



Cervical radiculopathies: conservative approaches to management

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Cervical radiculopathy is a term that describes signs and symptoms of neck, shoulder, and upper limb pain, paresthesias, and weakness. These symptoms arise from cervical nerve root irritation, which may be secondary to cervical disc herniation, cervical spondylosis, tumor, or trauma. The natural course of radiculopathy seems to be generally favorable. A minimal amount of published literature studying various nonoperative treatments for this condition exists. To date, the efficacy of any specific treatment is not established firmly. Subsequently, many physicians base treatment of this condition on individual experiences instead of on objectively proven methods.

A large epidemiologic study in Rochester, Minnesota demonstrated the average incidence rate of cervical radiculopathy to be 83 per 100,000, with a peak-incidence age of 50 to 54. This study and several others demonstrated that only a small percentage of patients with cervical radiculopathy required surgery. Most patients made a full recovery or were only minimally symptomatic [1–4]. Disc herniations are more common in younger patients, whereas cervical spondylosis is more frequent in older patients [5]. In the workplace, the frequency of neck complaints increases with age. Overall, it is estimated that 45% of working men will experience at least one episode of neck discomfort, 23% will experience at least one episode of upper limb pain, and 51% will report both cervical and upper limb symptoms [6].

Information related to spine care continues to advance, both in the lumbar and the cervical regions. Although there is more research available on the lumbar spine, there have been definite advances in knowledge related to anatomy, pathophysiology, and treatment of cervical spine conditions. In some instances, information from the lumbar spine can be extrapolated

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to the cervical spine. Currently, a multitude of modalities, procedures, and other interventions exist which, in combination with medications, can be used to treat cervical radiculopathy. The focus of this article is a review of the most recent and classic literature related to management of cervical radiculopathies.

Natural course of cervical radiculopathy

Few studies compare the role of surgical versus nonsurgical treatment of cervical disc herniations and cervical radiculopathy. Those studies that have been published have shown favorable outcomes for the natural course of cervical radiculopathy. These studies detail that comprehensive, aggressive, nonsurgical management is often successful with respect to functional outcome, pain reduction, and patient satisfaction [1–4].

An outcome study of conservatively versus surgically treated patients with primarily acute cervical radiculopathy secondary to herniated cervical discs revealed that 65% were successfully treated conservatively, whereas 35% underwent surgery. Long-term comparison of these two groups showed that the conservatively managed group did better with respect to resolution of brachialgia, sensory disturbances, reflex abnormalities, motor weakness, return to occupation, self-perception of satisfaction, and activities of daily life capacity. Residual intermittent neck pain persisted in both groups, although it improved somewhat [1]. Similar positive results demonstrating that medically managed patients had significant improvement in pain and overall functional status also were found in multiple studies, including a recent large, multicenter, prospective study [1–4,7].

Several studies have supported the assertion that there is significant natural regression of cervical disc herniations [8,9]. Bush et al [10] found a correlation between clinical improvement and regression of disc herniation in 12 of 13 patients. In the one patient who did not have significant regression, there was some persistent minor neck pain. Another study found that larger disc herniations and even sequestered discs had the greatest decrease in size, which occurred in a time frame similar to that seen in the lumbar spine [9]. It has been demonstrated that symptoms and signs of radiculopathy do not always correlate with the size of disc herniation [11]. Disc abnormalities, such as herniations, may be present in asymptomatic people with no history of cervical radiculopathy [5]. Clinical correlation with anatomic findings is essential.

Anatomy and pathophysiology

A brief summary of anatomy is reviewed here for completeness. The cervical spine consists of seven cervical vertebrae. Between each cervical segment

from C2 to C7, there is an intervertebral disc. There is no disc between the atlantooccipital and the atlantoaxial joints. There are eight cervical nerve roots. The C2 to C8 nerve roots branch off segmentally from the spinal cord and thecal sac and run from the upper border of the pedicles, sloping laterally and anteroinferiorly to the upper surface of the transverse process. The nerves exit the root canals, dividing into the dorsal and ventral primary rami.

Many sites on the neck can represent pain generator sites. Studies have demonstrated that the disc is innervated peripherally and that there is a chemical component associated with cervical radiculopathy [3,12,13]. Recent studies have led to advances in understanding of the ligamentous and annular structure of the cervical intervertebral disc. It is now recognized that the annular fibers in the cervical spine are different than in the lumbar spine. Instead of a concentric ring of fibers surrounding the nucleus as seen in the lumbar spine, the annulus in the cervical spine is thick anteriorly and progressively tapers, becoming very thin posteriorly [14]. The gray ramus communicans innervates the anterior and lateral portions of the outer annulus. The sinuvertebral nerve feeds the posterolateral aspects of the disc. Biochemical factors have been identified to play a role in radiculopathy. High levels of an inflammatory enzyme, phospholipase A₂, have been identified in disc herniations [13]. Treating the biochemical component of cervical radiculopathy often allows for significant clinical improvement.

