulder pain (Lev et al 2001), paraesthesia in 1 or both arms or hands (Good et al 1984), or radiculopathic signs (Nurick 1972, Montgomery & Brower 1992).

b) Active and passive movements: Both active and passive neck movements are often limited, specifically rotation, side flexion, and extension. Range of motion loss in the upper extremity is inconsistently found. Symptoms may or may not be reproduced during movements. In some cases, extension triggers neurological symptoms down the thoracic spine but this condition typically only occurs in patients with chronic spondylar changes.

c) Gait symptoms associated with myelopathy are slow and progressive. Symptoms may involve difficulty in initiating movements, walking briskly, and tendencies to trip (Masdeu et al 1997). Other gait changes include development of paraparesis described as heaviness of legs, trembling and cramming of thigh and calf muscles, and difficulty negotiating steps, curbs, and getting in and out of vehicles (Masdeu et al 1997).

d) Clinical tests such as single leg stance, tandem walking, and basic coordination exercises will be challenges to patients with myelopathy. A test referred to as the head shake and gait involves having the patient attempt to walk a straight line while moving one’s head up and down (as if shaking one’s head in agreement). In patients with spondylotic bars, the friction of the cord during the movements often facilitates the challenges in normal gait and coordination.

In some occasions, symptoms may include hyper-reflexia, which in severe cases may involve bilateral clonus and extensor planter reflexes. Pathological reflexes are
generally only present in long standing, chronic degenerative conditions (Brown et al. 2009). Upper extremity reflex changes are less consistent and are often dependent on the site of structural impairment (Masdeu et al. 1997). Higher level cervical involvement can cause hyper-reflexia throughout the upper and lower extremities. Mid or lower levels of cervical involvement may result in hyporeflexia (radicular symptoms) at the levels above the site of the injury and hyper-reflexia below the levels.

Coordination testing such as nose to hand tests, braiding, Frenkel’s, and arm rolling are often poorly performed in patients with late-stage myelopathy. Patients may overshoot targets and demonstrate poor dexterity during activities and struggle with fine motor tasks.

**Confirmation tests**

The clinical examination for myelopathy includes the use of Hoffmann’s test (Emery et al. 1998, Cook et al. 2007, 2009), deep tendon reflex testing (Denno & Meadows 1991, Cook et al. 2007, 2009), inverted supinator sign (Estanol & Marin 1976), suprapatellar quadriceps reflex testing (de Freitas & Andre 2005), hand withdrawal reflex testing (Denno & Meadows 1991), Babinski sign (Ghosh & Pradhan 1998), and clonus (Young 2000). Nearly all of these tests are specific, versus sensitive, and are useful to rule in a suspected condition versus ruling out the condition. Despite the fact that most of these tests are routinely used to screen for myelopathy, the inherent diagnostic accuracy of each test limits the effectiveness as screens.

a) **Hoffmann’s Sign** (Fig. 9.1). Hoffmann’s sign consists of involuntary flexion of a varied combination of the neighbouring fingers and/or thumb, and is commonly used to detect an upper motor neuron dysfunction (Emery et al. 1998). The test is performed by stabilizing the middle finger proximal to the distal interphalangeal joint and striking the fingernail of the middle finger with the opposite hand. A number of studies have analysed the sensitivity and specificity of the tests and have demonstrated that the Hoffmann’s sign is generally a specific test having yielded sensitivity values of 25–68% (Glaser et al. 2001, Houten & Noce 2008, Cook et al. 2009).

b) **Inverted Supinator Sign** (Fig. 9.2). The inverted supinator sign is a C7 response during a deep tendon reflex assessment of C6 (brachioradialis). The test is performed in the same fashion as a brachioradialis deep tendon reflex test and the response for a pathological finding involves finger flexion and/or elbow extension, versus a normal response of wrist pronation and/or elbow flexion. To our knowledge, the test has been investigated only once and demonstrated a sensitivity of 61% and a specificity of 78% (Cook et al. 2009).

c) **Suprapatellar Reflex Test.** The suprapatellar reflex test involves a tapping of the quadriceps tendon just superior to the patella. A normal response involves slight knee extension, whereas an abnormal response associated with upper motor neuron problems involves an exaggerated knee extension response, a possible hip flexion response, and in some occasions internal rotation and adduction of the hip joint. The test has been investigated only once and demonstrated a sensitivity of 56%; but only a specificity of 33% (Cook et al. 2009).

