Cervical spine: degenerative conditions

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Abstract Degenerative cervical spine disorders will affect up to two-thirds of the population in their lifetime. While often benign and episodic in nature, cervical disorders may become debilitating resulting in severe pain and possibly neurologic sequelae. Non-operative treatment continues to play an important role in treating these patients, with medications, therapy and interventional pain injections playing increasing roles in treatment. Surgical treatment including anterior and posterior decompression and fusion have been effective treatments of many cervical disorders, but may lead to significant problems including adjacent level disease. Laminotomy/foraminotomy and total disc arthroplasty may avoid some of these problems while providing similar clinical results. Ongoing clinical trials and studies are helping to define the role of these new technologies in treatment of patients with degenerative cervical disorders, although their greater benefit has yet to be proven.

Keywords Cervical spine · Cervical degenerative disc disease · Cervical stenosis · Cervical myelopathy

Introduction

Degenerative cervical spine problems can be approached systematically by dividing patient presentations into axial neck pain, radiculopathy, myelopathy or a combination of these presentations. Axial pain refers to pain that occurs

along the spinal column, while radiculopathy refers to complaints in a dermatomal or myotomal distribution often occurring in the arms. Patients may complain of numbness, pain or loss of function. Myelopathy refers to a cluster of complaints and findings due to intrinsic damage to the spinal cord itself. Patients might report numbness, coordination and gait issues, grip weakness and bowel and bladder complaints with associated physical findings. These various problems can be due to a wide variety of pathology and the clinician must be able to discern not only the type of problem a patient may be having, but also appropriately treat or refer these patients in a timely manner. Understanding the natural history of these conditions and the various treatment options are both important when treating patients with cervical-related problems.

The lifetime incidence of neck-related pain in the population has been reported to be as high as 67% with up to 54% of the population experiencing it within the last 6 months [1, 2]. In addition, cervical related complaints are more common in patients who are better educated, those who have a history of headaches and low back pain, as well as a history of previous whiplash or traumatic injury [1, 3, 4]. The incidence of cervical radiculopathy is much lower. Point prevalence has been placed at 3.5/1,000 while the annual incidence has been reported at 83/100,000 population [5, 6].

Non-operative treatment of axial neck pain has been reported to benefit most patients [7]. Rothman and Rashbaum reported no significant difference between patients treated operatively and those treated conservatively [8]. Cervical radiculopathy generally follows a benign course. A study on 205 patients treated for 10–25 years with modalities such as rest, traction, collar, and medications indicated that 43% of patients had complete resolution of symptoms, 25% had mild pain, and 32% had severe

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residual pain [9]. Patients with myelopathy have an entirely different history. Epstein reported that 64% of patients with myelopathy showed no improvement with conservative treatment [10]. Others have shown that up to two-thirds of patients deteriorate, 20% slowly and 5% with rapidly progressive symptoms [11].

Patient evaluation

The basis of patient evaluation begins with a thorough history. The location, duration and quality of pain are all important considerations in assessing cervical spine patients. Questionnaires and visual analog scores are helpful for quantifying debility and how much the symptoms are affecting their activities of daily living. Aggravating and alleviating factors are clues which often help the clinician formulate a differential diagnosis, and then narrow the options to the most likely etiology for the complaint in the majority of cases. The distribution of complaints (ie. axial, radicular, or myelopathic) is paramount in the patient evaluation, in that the particular pattern may help to localize where a structural pathology exists within the neuroaxis. For example, longstanding dull axial neck pain, possibly due to facet or disk degeneration in a multitude of sites in the neck, is much less specific as a complaint than acute burning pain into the right shoulder/deltoid that would suggest a disk herniation at C4/5. During the clinical evaluation, gait troubles, loss of function, coordination issues, and symptoms consistent with relative progression are all important factors to consider for these patients. Additionally, the physician must not overlook less common etiologies for neck pathology, such as exposure to infectious agents and environmental toxins, particularly in the setting of myelopathy.