The natural progression of lumbar disc disease with the degenerative cascade and the motion segment model has been well proven. One can extrapolate that the cervical spine may follow this model. Recent studies have demonstrated that there is a common genetic risk factor for the development of lumbar disc disease [15]. This finding has not been demonstrated in the cervical spine but may be demonstrated to be similar in the near future.

Evaluation

Evaluation should include a detailed history and physical examination. Additional information may be gained from correlating imaging and electrodiagnostic studies when indicated [16]. There are other articles in this issue dedicated to each of these topics, and the reader is referred to them for more detailed review.

Differential diagnosis

Many differential diagnoses must be considered during initial evaluation of a patient with cervical radiculopathy. Use of the mnemonic device “PS VINDICATES” serves as a reminder of the categories to consider for completeness of a differential diagnosis. This acronym stands for psychogenic, systemic, vascular, inflammatory, neoplasm, developmental, infectious, congenital, autoimmune, traumatic, and endocrine. Potential causative agents

to consider include arteriovenous malformations; discitis; herpes zoster; AIDS; benign, malignant, extradural, intradural, extramedullary, and intramedullary tumors; stenosis; inflammatory processes; pituitary disease; Paget's disease; osteoporosis; osteomalacia; parathyroid disease; cervical sprain; cervical strain; herniated nucleus pulposus; osteoarthritis; cervical stenosis; cervical spondylosis; focal nerve entrapments such as carpal tunnel syndrome, anterior interosseous syndrome, pronator teres syndrome, cubital tunnel syndrome, and brachial plexus disorders; primary shoulder disease; neuropathies; and others [7,16–18].

Clinical presentation

Patients with cervical radiculopathy often present with signs and symptoms specific to each level. Although there may be some variation, a summary of the classic findings follows:

- C2 radiculopathy is extremely rare. It is described classically as the nerve that is irritated in cervical whiplash injuries. It may account for the headache commonly reported after a person sustains a motor vehicle accident. No motor deficits are seen.
- C3 nerve root rarely is involved secondary to the limited motion of the C2-C3 disc. The distribution of the C3 radiculopathy may include headache, and possibly, posterior neck pain. There is no appreciable motor loss from a C3 radiculopathy.
- C4 radiculopathy may be associated with neck, trapezial, and deltoid pain. Rarely is there any involvement of the diaphragm, despite the fact that the C3, 4, and 5 segments innervate the diaphragm.
- C5 radiculopathy may produce pain or sensory changes over the superior aspect of the shoulder and lateral humerus at the deltoid insertion. There may be weakness of the deltoid, supraspinatus, or infraspinatus. It can be difficult to discriminate from a shoulder abnormality, such as a rotator cuff tear or suprascapular nerve injury.
- C6 radiculopathy is either the most or second most commonly affected nerve root by either degenerative disease or disc herniation, most likely because of increased mobility at this level. There is some controversy in the literature regarding whether C6 or C7 is the most commonly affected level [2,18–20]. Patients may have weakness with elbow flexion or wrist extension. They may have pain or sensory disturbances into the biceps region of the arm, radial aspect of the forearm, and into the thumb and sometimes, index finger. The brachioradialis reflex may be depressed.
- C7 radiculopathy is either the most or second most commonly affected nerve root by either disc herniation or spondylosis, most likely because of increased mobility at this level. Signs and symptoms usually include pain or sensory disturbance down the posterior aspect of the arm and posterolateral aspect of the forearm to the long finger. There may be weakness of elbow extension or wrist flexion.

- C8 radiculopathy is more unusual, but it may result in decreased hand interossei strength or numbness of the ulnar aspect of the hand.

Treatment

The major objectives of treatment for cervical radiculopathy include (1) the reduction or resolution of pain, (2) the improvement or resolution of neurologic deficits and increased function, and (3) prevention of recurrence. In treating a patient with cervical radiculopathy, one must remember to treat the entire person, not just the injured structure. Treatment must be modified depending on the patient's status, symptoms, examination findings, and disease state. Initial treatment may include education, pain control, medication, activity modification, modalities, and use of cervical orthoses.

Patient education

Early in rehabilitation, the patient should be educated about his or her condition. This instruction should include information about proper positioning and body mechanics, which will assist in avoiding further irritation. The patient must learn to keep his or her cervical spine in a neutral position during activities of everyday life. Also, education about the disease process of cervical radiculopathy, spine anatomy and function, normal and abnormal responses to pain, and ergonomics will aid in reasonable patient expectation, which ultimately may contribute to improved outcome [21].