d) **Babinski Test.** The Babinski test involves the elicitation of an extensor toe sign during stroking of the plantar aspect of the foot. The test is more specific than sensitive, demonstrating a sensitivity of 33% (Houten & Noce 2008) and 24% in two recent studies (Cook et al. 2009). Cook et al (2009) found the Babinski sign to have the best diagnostic value of all tests for confirmation providing a positive likelihood ratio of 4.0 (95% CI 1.1–16.6).

e) **Clonus Test.** Repetitive beats of 3 or more upon striking the anterior aspect of the patient’s foot during sitting is associated with a positive finding of clonus. Clonus has been investigated in two studies, both of which have demonstrated poor sensitivity, 10% in Houten & Noce (2008) and 14% in Cook et al (2009).
Combinations of testing

Only one study has combined values to determine if clusters of clinical findings improve the diagnostic accuracy of the tests. Cook et al (2009) reported no improvement in post-test probability adjustments after clustering patient history factors such as clumsiness in the hands or gait problems with clinical tests such as clonus, Babinski, Hoffmanns, and others.

Cervical radiculopathy

Patient history

It is important to determine the main complaint (numbness, weakness, location of symptoms) of the subject (Wolff & Levine 2002). If pain is a complaint, a pain drawing is beneficial to establish a pattern and location of the pain. A pain drawing allows one to determine if the pain radiates and if so, the distribution of the symptoms (Honet & Puri 1976). In addition to identifying the main complaint it is important to isolate activities or head movements that trigger the concordant symptoms. One must also check for presence of concomitant symptoms such as gait changes, bowel or bladder or lower extremity conditions which are suggestive of myelopathy, and address if there were any similar episodes in the past and if any treatment was provided for the present and/or past episodes. Identifying demographic and social history such as age, sex, stress, occupation, recreational activities, and nicotine use is suggested (Honet & Puri 1976).

Outcomes measures

There are no specific outcomes measures for cervical radiculopathy. The Neck Disability Index (NDI) is the most frequently used functional outcome tool for cervical related disabilities. This outcome assessment tool was created by modifying the Oswestry Disability Index and is extremely reliable. The NDI determines the extent of disability and is designed to measure activity limitations due to neck pain and disability (Pietrobon et al 2002). The NDI has been used regularly in previous studies that have investigated functional status (Smith 1979).

Visual Analogue Scale (VAS) or a Numeric Analogue Scale is a common scale used to quantify pain and has historically been used as an outcome tool (Downie et al 1978, Langley & Sheppeard 1985). The VAS for pain in the cervical spine has a test-retest reliability of 0.95 to 0.97 (McCormick et al 2003) and MCID of 12 ± 3 mm (Kelly et al 2005). The VAS involves quantification of pain on a numbered line (0–100, the level of pain he/she is currently experiencing: 0 indicates no pain and 100 indicates the worst pain imaginable). The scale is easy to administer but lacks any dimensions other than intensity (Szpalski & Gunzburg 2001).

Physical examination

a) Observation: Patients with cervical radiculopathy will often hold their head away from the injurious side avoiding rotation to the offending side (Wolff & Levine 2002). In some cases, the patients may cradle their affected arm or place the arm behind or on top of their head to reduce the tension on the nerve root (Davidson et al 1981).

b) Active and Passive Movements: All planes of motion of the cervical spine should be assessed with active and passive movements. Active range of motion is typically decreased, specifically rotation to the offending side (Wainner et al 2003) and extension. Range of motion assessment is typically reliable and is considered a useful clinical measure (Fletcher & Bandy 2008). Responses to look for are any movements that are associated with the pain/symptoms noted during the history portion of the exam.

c) Dermatome Testing: Dermatome testing involves examination of motor function, sensibility changes, and deep tendon reflex modifications along a nerve root distribution. Cervical nerve roots exit above their correspondingly numbered pedicles (e.g. C6 exits between C5 and C6 vertebra), with the exception of the C8 nerve root which exits above T1. With infrequent exceptions, disc herniation or some other space offending structure at a specific site (e.g. C4–5) will affect the nerve root from that site (Rhee et al 2007).