A detailed physical exam is essential in evaluation of cervical spine disorders. A generalized inspection of the cervical spine and shoulder area should begin each examination. Evidence of trauma, abnormal moles, café-au-lait spots can all suggest different etiologies for pain. As some shoulder issues may mimic cervical spine problems, a brief shoulder exam is often helpful to rule this out, looking specifically for signs of impingement. Palpation about the spine may reveal tenderness over bony prominences, spasm, and painful trigger points. Active and passive range of motion must also be assessed. At the same time Spurling's maneuver may be performed which involves rotation and extension of the neck to each side, thereby closing down the ipsilateral neuroforamen to the rotation, which may elicit pain in the setting of radiulopathy. L'hermitte's sign can be seen during the course of range of motion, which will be reported by the patient as the presence of an electric shock sensation with flexion and

extension of the neck in some patients with cervical myelopathy. Interpretation of deep tendon reflexes may indicate radiculopathy, with loss of muscle activation unilaterally, while hyperreflexia or reflex spreading (ie. the inverted radial reflex) may indicate myelopathy or higher central nervous system disease. The Hoffman's test is performed by the examiner rapidly flexing (ie. flicking) the distal interphalangeal joint of the middle finger, which elicits spontaneous thumb and index finger flexion in the patients demonstrating this sign. This should be performed to rule out myelopathy in conjunction with a Babinski reflex and assessment of clonus. A full muscle power examination of the upper and lower extremities with results reported on a scale of 0 to 5 is essential. Sensation should be evaluated in a dermatomal pattern looking for specific distributions of numbness, pain, or other dysesthesias. Sensation to pinprick and vibration are also helpful in evaluating the condition of the cervical cord. Finally, an assessment of gait may point to cervical spine pathology. Myelopathic patients often struggle with tandem gait, may exhibit scissoring when they attempt to walk, and frequently have a mechanical appearing and wide based gait when they ambulate spontaneously.

At this point in the assessment, the clinician should be formulating a differential diagnosis. In patients with axial neck pain and/or radicular symptoms, a variety of possibilities exist outside of cervical pathology including peripheral nerve entrapment syndromes, shoulder pathology, brachial plexitis, herpes zoster, thoracic outlet syndrome, sympathetic mediated pain syndrome, intraspinal or extraspinal tumors, epidural abscess, and cardiac angina. Neck pain may be related to muscle sprains, degeneration of the cervical discs and facet related pain. Radicular complaints are usually due to irritation of the nerve roots as they exit from the foramen which can be caused by soft disc herniations, stenosis, intrinsic root pathology, trauma and degenerative changes. These same conditions may play a role in the myelopathic patient, but it is imperative to rule out medical causes of myelopathy including multiple sclerosis, transverse myelitis, viral involvement (including HIV, Herpesvirus and enteroviruses), syphilis, tuberculosis, fungal and parasitic involvement, epidural abscesses, arachnoiditis, vascular causes, autoimmune and connective tissue diseases, sarcoid, vitamin B-12 deficiency, paraneoplastic syndromes and exposure to toxins.

Imaging begins with radiographs. An anteroposterior and lateral image is often enough to give a clinician an initial impression. Open mouth odontoid views are helpful in patients with a history of trauma. Oblique images allow for evaluation of the foramina and facet joints. Flexion and extension views may reveal instability, which can occur in the setting of trauma or in advanced degenerative conditions.

In patients with persistent radicular complaints, neurologic deficits or signs and symptoms of myelopathy, 3-dimensional imaging should be considered. Different modalities may be considered based on patient signs and symptoms. In patients with axial neck pain advanced imaging should be considered when patients have failed a prolonged course of nonoperative care including active rehabilitative component. And MRI to assess the cervical disks, nerves and remaining architecture is the study of choice unless contraindicated (eg. pacemaker or intracranial clips), at which time a CT myelogram may be considered. MRI is the primary tool for evaluating patients with radiculopathy and myelopathy. It provides excellent visualization of the neural elements, posterior longitudinal ligament, disc herniations, sequestered fragments, tumors and the spinal cord itself. It is important to correlate the radiographic findings on MRI and CT myelograms with the patient's symptoms as there is a very high incidence of false positive findings associated with these studies. Up to 19% of asymptomatic patients have been reported to have major abnormalities on cervical spine MRI [12]. If a patient is considering surgical intervention, selective nerve root blocks and facet blocks may be very helpful in making definitive evaluations for which portions of the spine are contributing to symptoms and necessitate intervention. Provocative discography may also play a role in indicating patients for surgery that have predominantly axial neck pain symptoms.

Non-operative treatment

The majority of cervical spine disorders are self limiting and may be treated non-operatively. When determining what course to take in treatment, it is important to keep in mind treatment goals both from the standpoint of the patient and the clinician. Immediate goals include controlling a patient's pain while limiting the impact that the condition has on their daily life. Beyond this, restoration of function is perhaps the most important long term goal, although for some patients it may be a slow and arduous process.