Medications

Many different medications are used commonly in the treatment of cervical radiculopathy. There should be an ordered and logical approach to their use. Nonsteroidal anti-inflammatory drugs (NSAIDs) usually are the first line of medication used in treating the pain and inflammation of cervical radiculopathy. They provide analgesic relief at lower doses and anti-inflammatory benefits at higher doses when used consistently. All classes of nonspecific NSAIDs reversibly inhibit the cyclooxygenase pathway by inhibition of the enzyme cyclooxygenase, which converts arachidonic acid to prostaglandins and thromboxane. This process involves both Cox-1 and Cox-2 pathways. The Cox-1 pathway maintains normal physiologic function of the gastrointestinal tract, kidneys, and platelets, whereas the Cox-2 pathway seems to mediate the inflammatory response. Nonselective NSAIDs are toxic to the gastroduodenal mucosa secondary to inhibition of the production of cytoprotective prostaglandins in the stomach. Additionally, blocking the Cox-1 pathway inhibits platelets, cell function in the synovium, and kidney function.

Numerous factors are known to increase the risk of gastric toxicity, including a history of peptic ulcer disease; high-dosage or prolonged NSAID use; concomitant administration of aspirin, anticoagulants, or corticosteroids; advanced age; alcoholism; and smoking. It has been demonstrated that awareness of risk factors and appropriate prophylactic agents assists in minimizing the risk to patients [22]. High-risk patients should receive gastroprotective prophylaxis with either a proton pump inhibitor (omeprazole) or a prostaglandin analogue (misoprostol) [23]. Standard H₂ antagonists do not protect adequately against NSAID-induced gastric ulcers [24].

Cox-2-selective NSAIDs are highly specific inhibitors of the Cox-2 pathway. Initial studies have shown that they provide analgesic and anti-inflammatory properties similar to nonselective NSAIDs, with better gastrointestinal tolerability. These medications leave the Cox-1 pathway undisturbed, so there is no inhibition of gastroprotective properties. Clinically, another benefit of the new Cox-2 medications includes the ability of clinicians to perform diagnostic and therapeutic spinal injections without stopping their use, because these medications do not inhibit platelet function [22,25,26].

Steroids

Steroids are potent anti-inflammatory medications. They are indicated in the treatment of cervical radiculopathy when NSAIDs are not effective and an inflammatory cause is present. Glucocorticoids have anti-inflammatory effects through inhibition of phospholipase A₂ and secondary decrease in arachidonic acid and prostaglandin production. They also have anti-inflammatory effects by inhibition of the antigenic response of macrophages and leukocytes and reduction of vascular permeability by inhibiting histamine release. Potential adverse side effects include hyperglycemia (caution must be used when considering use in diabetics), adrenal suppression, osteoporosis, peptic ulcers, hypertension, cataracts, increased intraocular pressure, sodium retention and edema, immunosuppression, and poor wound healing. One must ensure that there are no contraindications before prescribing steroids.

One of the most often thought of side effects of steroids is avascular necrosis; however, a recent extensive search of the literature dating to 1966 did not document a definitive case of avascular necrosis associated with short-term use of steroids. A rapid oral steroid taper, which is used commonly in the treatment of cervical radiculopathy, can be prescribed without overwhelming fear of avascular necrosis. Numerous variations of oral steroid tapers are used commonly. These tapers vary in specific type of steroid used, dosage, and duration of treatment. No published outcome studies comparing these differences and their effectiveness were found in the literature. No single variation has been demonstrated to be superior. The authors of this article commonly prescribe prednisone starting at 70 mg and decreasing by 10 mg/d (total dose, 280 mg).

Adjunct medications

Adjunct medications are often of benefit in the treatment of cervical radiculopathy. These drugs may include muscle relaxants, low-dose tricyclic antidepressants, anticonvulsants, and other adjunct medications. Most muscle relaxants cause some degree of sedation centrally and relax the patient and all of his or her muscles secondarily. They are not selective for the injured anatomic area that has involuntary muscle guarding. The mechanism of action of muscle relaxants varies depending on the medication used. Some relax muscle by acting on internuncial spinal neurons to depress polysynaptic pathways. Others, such as benzodiazepines, act on gamma-aminobutyric acid receptors centrally. They may produce somnolence, dizziness, fatigue, ataxia, and anxiolytic effects. Most commonly, these medications can be used acutely for limited periods to help potentiate analgesia.