For two primary reasons, it is important to note that absence of radiating symptoms in a dermatomal distribution does not rule out the presence of nerve root compression (Rhee et al 2007). Firstly, the presence of upper trapezius or interscapular pain may be the extent of the symptoms for that patient (Rhee et al 2007). As the condition progresses, symptoms may or may not migrate to the upper arm. Secondly, the clinical tests associated with motor testing, sensibility testing, and deep tendon reflex testing have routinely demonstrated very low sensitivity values suggesting that the clinical findings may be below the threshold of these particular tests (Cook & Hegedus 2008). The most common nerve roots affected are C5, C6, C7, C8, and T1. Specific nerve roots may demonstrate predictable patterns of motor functional losses, sensory changes, or reflex changes.

A manual muscle test is performed to identify minimal weakness along a myotome distribution to determine a local nerve root involvement. According to Yoss et al (1958), a manual muscle test offers greater specificity than either the reflex or sensory testing and single root level involvement can be diagnosed clinically 75–80% of the time. The manual muscle tests may best be initiated in a gravity induced position, testing the uninvolved limb first for a comparison of both sides. The clinician should look for subtle changes and apply the force proximal to the
next distal joint (Ellenberg et al 1994, Malanga 1997). Grading of 0 to 5 is recommended as follows: 0/5 no movement; 3/5 antigravity; 5/5 normal (Honet & Puri 1976).

The grading of deep tendon reflexes (DTR) are from 0 (absent) to 4 (clonus, very brisk). Reflex abnormality is found primarily from nerve root involvement of C5 through C8 (Polston 2007, Chien et al 2008). The DTR is tested with the muscle of the tendon relaxed and the clinician applying a slight stretch to the tendon followed by tapping the tendon with a reflex hammer. Reflex abnormality of deltoid, biceps, brachioradialis is noted from C5 and C6 involvement, triceps from C7, and finger flexors from C8 (Honet & Puri 1976).

**Confirmation tests**

There are a few provocation tests that are typically performed when assessing for cervical radiculopathy. Spurling’s sign combines the motions of cervical lateral bending and compression which reduces space within the foraminal area (Tsao et al 2003). The test is considered positive if symptoms of radicular pain are reproduced or worsen. According to Honet & Puri (1976) the Spurling’s sign demonstrates high specificity and low sensitivity for cervical radiculopathy (Cook & Hegedus 2008) (Fig. 9.3).

The cervical distraction test is another test offered for cervical radiculopathy assessment. The test is performed with the patient supine and the clinician supporting the head with a chin cradle grip. The clinician applies a traction force to the cervical area (Fig. 9.4). If symptoms are reduced with this test, it is considered positive. Viikari-Junutra et al (2000) noted a specificity of 100 with a QUADAS score of 11 for ruling in cervical radiculopathy.

Another test to consider is the Upper Limb Tension Sign (ULTT). According to Cook & Hegedus (2008) this test is excellent as a screening test for ruling out cervical radiculopathy. The test is performed with the patient supine, forearm supinated, wrist and fingers extended. Ulnar deviation is applied. If no symptoms are reproduced the clinician then extends the elbow (Fig. 9.5). If symptoms are still not reproduced lateral flexion of the neck is performed. Reproduction of concordant, asymmetric symptoms in the distal area denotes a positive test.

**Combination of tests**

Wainner et al (2003) developed a clinical prediction rule for ruling in cervical radiculopathy: the combined tests include Spurling’s, ROM < 60 degrees, the cervical distraction test and ULTT. When all 4 tests are positive the specificity was 99% with a LR+ of 30.0 (QUADAS = 10).
Cervical myeloradiculopathy

Patient history

The most common report of symptoms include subtle neck pain, radiculitis and radicular pain in the arms and trouble with gait or coordination of the lower extremities. In chronic conditions, patients may indicate difficulty with upper extremity coordination activities as well. Most of the reported signs and symptoms are analogous to concomitant myelopathy and radiculopathy. Outside of infectious condition most myeloradiculopathic symptoms are insidious, progressive, and have a chronic presentation.

Physical examination

Positive findings may occur with stenotic movements of rotation, side flexion and extension. Most patients will exhibit problems with gait examination but typically only during higher level gait changes such as single legged stance, tandem walking and Rhomberg positions. Coordination losses may be prevalent in the lower and potentially, upper extremities, with sensation changes most common in the upper extremities.

Outcomes measures

There are no exclusive outcomes measures for myeloradiculopathy, thus the same tools used for measurement of myelopathy (e.g. Nurick scale, JOA, and European Myelopathy Scale) and radiculopathy (NDI and VAS) are used to evaluate changes in patients’ conditions.