Oral medications are the most common first line treatment for patients, including narcotics, anti-inflammatories, muscle relaxants, anti-depressants and neuroleptic medications. Narcotics are ideal for short-term treatment only. They do not change the character of pain even in increased doses. Side effects include constipation, sedation, depression and issues of abuse. The long-term use of narcotics in patients with chronic pain is usually discouraged. This generally results in an unending cycle of increasing demand for medication. Non-steroidal anti-inflammatory drugs and corticosteroids are frequently prescribed, especially in the setting of acute radiculopathy and/or neck pain. Tapered doses of steroids

have been shown to be much more effective in patients with arm pain as opposed to neck symptoms [13]. Steroids should not be prescribed more than a few times over a few month period as their side effects include hyperglycemia, weight gain, osteoporosis and gastric ulcers among others. Nonsteroidal anti-inflammatories are a good first line medication in patients with cervical disease. Aspirin, ibuprofen and other over the counter medications are effective with minimal cost to the patient. Most prescription strength anti-inflammatories are available in low-cost generic form, although side effects may include nausea, gastric ulcers and kidney dysfunction. Newer COX-2 inhibitors appear to have a decreased incidence of stomach ulcers and upset. In patients with significant cardiac risk factors, there is growing evidence of increased cardiac risks with almost all anti-inflammatories, preventing their use in a certain subset of patients.

The other commonly used oral medicines are directed to managing muscle spasm, and dysesthesias. Muscle relaxants should be considered in the manner as narcotic medications. They are prone to be abused and can cause sedation, fatigue as well as depression. They should be used sparingly and for short periods of time. Anti-depressants are less commonly used in patients with cervical spine disorders. Amitriptyline has been used for years and has been shown to improve sleep patterns, decrease depression due to pain and improve neuropathic pain of various causes [14]. Newer medications such as duloxetine are being used increasingly in these patients. Duloxetine has recently been indicated in patients with chronic low back pain and arthritic pain, allowing for treatment of chronic pain as well as the depression, which is often seen with these conditions. Neuroleptic medications have a role in patients with cervical spine disorders, especially in the setting of radiculopathy. Gabapentin has been used commonly to treat neuropathic pain as well as spine related nerve pain. Pregabalin, a medication approved to treat fibromyalgia, is increasingly being used to treat patients with radicular pain. The side effects of these medications are significant, including sedation, weight-gain and depression. These medications are less likely to become objects of abuse in at risk patients, but they do require dosing on a regular, daily schedule.

Bed rest should be used sparingly in these patients with a maximum of 48 h recommended in an acute pain setting [15]. Bedrest leads to deconditioning, loss of strength and flexibility. Modalities such as ice may provide quick relief of comfort, while heat may in fact worsen pain [13]. Other passive treatments such as massage, ultrasound and iontophoresis have not been shown to be effective in patients with cervical spine pain [16]. Traction has been shown to relieve arm pain in patients with acute radiculopathy, but only anecdotally. Isometric exercises, while strengthening

the musculature of the cervical spine, fail to increase motion and may in fact increase loading on cervical disks, suggesting that patients be progressed rapidly to an active motion program. Active range of motion exercises are the most effective for these patients, maintaining the motion of the facet joints and encouraging proper postures. The popping and clicking reported by patients is generally due to degenerative facet joints and patients experiencing this may need to be reassured. Resistance rehabilitation can be very helpful in cervical spine patients as it requires patients to be actively involved in their rehabilitation. Patients may initially experience increasing pain due to muscle soreness requiring education and reassurance by therapists. All therapy programs should include a whole body program with some amount of aerobic conditioning as well. Home exercises should be considered in these patients as well. Manipulation has not been shown to be clinically effective in patients with cervical pain [17]. These maneuvers may actually be dangerous as spinal core and vascular injuries have been reported and should be avoided in most patients.

Interventional pain management

In patients with persistent symptoms of cervical conditions despite non-invasive measures, referral to an interventional pain specialist may be an effective option. Procedures that can be offered to patients include epidural steroid injections (interlaminar and/or transforaminal), facet blocks and facet rhizotomies. Cervical interlaminar injections are commonly used to treat patients with neck pain and radicular arm pain due to cervical degenerative conditions. Injections both with and without steroids have been shown to be effective in up to 77% of patients in which efficacy was defined as up to 4 weeks of symptom relief [18]. Transforaminal injections and selective nerve root blocks are thought to deliver medication in a more direct manner to the site of pathology. In a prospective review of 68 subjects with cervical radiculopathy, Bush and Hillier reported that 62% of patients reported relief after transforaminal steroid injections as opposed to 16% with interlaminar epidural steroids [19]. Although these injections may be effective, they are not without significant risk, including increased neck and arm pain, dural puncture, lightheadedness, vertebral artery injury, paralysis, cord infarction, cerebellar infarction and death [20–22]. Patients should be counseled appropriately before undergoing these procedures.