Low-dose tricyclic antidepressants may be beneficial in treating cervical radiculopathy. They may help to decrease neuropathic pain and to improve sleep [27]. Their mechanism of action is in the central nervous system, blocking the reuptake of norepinephrine and serotonin. Their mechanism of action also improves sleep by increasing stage IV sleep. They also affect substance P concentration, reducing pain [28]. Possible side effects include dry mouth, urinary retention, oversedation or drowsiness, constipation, and weight gain.

Anticonvulsants have been used to aid in controlling neuropathic pain. Gabapentin is an antiseizure medication that is used commonly for control of neuropathic pain. The mechanism of action is not well understood. The beneficial dosage is highly individualized and may vary from 300 mg/d to a maximum manufacturer-recommended dose of 2400 mg/d. There have been studies demonstrating that doses as high as 3600 mg/d for short periods were well tolerated without adverse side effects [29]. It is recommended to start at a low dose, 100 to 300 mg/d, and gradually increase until either pain control is achieved or adverse effects occur within the recommended range. Potential side effects may include lightheadedness, somnolence, ataxia, fatigue, and dry mouth. Liver and renal function should be monitored with the use of this medication.

Opioids

Opioids may be useful for analgesia, especially during the acute or sub-acute phase when pain is usually most intense. Pain may limit a patient's ability to participate in activity or progress in therapy. Adequate pain control is essential to allow participation in therapy and restorative sleep. Different potencies and durations of action of these medications must be considered on a case-by-case basis when using opioids. Use on a scheduled basis provides more effective pain control than when used on an as-needed basis. An opioid agreement between the physician and the patient should be reviewed and signed when long-term use is anticipated.

Activity limitation

Although there are studies examining activity modification (ie, bedrest and so forth) in lumbar radiculopathies, there are no comparative studies for activity limitation in relation to cervical radiculopathy. It can be extrapolated that relative rest is probably preferable to absolute rest [30]. During the acute period, relative rest or a short period of absolute rest is advocated to avoid progression of herniation and exacerbation of pain. Relative rest also can incorporate the use of cervical orthoses to help control movement. It is generally believed that medium-heavy to heavy work requirements and cervical positioning in hyperextension or ipsilateral flexion and rotation to the symptomatic side should be avoided to decrease the possibility of further root irritation owing to foraminal encroachment [18,31]. Many patients can continue to work with only minimal modifications.

Modalities

Physical therapeutic agents often used in the clinical setting include ultrasound, superficial heat, hydrocollator packs, ice, and electrotherapy. Almost all of these agents can be of assistance in treating cervical radiculopathy.

Thermal therapy

Thermal therapy in the form of hot or cold can be used and often is based solely on the patient's sense of pain reduction. An extensive literature search failed to provide defining guidance for the use of thermal therapy for the treatment of cervical radiculopathies despite the often-quoted reviews and treatment statements advocating the use of such agents [32]. Heat, in the form of hydrocollator packs, often is used for 15 to 30 minutes to decrease muscular tension and to allow improved tolerance of cervical traction. Passive superficial heat in the form of showers and hot tubs often is described as an alleviating factor by patients. Cold application is typically for 15 minutes, followed by a period with no application to avoid possible reactive hyperemia [14,32]. The use of ice as a counterstimulation may help relieve "spasm" during acute therapy. The deeper penetrating capabilities of ultrasound (up to 5 cm) typically are not indicated in the treatment of cervical radiculopathy. It is believed that the increase in metabolic response and inflammation acts on the nerve root, possibly aggravating symptoms [32].

Electrotherapy

The common forms of electrotherapy include transcutaneous electrical nerve stimulators and electrical stimulation. The literature does not contain enough information to indicate that either of these devices provides significant benefit for the treatment of cervical radiculopathy. There are studies showing that electrotherapy may provide some relief in the treatment of low

back pain, but return to work or ultimate functional status was unchanged by its use [33]. Electrotherapy may be used as an adjunct in the nonsurgical treatment of cervical radiculopathy, with varying benefits.

Cervical orthoses

Cervical orthoses have been a mainstay of the conservative treatment of cervical radiculopathies for quite some time. As early as 1908, Smith [34] described the use of cervical orthoses in the fifth Egyptian dynasty of 2750 to 2625 BC. Clinicians have continued to use and adapt newer materials, such as plastics, to provide better and more functional bracing.

A cervical collar may be reasonable to use for aid in immobilization and pain control during the acute phase of cervical radiculopathy [35,36]. A soft collar diminishes rotation by approximately 26%. It is believed that this device works as a kinesthetic reminder only. The feeling of warmth around the neck may contribute to the usefulness of the cervical orthosis in controlling pain. Hard collars can diminish movement by 75° in the sagittal plane but still have difficulty controlling rotation and lateral bending [37]. The use of a cervical collar in the nonoperative management of herniated cervical intervertebral disc with radiculopathy has met with good outcomes [3]. A collar should be placed with the narrow portion in front, which is often the position of most comfort. This position places the neck in slight flexion and aids in avoiding extension, which causes foraminal narrowing and possibly, increased pain [31]. The use of a cervical pillow as a means of diminishing cervical mobility and relieving axial loads also has been advocated [35,38].