Confirmation tests

There are no dedicated clinical tests designed to identify myeloradiculopathy. Typically, the same tests used to confirm myelopathy (Hoffmann, Inverted supinator sign, suprapatellar reflex) and radiculopathy (Spurling’s sign, cervical distraction test) are used in the clinical confirmation phase.

Imaging

Plain film radiograph

Plain film radiography is useful in identifying stenosis and the extensiveness of degenerative joint disease (Brown et al 2009). In addition, radiography is used to determine canal stenosis and at present, 13 millimetres of anterior-posterior (sagittal diameter) width or less is considered a risk factor in the development of myelopathy (Brown et al 2009). Nonetheless, smaller patients may have decreased diameters and this value may not be as useful as a ratio measure (Brown et al 2009).

Magnetic resonance imaging (MRI) and computed tomography (CT) scan

MRI is considered the best imaging method for myelopathy because it expresses the amount of compression placed on the spinal cord (Fukushima et al 1991), and demonstrates relatively high levels of sensitivity (79–95%) and specificity (82–88%) (LR+ = 4.39–7.92; LR− = 0.06–0.27) in identifying selected abnormalities such as space occupying tumours (Fujiwara et al 1989), disc herniation (Yousem et al 1992), and ligamentous ossification (Mizuno et al 2001). The MRI provides the ability to rule out a tumour or syrinx (fluid-filled cavity that develops in the spinal cord), and provides detailed views of the spinal cord, intervertebral disc, vertebral osteophytes and ligaments, all structures that potentially compress the spinal cord (Gross & Benzel 1999). Furthermore, MRI findings have been shown to correlate with preoperative severity of cervical compressive myelopathy and prognosis after surgery (Ono 1977, Yousem et al 1992). Patients with advanced cord changes often demonstrate poor outcomes after surgery and those with only minor compression tend to demonstrate fair recovery or retardation of progression of symptoms (Yoshimatsu et al 2001).

Changes associated with myelopathy may lead to anterior-posterior width reduction of the spinal cord, cross sectional evidence of cord compression, or obliteration of the sub-arachnoid space (Fukushima et al 1991). At present, there are no definitive objective findings on MRI consistently described by radiologists that are reflective of myelopathy with the exception of myelomalacia (identified through signal intensity changes to the cord). Signal intensity changes have been described as the most appropriate ‘gold standard’ for confirmation of a spinal cord compression myelopathy (Fukushima et al 1991), but are also only present in advanced chronic cases (Fig. 9.6).

Fig 9.6 MRI changes reflecting cord compression and myelomalacia.
MRI findings are not conclusively indicative of cervical myelopathy (Bednarik et al 2004). Cord related changes and subsequent symptoms from cervical myelopathy overlap other types of intrinsic myelopathy, e.g. multiple sclerosis, syrinx or amyotrophic lateral sclerosis. Careful screening of the MRI, including the presence of T2 weighted changes, is crucial to show clear, relevant, spinal cord compression (Jeffreys 2007). False positives are common as cord compression alone does not directly equate to clinical signs and symptoms (Estanol & Marin 1976). Diagnosis is usually made from a detailed history of progressive patient symptoms, weakness and hyper-reflexia on examination, and clear compression of the spinal cord at an appropriate symptomatic level on the MRI scan, with or without T2 changes. Since T2 MRI changes usually do not abate with surgery (Wada et al 1999), these changes are more indicative of damage rather than reversible ischemia. A dedicated criterion standard, such as the singular use of an MRI scan used to determine myelopathy does not exist (Sung & Wang 2001).

The MRI has demonstrated superiority in identification of a herniated nucleus pulposis (Wilmink 2001) and structural changes from spondylosis (Wilmink 2001). The MRI has demonstrated comparable findings with myelography and cervical radiculopathy-myelography (Larsson et al 1989) but may exhibit limitations in identifying the extent of root compression (Barlett et al 1996).

It is difficult to differentiate a soft and a hard disc herniation through imaging methods (Rhee et al 2007). Specificity of the MRI for nerve root compression is suspect, identifying abnormal findings in 10% of subjects who were asymptomatic (Boden et al 1990). Sensitivity of an MRI is very good (Birchall et al 2003). Significant compression can occur before one sees changes clinically (Birchall et al 2003).