In patients with chronic axial neck pain, medial branch facet blocks and possible rhizotomy may be therapeutically helpful. Up to 85% of patients receiving facet blocks with local anesthetic alone maintained pain relief at up to 2 years after the procedure while 93% of those receiving steroid and local anesthetic injections maintained their relief [23].

Rhizotomy, or ablation of the nerves innervating the suspect facet joints, may play some role in the treatment of neck pain and is minimally invasive with low morbidity. No long term studies exist to support its use and patient results have been reported to be inconsistent [24].

Surgical treatment of radiculopathy

Traditionally, there have been two options for surgical treatment of radiculopathy. The posterior approach involves a laminotomy with or without a discectomy to treat foraminal stenosis or a soft disc herniation. The anterior approach has involved an anterior cervical decompression or discectomy and fusion to relieve central and foraminal stenosis as well as soft disc herniations. In recent years, motion preserving devices such as disc replacement or arthroplasty have been proposed to prevent long term adjacent level degenerative disease which has been attributed to cervical fusion.

A posterior foraminotomy, or keyhole foraminotomy, involves removing a small portion of the lamina and medial portion of the facet. This allows access to the foramen and lateral aspect of the spinal canal providing a means to decompress the exiting nerve root and perhaps the lateral spinal cord as well. Jagannathan et al. reported a series of 162 patients with 5 year follow-up showing no significant trend towards kyphosis, long lasting pain relief and improvement in quality of life scores [25]. A retrospective study of 303 patients undergoing foraminotomy with average follow-up of 7.1 years indicated a 5 and 10 year risk of adjacent segment disease to be 3.2 and 5.0% respectively, considerably less than cervical fusion [26]. Additionally, this procedure lends itself to being performed safely in a minimally invasive manner as an outpatient procedure [27]. Significant complaints of neck pain have been reported as well as neurologic injury, paraspinal muscle spasm, dural tears and transient ulnar nerve palsy [28, 29]. Taking into account the anatomical indications for this surgery, results seem to approach those seen in anterior cervical fusion.

The anterior approach has traditionally involved anterior cervical discectomy and fusion. This procedure allows for central and foraminal decompression through a generally muscle-sparing approach. The decompressed level is then stabilized using bone graft and usually a plate. Faldini et al. reported a series of 51 patients treated with anterior cervical discectomy and fusion followed for 10 years noting that over 75% of patients rated their outcome good to excellent according to Odom's criteria [30]. Another study of 125 patients followed for 11 years on average indicated a 96% favorable outcome with only 5 patients undergoing adjacent level surgery [31].

Although initial reports of anterior cervical discectomy and fusion involved autograft without instrumentation, in recent years use of various materials including allograft bone, polyetheretherketone (PEEK) cages and various types of instrumentation have been reported. The use of allograft with an anterior plate has been used quite successfully and is becoming very common for use in anterior fusions. Papadopoulos et al. reported 46 patients of whom 38 underwent multilevel cervical fusion with fibular ring allograft and plating reporting a pseudarthrosis rate of 3% [32]. Newer PEEK stand-alone cages have been developed to avoid the risk of dysphagia which may be caused by the prominence of anterior plating, while allowing for instrumentation to be placed through the cage in a zero-profile manner. Use of a stand-alone cage with bone marrow-soaked tricalcium phosphate has been reported with 100% fusion at 6 months and comparable reduction in pain relief at 6 months [33]. Scholz et al. followed 38 patients for a mean of 8 months who underwent stand-alone fusion all of whom showed radiographic evidence of fusion and only 1 patient with persistent dysphagia at 6 months [34].

As the instrumentation has evolved in spinal surgery, so have the options for bone grafting. Autograft bone, allograft bone and synthetic options have all been used safely in the anterior cervical spine. The development of BMP-2 has been an important part of spine surgery in the past 10 years, assuming a major role in bone grafting options in the lumbar spine. In turn, attempts have been made to expand its role in the cervical spine. Currently, its use anteriorly is not recommended in anterior surgery. Reports of significant complications with its use in anterior cervical fusion have come about including acute airway obstruction and soft tissue swelling resulting in reintubation and even death [35, 36•].