Potential negative effects are associated with the use of spinal orthotics, including weakness, muscle atrophy, promotion of contractures, and psychologic dependence [39]. The use of collars should be limited to less than 10 days to 2 weeks, followed by a period of gradual weaning [7,40,41]. After the weaning period, the paraspinal muscles can be strengthened with a combination of isometric exercise and other progressive-resistive exercises within a short range of motion to avoid endpoint injury [32,38,42,43].

Proper instruction in cervical spine positioning, even without the use of orthotics, is encouraged [18]. Examples include switching from cervical lateral flexion in using a telephone to incorporating a headset to maintain the spine in a neutral position. Additional examples include correction in bifocal eyeglass use to avoid cervical extension and proper placement of objects, monitors, and X-ray view boxes at eye level [44,45].

Traction

Traction is used to apply a distracting force, usually carried out through pneumatic or pulley devices. Traction has been recommended since the time of Hippocrates for the treatment of scoliosis or kyphosis [46–50]. Several articles have confirmed that cervical traction can benefit those with nerve root compromise or radiculopathy by diminishing the compression

component and alleviating pressure on soft tissues (presumed to be annular pressure) [34,48,49,51].

Traction can be applied through several different methods, including manual, mechanical, motorized or hydraulic, pneumatic, and specialized tables. Traction can be divided further into intermittent, continuous, and sustained types. Sustained traction is most common. It uses relatively large forces maintained at 20- to 60-minute time periods. Maximum separation depends on the combination of factors: angle of traction, force generation, and traction time. It seems from classic studies by Colachis and Strohm [48–50] that 24° of anterior flexion is optimal [34,52]. It is known that in the middle to lower cervical segments at least 25 lb of force need be applied for distraction. Maximum separation occurs at the C4-C5 segment anteriorly at 25 minutes of traction time and posteriorly at C6-C7 at 20 minutes.

Newer pneumatic devices have come about to counter the limits of the previous water-bag, over-the-door home traction units. A limitation of the water-bag devices is the minimal distracting force because the weighting system can generate only 15 lb of force, and the adult head weighs approximately 7 to 12 lb; thus, significant distraction is difficult to obtain because distraction begins to occur at 25 lb in the middle to lower segments. Separation at the atlantooccipital region occurs at 10 lb of force, so less force is required for treatment of the upper cervical spine [53]. Other difficulties with water bag-style home traction devices include improper positioning and setup, causing a cervical extension moment, and poor compliance owing to difficulty in obtaining good placement on the occipital and chin regions, with undue pressure placed on the temporomandibular joint. Drawbacks to the pneumatic-type devices include the cost and relatively decreased portability as compared with a water-bag device. Home traction devices provide several advantages, including the ability to provide cost-effective, frequent self-management at home. Newer devices minimize temporomandibular joint difficulties and provide the capability of supine positioning during treatment.

It is believed that traction is particularly useful in conditions that involve compression of the nerve root. Traction seems to provide this benefit by enlarging intervertebral foramina, separating apophyseal joints, stretching muscles and ligaments, tightening the posterior longitudinal ligament to exert a centripetal force on the adjacent annulus fibrosis and enlarging the intervertebral space, diminishing disc protrusion, reducing cervical disc space pressure, separating intervertebral joints, stretching a tight or painful capsule, releasing entrapped synovial membrane, freeing adherent nerve roots, producing central vacuum to reduce herniated disc, producing posterior longitudinal ligament tension to reduce herniated disc, and relaxing muscle spasms [54]. Interestingly, there are many patients with cervical radiculopathy who tolerate the application of traction but who have severe pain as the traction is diminished at the end of the treatment session, precluding the use of traction devices. It is believed that this event is a resettling phenomenon, with return of pressure to an already irritated nerve root.

Manual medicine and manipulation

An extensive literature search did not produce any controlled perspective, retrospective, or cohort studies to support or refute the use of manipulation in the treatment of cervical radiculopathy. A few case reports with positive results were found, however [55]. Conversely, there were several case reports of negative and even catastrophic results [1,21,56]. A contraindication for high-velocity manipulation techniques is central cervical intervertebral disc herniation [46].