As a whole, the most compelling findings are associated with complete occlusion of the entrance to the intervertebral foramen by a laterally migrated mass on MRI followed by narrowing of a foramen by osteophytes (may only cause nerve root swelling). Poorest association includes disc herniation because the nerve root can often move out of the way of the offending intruder (Birchall et al 2003).

Computed tomography (CT) is less commonly used in assessment of the extent of degenerative of the cervical spine. Although CT is less costly and is faster and more reliable, it does have significant limitations in detection of both cervical radiculopathy and myelopathy. The inherent low-contrast resolution during assessment of soft tissue obviates the need for a CT myelography, which is troublesome when dealing with small disc herniations or limited intrusion into the intervertebral foramina (Maigne & Deligne 1994).

**Nerve condition responses**

Aside from MRI, a neuromuscular test, such as an electromyogram/electroneurogram (EMG/ENG), is often used to differentiate cervical myelopathy from carpal tunnel syndrome, or other peripheral nerve problems. Since cervical myelopathy is an upper motor neuron syndrome, the EMG is expected to display a normal finding unless there are intervening root or peripheral nerve problems. Kang & Fan (1995) reported normal results for EMG in 100% of patients diagnosed with cervical myelopathy. Evoked potentials have demonstrated the greatest assistance with the diagnosis of cervical myelopathy. Motor evoked potentials have a reported 70% sensitivity in the upper extremity muscles and 95% sensitivity for muscles of the lower extremity for the diagnosis of cervical myelopathy (De Mattei et al 1993). From an electrodagnostic standpoint, the use of sensory evoked potentials (SEP) have demonstrated superior diagnostic ability as Kang & Fan (1995) reported abnormal SEP in 19/20 patients diagnosed with cervical myelopathy.

Tests of nerve condition responses such as electromyography (EMG) and nerve conduction studies (often abbreviated to NCV, V for velocity) tests are occasionally used to differentiate radiculopathy for peripheral entrapment disorders (Rhee et al 2007). Because of limitations in nerve condition testing, the MRI has supplanted nerve condition responses as the tool of choice (Polston 2007). For example, of the cervical spinal nerves, only C4–C8 has limb representation that allows differentiation (Truumees & Herkowitz 2000). In addition, results of the tests may vary considerably depending on the age of the lesion, the segmental level analysed, and the diagnostic application of the test (Polston 2007).

EMG is an electrical recording of muscle activity and involves insertion of a fine needle into the tested muscle. In order to diagnose with an EMG the reading must be abnormal for two or more different muscles and peripheral nerves from the same nerve root (Durrant & True 2002). The EMG is considered a useful diagnostic tool for cervical radiculopathy (Durrant & True 2002). Two recordings are taken, one at rest and one during a contraction. A normal response involves only brief EMG activity during needle insertion, then no activity when the muscle is at rest. During contraction, motor unit action potentials that reflect electrical activity within the muscle appears on the recording screen with corresponding increases as more muscle fibres are solicited.

Abnormal responses exhibit electrical activity at rest, alterations in the pattern of firing activity and decreases in amplitude and duration of the spikes on the recording screen. The findings may demonstrate contractions of other muscles (compensatory) and poor recruitment in nerve related disorders such as radiculopathy. Concentric needle EMG testing has demonstrated sensitivities of 50–93% and appears to be the best and most widely accepted method of electrodagnostic testing (Prahlow & Buschbacher 2003).

A NCV consists of stimulation of the nerve and recording of the evoked potential, either from the muscles, or...
from the nerve (to study the sensory response). NCV assesses the extent of axonal loss of large myelinated nerve fibre (Cook et al 2009). The test involves measurement of the time delay between stimulation and response at two stimulation sites with a calculation of the distance of the sites (Smith 1979).

The two late responses most commonly analysed include the H-reflex and the F-wave. The H-reflex (Hoffmann’s reflex) assesses an afferent 1a sensory nerve and an efferent alpha motor nerve. The F-wave analyses motor nerves only and is often normal in patients who have suspected radiculopathy. Because of a propensity for poor sensitivity, NCV tests should never be used in isolation (Rhee et al 2007).

Selective diagnostic nerve root block (SNRB) is a test to identify if a specific nerve root is causing the patient’s pain. The test is considered sensitive and specific for radiculopathy (Malanga 1997).