Anterior cervical decompression and fusion has been shown to be very effective in relieving symptoms of radiulopathy, but has one very important long-term issue: adjacent level disease. Hilibrand et al. reported a rate of 25.6% at 10 years of symptomatic adjacent level disease in patients having undergone cervical fusion [37]. As a result, new motion preserving technologies such as cervical disc replacement have been developed with the aim of preserving segmental motion and thus preventing adjacent level disease. Burkus et al. recently reported 5 year clinical and x-ray followup in 541 patients indicating a greater improvement in neurological status at all time points out to 5 years when compared to interbody fusion patients as well as maintenance of angular motion with the prosthesis at 5 years [38••]. Similarly, Garrido and associates reported greater improvement in Neck Disability Index scores, Visual Analog Scores, and arm pain scores when compared to a control group of anterior fusion at 4 years [39]. In addition, reoperation was noted to be six times less in the arthroplasty group.

In general, most studies of cervical arthroplasty have reported similar or slightly better results than traditional anterior cervical fusion. It is still unclear if this procedure actually prevents adjacent level disease as few long term studies exist beyond 5 years. A recent study with a minimum of 2 year radiological follow-up has indicated progression of facet arthrosis at 7 of 36 levels and heterotopic ossification at 27 of 36 levels which underwent replacement, approaching those numbers seen after anterior cervical fusion [40]. Jawahar et al. reported single site data from three clinical trials indicating that arthroplasty was equivalent to cervical fusion in providing relief of symptoms, but that the risk of developing adjacent level disease remained the same in both groups [41••]. The 10 year data from current ongoing clinical trials should provide the clinician a better idea on prevention of adjacent level disease when it becomes available in the next few years.

Surgical treatment of myelopathy

Both anterior and posterior cervical surgical options exist for treatment of cervical myelopathy as well. Anterior cervical decompression and fusion, cervical arthroplasty, anterior corpectomy and fusion, posterior cervical laminectomy with or without fusion and laminoplasty are all considerations in this challenging patient population. Location of pathology, patient anatomy and surgeon preference are all considerations in indicating these patients for specific surgical procedures.

Anterior procedures provide direct decompression of the spinal cord while allowing for correction of kyphosis in patients with loss of the normal cervical lordosis. In fact, severe kyphosis may actually contribute to the amount of cord compression that occurs in these patients as the spinal cord becomes draped over the kyphotic spine accentuating pressure on the cord. Segmental anterior fusions at multiple levels may provide a powerful corrective force in patients with kyphosis while at the same time decompressing the spinal cord. Performing anterior corpectomy with strut grafting may decompress the spinal cord, but allow for less aggressive correction of kyphosis [42]. In patients with single level compression, both anterior cervical fusion and cervical disc arthroplasty have been shown to be effective as surgical treatment for patients with myelopathy [43]. This biggest draw back to use of multi-level anterior cervical fusion for these patients and perhaps the greatest advantage to performing corpectomy and strut grafting is the rate of pseudarthrosis. In the corpectomy setting only two graft interfaces require fusion while in the multi-level fusion setting, four to eight interfaces may need to heal to provide a solid fusion.

In patients with cervical stenosis causing myelopathy who have maintained their lordosis or at least a neutral alignment, posterior surgical options may be considered. Laminectomy alone, laminectomy with instrumented fusion and laminoplasty, which preserves motion have all been considered in the treatment of cervical myelopathy. Anderson et al. performed a literature review of the treatment of cervical myelopathy using posterior techniques and found that laminectomy alone was associated with progression of kyphotic deformity, while laminectomy and fusion was not, noting that laminectomy and laminoplasty both showed similar results in improvement of functional outcome [44]. Laminoplasty has been proposed to decompress the spinal cord while preventing the morbidity associated with spinal fusion and maintaining motion. A recent randomized trial comparing laminoplasty with anterior cervical fusion has indicated better maintenance of lordosis in the fusion group as well as a better recovery rate [45]. A prospective series of patients undergoing laminoplasty followed for 5 years indicated some improvement in cervical lordosis as well as maintenance of a decreased incidence of posterior neck pain and significant improvements of function over the time period [46].

Conclusion

Degenerative cervical spine disorders remain a common diagnosis in the general population and can be thought of in terms of conditions causing axial pain, radicular complaints or findings of myelopathy. Most of these conditions follow a benign course and may be treated with supportive, symptomatic care. New medications have become indicated in treating these disorders such as neuropathic pain medications and new antidepressants, while active and aggressive physical therapy may be beneficial as well. The mainstay of surgical treatment for degenerative cervical disorders involves decompression of the neural elements often combined with arthrodesis. There continues to be a concern for development of adjacent level disease which has led to the development of total disc arthroplasty. It remains to be seen whether these new technologies will provide a better benefit than anterior cervical fusion. There continues to be conflicting data concerning treatment of myelopathy as to the efficacy of laminoplasty versus laminectomy and fusion versus anterior decompression and fusion. The most important determining factor for surgical option appears to be alignment of the cervical spine.

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