Manual medicine incorporates manipulations to restricted areas to enhance maximal pain-free movement and to restore postural balance and optimal function. There are many theories as to the principles of its restorative properties, including restoration of normality of disc or facet function, mechanically restoring optimal muscular and myofascial range, changing afferent signal transmission, endorphin release, and placebo effect [46,57]. Specific types of manual medicine techniques include mobilization with impulse, articulatory technique, muscle energy technique, strain-counterstrain, myofascial release, soft tissue release, and craniosacral manipulation [46,58].

Massage

An exhaustive literature search revealed minimal specific information in relation to treatment with massage for cervical radiculopathy. Both of the authors of this article, from personal experience, can report anecdotally that massage can help at least transiently to alleviate some of the pain associated with cervical disc herniation and associated radiculopathy. It can help lessen the pain associated with muscular guarding and splinting. Massage can be used to provide the temporary effects of increasing cutaneous blood flow, mobilization of tissue, relief of muscle hypertonicity, relief of discomfort, and reduction of swelling. Different massage techniques include effleurage (stroking massage), pétrissage (compression massage), friction massage, tapotement (percussion massage), acupressure, shiatsu, reflexology, rolfing, Trager psychophysical integration, and lymphatic massage [46].

Acupuncture

Acupuncture is used in some clinical practice settings with varying degrees of success. It has gained popularity recently in Western medicine and is reported to provide clinical benefits for pain control. An extensive literature search produced minimal corroborating research to validate its use, however. A few studies did suggest that there was some benefit, whereas others demonstrated contradictory results.

Modifiable factors

There are certain modifiable risk factors that can affect the treatment outcome of cervical radiculopathy. It is known that tobacco use is an adverse

health habit that has multiple negative effects, including being an epidemiologic risk factor for the development of lumbar disc disease. It is postulated that the smaller vessels may be compromised, making the discs, surrounding tissues, and nerves more sensitive to injury and slower to recover from injury. Cessation of tobacco use should be addressed in the treatment of cervical radiculopathies [59]. Other factors causing problematic spinal conditions include heavy repetitive twisting and sustained overhead activities and the operation of motorized machinery. It has been demonstrated that depression, poor social and family interactions, substance abuse, and mental health issues are negative factors in relation to spinal pain. Adequate nutrition is also a factor to consider.

Therapeutic exercise

Several studies have reported excellent outcomes with aggressive nonsurgical treatment of cervical radiculopathy [2–4,56]. This treatment included active physical therapeutic exercises in combination with multiple modalities reviewed elsewhere in this article. Various exercise protocols are reviewed in different studies with successful outcomes; however, there is no definitive evidence for the superiority of one specific protocol. On careful review, there does seem to be a common logical theme among them—there is slow progression in activity level that is advanced as tolerated [34].

Saal et al [3] conducted a longitudinal cohort study that demonstrated excellent results in 26 consecutive patients with cervical radiculopathy and documented herniated nucleus pulposus treated nonoperatively. Results showed that 24 of 26 patients were treated successfully without surgery. The treatment consisted of a program that initially focused on adequate pain control using multiple methods applied in a sequential manner as necessary to allow for successful participation and progression. Initial treatment included physical modalities and pharmacologic management. All patients were treated initially with relative rest, ice, and a hard cervical collar worn in a position that maximally reduced neck and arm pain for up to 2 weeks. Patients were given NSAIDs for 6 to 12 weeks. Patients received a 1-week course of prednisone (60 mg/d for 3 days followed by a rapid taper) when adequate control of symptoms was not obtained with NSAIDs. If necessary, patients were given radiographic-guided epidural or selective nerve root injections. If still necessary after injection, patients were managed with six sessions of acupuncture and transcutaneous electrical nerve stimulation. Physical therapy included manual and mechanical traction followed by home cervical traction. Education in postural control and body mechanics in conjunction with progressive strengthening exercises of shoulder girdle and chest musculature was an essential component of the rehabilitation protocol.

SamPATH et al [4] conducted a prospective, multicenter study of patients with cervical radiculopathy with either cervical spondylosis or disc disease. In this large study, only 33% underwent eventual surgery, and 67% were

treated nonsurgically. A significant percentage (26%) of those who underwent surgery reported persistent pain. The nonsurgical management consisted of pharmacologic therapy with NSAIDs, narcotics, or steroids when necessary. Cervical traction and cervical collars were used, and spinal injections, such as epidural steroid or selective nerve blocks, were used on an as-needed basis. Exercise was an essential part of nonsurgical rehabilitation. Heckman et al [1] similarly found positive results with conservative treatment of patients with herniated cervical intervertebral discs and cervical radiculopathy in a retrospective cohort study. Successful nonsurgical management included a multimodality approach. This approach included medications similar to those used in the studies discussed previously and short-term initial use of a cervical collar. After pain symptoms were improved, the patient underwent therapeutic exercises. No specifics regarding the type of exercise protocol used were described in this investigation.