Two definitive elements of differential diagnosis are necessary. Firstly, one must rule out the presence of red flags such as fever, chills, history of cancer, intravenous drug use, and other sinister conditions. Secondly, infectious conditions such as schistosomiasis will have a rapid onset (uncharacteristic of spondylotic causes) and may progress toward quicker debilitation. Cervical myelopathy requires differentiation from a number of other conditions including amyotrophic lateral sclerosis, multiple sclerosis, spinal cord tumours, and cerebrovascular disease (Brown et al 2009). In some cases, viral diseases can cause spinal cord degeneration. The most difficult differential diagnosis is when both radicular and myelopathic changes are present (Table 9.1).

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<th>Table 9.1 Differentiation of referred pain characteristics</th>
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<td>Characteristic</td>
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<tr>
<td>Axial Distribution</td>
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<tr>
<td>Upper Extremity Muscle Weakness</td>
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<tr>
<td>Lower Extremity Muscle Weakness</td>
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<tr>
<td>Upper Extremity Sensory Disturbance</td>
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<tr>
<td>Clumsiness</td>
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<td>Gait Disturbance</td>
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<td>Spurling’s Sign</td>
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<td>Sensory Deficit</td>
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<td>Loss of Vibratory Sense</td>
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<td>Tendon Reflex Changes</td>
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<td>Muscle Wasting</td>
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<td>Babinski Sign</td>
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<td>Hoffman’s Sign</td>
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<td>Limb Tension Test</td>
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Chapter 9 | Cervical myelopathy and radiculopathy
CURRENT BEST EVIDENCE WITH REGARD TO PROGNOSIS

Prognosis for myelopathy and myeloradiculopathy without surgical intervention is mixed. Generally, it is assumed that the condition, which is a progressive degenerative process, will result in continuing worse outcomes over time. However, a number of subjects with mild cases of cord compression who do not receive prophylactic surgery do not decline and maintain their current level of function (Matsumoto et al 2000).

There is limited research on the prognosis of cervical radiculopathy. Most authors indicate that about two-thirds of conditions of cervical radiculopathy resolve with conservative care (Lees & Turner 1963). Some authors note that due to the benign course of cervical radiculopathy, with up to 75% rate of natural recovery, conservative care is the recommended treatment initially (Polston 2007). A long-term follow up study of 51 subjects with cervical radiculopathy who were treated conservatively showed that 45% had one episode of pain and 30% had mild symptoms (Lees & Turner 1963).

CURRENT BEST EVIDENCE WITH REGARD TO TREATMENT

Conservative approaches

Myelopathy

Conservative management including treatment of pain, limb mobility, treatment of gait impairments and reduction of risk of falls may be appropriate for a number of patients because myelopathy may exhibit only minor impairment with no progression (Matsumoto et al 2000). Initially, immobilization of the cervical spine with a collar is used to stabilize the spine in neutral or slight flexion. While some evidence exists for the effective treatment of early myelopathic changes via conservative physical therapy interventions (traction and thoracic manipulation) (Browder et al 2004, Murphy et al 2006), conclusive evidence for the effectiveness of surgical intervention for myelopathy suggests that surgery should be pursued when symptoms are progressive and destructive (Fujiwara et al 1989). Conservative care has been shown beneficial in 30–50% of patients (McCormick et al 2003).

Treatment after surgical intervention may include strengthening weakened areas, gait training, and proprioceptive exercises. At present, there is no literature that supports or refutes the use of conservative rehabilitation after surgical management of myelopathy.

Radiculopathy

A stepwise approach addressing predominant signs and symptoms of cervical radiculopathy is usually used. Typically, during the acute stage of cervical radiculopathy the treatment should aim at reducing inflammation and pain, patient education, and avoidance of increasing any neurological deficits. Treatment for inflammation and pain may include ice, heat, NSAIDS, analgesics, rest, possible immobilization, and traction.

A recent derivation clinical prediction rule was developed that outlined patients with neck pain who were most likely to benefit from a concomitant program of cervical traction and exercise (Raney et al 2009). The study identified: (1) a positive abduction test, (2) peripheralization of symptoms, (3) a positive upper limb tension test, (4) a positive neck distraction test, and (5) age ≧ 55 years. Although the authors reported an increase in post-test probability of improvement to 94.8% when four of five variables were present, one must use caution as the findings demonstrated very wide confidence intervals (2.5–227.9).