Postural training may be initiated early. Feedback from a mirror and the physical therapist may be used. The goal is to teach the patient to maintain a “neutral spine” while performing activities of everyday life. These proprioceptive skills then are applied during active rehabilitation-strengthening exercises and teach the patient to keep the cervical spine in a pain-free, safe, and stable position during strenuous exercises [16].

Stabilization

Cervicothoracic stabilization is a necessary part of the rehabilitation program to limit pain, to maximize function, and to prevent injury progression or re-injury. It requires coordination and training of anterior and posterior cervical and shoulder girdle musculature. Training begins within a pain-free range of motion. It progresses to maintaining stabilization even with advanced movements and positional changes [16,60]. Enhanced muscular strength and increased awareness of proprioception allow the patient to balance strength and forces around the cervical spine. Training the thorax and upper limbs aids in distributing forces away from the cervical spine. It is necessary to condition the lumbar spine and lower limbs as part of the kinetic chain for successful stabilization because they provide a base for the cervicothoracic spine [16]. Tables 1 and 2 detail the muscles used and the exercises involved in cervicothoracic stabilization.

Stretching exercises

Restoring full range of motion and normal functional movement is essential to prevent scarring, adhesions, and repetitive microtrauma to cervical structures [16]. Stretching exercises play an integral role in maintaining and restoring range of motion. Stretching and aerobic conditioning are initiated during the subacute period or injury. It is recommended that aerobic exercises be done before stretching exercises to increase blood flow and aid in warm-up. There are different types of stretching exercises: passive,

Table 1

Muscle groups and individual muscles used in cervicothoracic stabilization

Anterior muscles	Posterior muscles
Sternocleidomastoid	Rectus capitis posterior (major, minor)
Scaleni	Obliquus capitis (inferior, superior)
Pectoralis major	Levator scapulae
Biceps (long head)	Superior trapezius
	Latissimus dorsi
	Teres major
	Subscapularis
	Rhomboids
	Middle trapezius
	Lower trapezius
	Serratus anterior

From Sweeney T, Prentice C, Saal JA, et al. Cervicothoracic muscular stabilizing technique. *Phys Med Rehabil* 1990;4:345; with permission.

active-assisted, active, and facilitated stretching, such as contract-relax. As symptoms improve and the acute episode subsides, the patient usually progresses from a passive to an active-based stretching program as tolerated. Adequate range of motion is necessary before progressing from static to dynamic exercises.

Aerobic conditioning

Aerobic capacity may diminish rapidly with the inactivity that often accompanies cervical radiculopathy. A deconditioned status may limit a patient's ability to perform strengthening exercises. Early aerobic conditioning can be completed without significant loading of injured musculature. Aerobic exercises initially include pool therapy, walking, or riding a stationary bicycle. Activity is limited by patient comfort, and it is increased as tolerated. A goal of at least 30 minutes a day is optimal. It is postulated that increasing aerobic capacity may result in the release of neurotransmitters that have a beneficial effect on pain [61].

Strengthening

Patients with cervical disc degeneration tend to splint and protect the cervical region during acute exacerbation of cervical radiculopathy. Repeated exacerbations lead to muscle atrophy, ligament atrophy, joint adhesions, and abnormal joint lubrication. Patients with disc disease and degenerative changes of the cervical spine have been shown to develop increased fatigue of anterior and posterior neck muscles (indicating relative deconditioning) [62]. Subsequent disuse leads to decreased physical capacity. A specific exercise program designed to strengthen deconditioned cervical, shoulder girdle, and upper trunk and peripheral musculature is an essential part of rehabilitation. It is one of the most important protective mechanisms in preventing

recurrences. It is believed that if a patient can develop normal strength and endurance of essential muscles, the likelihood of overstressing any structure causing injury is reduced [33,63].

Isometrics

During the weaning from use of a cervical collar in the subacute period, isometric cervical strengthening exercises should be introduced. This form of strengthening muscles against a fixed resistance without motion is most appropriate at this stage; it allows for strengthening without reaggravation and aids in prevention of weakness and atrophy. Isometric exercise should include single-plane strengthening against cervical flexion, extension, lateral bending, and rotation, and scapular stabilizing muscles (ie, trapezius, rhomboids, serratus anterior, latissimus dorsi) [20]. Gentle range-of-motion exercises, limited stretching, and aerobic conditioning usually are initiated at the same time. It often can be helpful to measure isokinetic strength in the involved as compared with the uninvolved side. This measurement provides objective evidence of strength and allows the patient to be monitored for progress or development of progressive weakness. This form of exercise is not functional, so there should be progression to dynamic exercises as tolerated.