There is no evidence that immobilization via a cervical collar/brace will reduce the duration or severity of cervical radiculopathy (Naylor 1979). If immobilization is administered, the timeframe should be limited to 1–2 weeks due to the negative effects from long-term immobilization. Limited evidence is available to support traction as an early intervention. A recent randomized clinical trial by Young et al (2009) reported no significant differences between two patient groups classified with cervical radiculopathy when evaluating the effectiveness of mechanical cervical traction. Jensen & Harms-Ringdahl (2007) found that when comparing acute and chronic neck pain interventions, range of motion had the strongest evidence in reducing pain in the acute phase, and combined physical agents for acute and chronic pain reduction.

Patient education should address the cause of the pain, activity modification to improve or reduce further progression of the symptoms. Patients showed reduction in pain and increased patient satisfaction when instructed on an individual home exercise program compared to written information (Jensen & Harms-Ringdahl 2007). Patients should have a home programme of stretching and strengthening once the radiculopathy symptoms have resolved.

During subacute management physical therapy is typically prescribed. Modalities such as heat, ice, massage, ultrasound, and electrical stimulation are not verified in the literature for long-term benefits but have shown some benefit in uncontrolled studies (Rhee et al 2007). These modalities are typically administered to address muscle pain and spasm. Once the patient’s pain and inflammation are reduced, a progression by physical therapy to address ROM, flexibility, and strength is initiated. Strengthening exercises include isometrics of the cervical
muscles and isotonics for stabilization of the scapular region, which includes the trapezius, rhomboids, serratus anterior, and latissimus dorsi (Malanga 1997). Progression to resistive exercises is appropriate as long as the patient’s symptoms are not aggravated. The literature also encourages continued aerobic exercise throughout the course of rehabilitation to reduce overall de-conditioning (Malanga 1997, Tsao et al 2003).

Steroid injection is a common intervention in patients with cervical radiculopathy for reduction of inflammation despite only a few randomized clinical trials to support the efficacy of the approach (Polston 2007). The injections are often offered when a patient is not responding to a course of conservative treatment including meds, rest, and physical therapy. Studies that have been performed show a positive outcome of up to 60% for long-term relief (Malanga 1997).

### Myeloradiculopathy

At present, conservative treatment for myeloradiculopathy includes palliative care, gait training by physical therapists, and range of motion and strengthening exercises to retard the progression of the degenerative changes. There is a dearth of evidence to support conservative care for this condition as most patients receive surgical intervention.

### Surgical approaches

Surgical approaches are aimed at removing the offending compressive disorders from the nerve and decompressing the cord to allow the cord to move without friction and further damage (Frank 1993). In order to decide which surgical approach to use, surgeons must consider lesion location (Witwer & Trost 2007), the number of levels involved (Witwer & Trost 2007), the specific pathology (Witwer & Trost 2007), patient age, neurological function and cervical alignment (Heller et al 2001), radiographic imaging (Witwer & Trost 2007) as well as an individual surgeon’s familiarity with technique (Heller et al 2001). Surgical treatment has been shown to retard the effects of cervical myelopathy when caught in an expeditious manner (Fujiiwara et al 1989). A number of factors can influence the outcome of surgery, most notably, chronicity of symptoms (Matsumoto et al 2000), whether radiculopathy is also present with myelopathy (Shamji et al 2009), and age and integrity of the spine (Fujiiwara et al 1989). In addition, the type of surgical approach is often selected based on the symptoms at hand. All surgeries involve some element of decompression of the spinal canal and may involve an anterior or posterior approach (McCormick et al 2003). At present, a series of trials has failed to prove the superiority of one versus the other although short-term complications are higher in patients who receive posterior approaches (Cybulski & D’Angelo 1988).

It is important to note that in some occasions, continued neurological deterioration can occur after surgery secondary to ischaemia (Smith-Hammond et al 2004). This condition is a diagnosis of exclusion (once hematoma and dislocation is ruled out) and has a gradual but damaging progression.

### Anterior approaches

Anterior surgery is performed for unilateral/bilateral radiculopathy or myelopathy when there is a single dominant cervical level or in the face of kyphosis. Anterior fusion is considerably more common but is associated with increased operative time and use of instrumentation (Iwasaki et al 2007).

Generally, anterior decompression and fusion is performed when one or two levels of cervical myelopathy are present (Cybulski & D’Angelo 1988). The approach generally involves an anterior osteophysectomy and removal of the vertebral bodies. One significant benefit of this approach is that further formation of anterior and posterior bony spurs should no longer occur, spurs present may actually regress, and since the segment is distracted during the surgery, the buckling of the ligamentum flavum is improved (Masaki et al 2007).