Progressive-resistive exercise

Cervical and shoulder girdle weakness commonly develops with cervical radiculopathy, so more advanced exercises, such as progressive-resistive strengthening, may be initiated after the patient has some pain-free range of motion. This phase of rehabilitation marks the transition from static to dynamic exercises. These exercises should be performed within the pain-free range of motion and may advance as range of motion improves. They may start as uniplanar, working specific major muscles, and then advance to multiplanar exercises as tolerated. Exercise may progress from elastic bands to weight machines to free weights. Initially, weight is kept low and repetitions are increased as tolerated. Later, weight may be increased as tolerated [8]. Exercises concentrate on the upper trunk and shoulder girdle because they help to support the cervical spine. Stabilization exercises help to build paraspinal muscle strength and to protect from recurrence.

Home exercise program

There must be a transition to an independent home exercise program for successful rehabilitation. Consistent patient participation in a home program helps to prevent recurrence. This maintenance program must be tailored individually for patients. It may be based on specific diagnosis, patient status, available resources, and abilities.

Injections

Epidural injections are used commonly in the treatment of cervical radiculopathy. Many studies have shown various degrees of success with their

Table 2
Cervicothoracic stabilization exercises

	Level I: basic	Level II: intermediate	Level III: advanced
Direct cervical stabilization exercises	Cervical active range of motion	Cervical gravity Resisted isometrics	Cervical active Range gravity-resisted
Indirect cervical stabilization exercises	Cervical isometrics		
Supine, head supported	Thera-Band chest press Bilateral arm raise Supported “dying bug”	Unsupported “dying bug”	Chest flies Bench press Incline dumbbell press
Sit	Reciprocal arm raise Unilateral arm raise Bilateral arm raise Seated row Latissimus pulldown	Swiss ball reciprocal Arm raises Chest press	Swiss ball bilateral Shoulder shrugs Supraspinatus raises
Stand	Thera-Band reciprocal Chest press Thera-Band straight Arm latissimus pulldown Thera-Band chest press Thera-Band latissimus pulldown Standing rowing Crossovers Triceps press	Standing rowing Biceps pulldown	Upright row Shoulder shrugs Supraspinatus raises
Flexed hip-hinge position	0–30° Reciprocal arm raise Unilateral arm raise Bilateral arm raise Interscapular flies	30–60° Incline prone flies Reciprocal deltoid raise Cable crossovers	60–90° Bilateral anterior deltoid raises Interscapular flies
Prone	Reciprocal arm raise Unilateral arm raise Bilateral arm raise	Quadruped Head unsupported Swiss ball bilateral Anterior deltoid raises Swiss ball prone Rowing Swiss ball prone flies	Head supported Prone flies Latissimus flies
Supine, head unsupported	Not advised for level I	Partial sit-ups Arm raises	Swiss ball chest flies Swiss ball reciprocal

From Sweeney T, Prentice C, Saal JA, et al. Cervicothoracic muscular stabilizing technique. *Phys Med Rehabil* 1990;4:345; with permission.

use [19,64,65]. Recent literature has supported the use of fluoroscopically guided therapeutic selective nerve root blocks. This method has been demonstrated to be a safe and clinically effective intervention in conjunction with comprehensive nonsurgical treatment of cervical radiculopathy [64,65]. Epidural injections are indicated in patients whose pain does not improve or worsens with oral medications, treatment modalities, and physical therapy and who have a stable neurologic deficit. This treatment may aid in providing clinical improvement and avoiding the need for surgical intervention. A detailed article on cervical epidural injections can be found elsewhere in this issue. The reader is referred to that article for a more extensive review of this topic.

Surgery

Frequently, cervical disc extrusions seen on MRI have been considered an indication for surgery; however, studies have shown that even in cases of significant disc herniation, patients have done well with conservative management [3,66]. As reviewed previously in this article, disc herniations regress naturally, with associated clinical improvement in most cases, and only a small percentage of patients with cervical radiculopathy go on to have surgery. In general, studies have shown that patients who do require or are carefully selected for surgery do well [67]. Surgical intervention has been shown to provide faster improvement in pain intensity, sensory disturbance, and muscle strength at 3 months postoperatively than conservative treatment. At 1 year, however, there was no significant difference between the conservatively treated group and the surgical group [68]. It is reasonable to undergo at least 6 weeks of aggressive comprehensive nonsurgical management before consideration of surgical intervention. Surgery is absolutely indicated when there are progressive neurologic findings such as myelopathy. Surgery also may be relatively indicated in the presence of increasing weakness or unremitting pain despite a trial of nonsurgical management. So long as the patient is stable or improving, however, it is reasonable to continue nonsurgical management indefinitely.

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