The procedure involves a transverse (1 or 2 levels) or vertical (multiple levels) anterior approach following the anterior border of the sternocleidomastoid muscle. The discs are removed and replaced typically, with a bone intradisc transplant. In most cases, anterior plating is provided to reduce the risk of nonunion. The approach is considered useful when addressing the vascular elements associated with myelopathy and may reduce scar formations associated with a posterior approach (Masaki et al 2007).

The success rate for anterior decompression and fusion is very high (90%) (Masaki et al 2007) and complications are generally low (Cybulski & D’Angelo 1988). Many have promoted the use of anterior fusion versus laminectomy or laminoplasty indicating it results in fewer complications, vascular damage, and less osteophyte growth (Masaki et al 2007). Furthermore, an anterior approach may be preferred over a posterior approach such as laminoplasty when ossification of the posterior longitudinal ligament is prevalent (Glaser et al 2001). However, physician preference and skill-set likely dictates the selection of the surgical method to a greater extent than patient presentation and published outcomes.

### Posterior approaches

Posterior surgery is preferred for deformity, multi-segmental and dorsal pathology (Witwer & Trost 2007) and in cases of severe myelopathy as it decompresses the entire relevant
cervical spine, but is not preferred when there is a single dominant level or for kyphosis (Iwasaki et al. 2007). When multiple levels are involved, partial removal of two or more vertebral bodies, removal of the posterior longitudinal ligament, and any remaining spurs may be necessary. Anterior approaches are not warranted when radicular symptoms are predominant.

There are two primary posterior approaches to myelopathy: laminectomy with fusion, and laminoplasty. Posterior laminectomy and fusion is indicated when cervical stenosis causes lower extremity and/or upper extremity losses of function. Complications have included nerve damage, lack of fusion, high levels of blood loss during surgery, insufficient decompression, and infection (Epstein 2003). A laminoplasty is indicated in cases of cervical stenosis, which has originated from posterior longitudinal ligament ossification, buckling of the ligamentum flavum, or structural changes within the spinal canal. The most common complications reported have included loss of range of motion, inadequate decompression, and loss of sagittal alignment (Epstein 2002). The surgical approach involves decompression of the spinal cord posteriorly by enlarging the spinal canal but retaining the laminae. A laminoplasty is not considered superior to an anterior or posterior approach because it decompresses less space.

A laminoplasty involves one of two methods, the most common an open door laminoplasty. A cervical open door laminoplasty expands the diameter of the spinal canal decompressing the nerves and spinal cord. This surgery is typically performed in about two hours. During a cervical laminoplasty, an incision is performed in the back of the neck. The posterior portion of the bony spinal canal or lamina will be elevated. A portion of the thickened ligament is also removed. The spinal canal diameter will be widened, decompressing the spinal cord and nerves. The lamina will then be held in the open position using titanium miniplates.

A laminectomy and fusion approach generally involves posterior unilateral or bilateral removal of the lamina and a partial facetectomy. Candidates are patients who have adequate preservation of the cervical lordosis (minimum of 10 degrees) (Epstein 2002). Often, the decompression represents two segments above and below and is much more extensive than an anterior decompression. The procedure typically involves a posterior midline incision and dissection of the para-cervical muscles from the spinous processes between C2 and T1 (Heller et al. 2001). The laminectomy requires removal of either moderate or large amounts of the facets, furthering the likelihood of instability after surgery, unless fusion is concurrently employed.

To our knowledge, there is only one study (Kaminsky et al. 2004) that has retrospectively analysed outcomes for patients with myelopathy and radiculopathy and one study (Herkowitz 1988) that retrospectively compared anterior cervical fusion, posterior fusion and laminectomy, and laminoplasty. Another study (Nakano et al. 1988) analysed outcomes for patients with myeloradiculopathy. At present, no studies have prospectively randomly assigned comparable patients with myelopathy for a comparison of outcomes after laminoplasty or laminectomy and fusion.

**CONCLUSIONS**

The diagnoses of cervical radiculopathy, myelopathy, and myeloradiculopathy are clinical and involve both clinical and imaging findings. Conservative treatment outcomes for radiculopathy are mixed, whereas conservative outcomes for myelopathy and myeloradiculopathy are currently unknown. Outcomes associated with surgery are mixed in all three diagnoses and should involve careful reflection prior to selection.

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