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Diagnosis and Nonoperative Management of Cervical Radiculopathy

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Study Design: Qualitative, comprehensive literature review.
Objective: To discuss and summarize the current peer-reviewed literature related to the managment of patients with cervical radiculopathy.
Background: Cervical radiculopathy is a lesion of the cervical spinal nerve root with a reported prevalence of 3.3 cases per 1000 people; peak annual incidence is 2.1 cases per 1000 and occurs in the fourth and fifth decades of life. Nerve root injury has the potential to produce significant functional limitations and disability.
Methods and Measures: A search of the MEDLINE, CINAHL, and Web of Science databases for the periods 1966, 1982, and 1996, respectively, to December 1999 was conducted using selected keywords and MeSH headings. The bibliography of all retrieved articles were searched and pertinent articles were obtained. The Cochrane Database of Systematic Reviews was also searched. Literature related to the diagnosis, prognosis, and treatment of cervical radiculopathy were thoroughly reviewed and summarized using a critical appraisal approach.
Results: Although cervical radiculopathy remains largely a clinical diagnosis, the true diagnostic accuracy of the clinical examination for cervical radiculopathy is unknown. Imaging and electrophysiologic tests are capable of detecting clinically significant problems in many patients and each modality has inherent strengths and weaknesses; technical as well as practical factors affect the choice of procedure. The natural course of cervical radiculopathy appears to be generally favorable but no prognostic or risk factors have been firmly established and the efficacy of various nonoperative treatments for the condition is unknown.
Conclusion: A clear definition of terms and further research are required to establish definitive diagnostic criteria and effective treatment for the management of patients with cervical radiculopathy. *J Orthop Sports Phys Ther 2000;30:728–744.*

Key Words: *cervical radiculopathy, diagnosis, treatment*

Cervical radiculopathy is, by definition, a disease of the cervical spinal nerve root[33] and is most commonly caused by a cervical disc herniation or other space occupying lesion (typically osteophytic encroachment associated with cervical spondylosis) that may result in nerve root impingement, inflammation, or both.[116] The management of cervical radiculopathy merits careful consideration because a substantial proportion of patients with cervical radiculopathy may require surgical intervention[125] and are often treated by physical therapists.[69] Because cervical radiculopathy is a familiar condition encountered by many clinicians and is based on a patho-anatomic diagnosis, it would seem that the protocol for management should also be well established. The criteria for diagnosing cervical radiculopathy, however, have not been established. Current knowledge about cervical radiculopathy might not give health professionals adequate information to determine prognosis and identify risk factors or select interventions that are efficacious for the treatment of cervical radiculopathy.

Previously published reviews have focused on the surgical management of cervical radiculopathy,[31] have included patients with neck pain of unspecified origin,[34]

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TABLE 1. Search strategy MeSH headings and key words.

Cervical radiculopathy.mp
Cervical vertebrae
Intervertebral disk displacement
Nerve compression syndromes
Radiculitis
Spinal nerve roots
Diagnostic imaging
Radiography
Magnetic resonance imaging
Electromyography
Outcome assessment (health care)
Prognosis
Controlled clinical trial
Treatment outcome
Treatment failure
Physical therapy
Exercise therapy
Motion therapy
Occupational therapy
Acupuncture therapy
Salvage therapy
Behavior therapy

or dealt with an athletic patient population.[90] In addition, many reviews have included statements regarding diagnosis or treatment of cervical radiculopathy that are unreferenced, anecdotal, or from secondary sources.[1,3,31,37,140] The purpose of this review is to describe the current peer-reviewed literature related to the epidemiology, diagnosis, prognosis, and nonoperative treatment of cervical radiculopathy.

METHODS

In an attempt to locate all articles published in the peer-reviewed literature pertinent to review, a search of the MEDLINE, CINAHL, and Web of Science databases for the periods 1966, 1982, and 1996, respectively, to December 1999 was conducted using the keywords and MeSH headings in various combinations, depending on the management area concerned (Table 1). In addition, the bibliographies of all retrieved articles were searched and pertinent articles were obtained. The Cochrane Database of Systematic Reviews was also searched. Although several protocols related to the treatment of neck pain exist, none were specific to cervical radiculopathy and no reviews had been completed at the time our article was submitted. A numerical rating system was not used to grade the quality of the studies in our review and no attempt was made to numerically integrate data across studies or perform a meta-analysis of the literature. Literature related to the diagnosis, prognosis, and treatment of cervical radiculopathy were thoroughly reviewed and summarized using the critical appraisal guidelines recommended in the users' guides to the Medical Literature series.[52,53,66,79]

RESULTS

Etiology

Cervical radiculopathy is said to be of nontraumatic origin and occurs spontaneously in the majority of cases;[37] one large epidemiological study reported that a history of physical exertion or trauma occurred in only 14.8% of the 561 patients studied.[116] A number of less common or unusual causes have been reported in selected cases and include: metabolic disturbances[35]; surgical complications[59,146]; tumor[152]; sarcoidosis[5]; arteritis[126]; athetoid and dystonic cerebral palsy[45]; decompression sickness[165]; carrying heavy baggage[77]; parachuting[89]; ganglion compression[113]; Non-Hodgkin's lymphoma[108]; and vertebral artery torturosity and loop formation.[27]

Cervical radiculopathy is most often attributable to a lesion of the nerve root secondary to cervical disc herniation and spondylosis. These space occupying lesions are often classified as "soft" or "hard" discs, respectively.[105,129] True differences in the proportion of cervical radiculopathy attributable to disc and spondylosis are difficult to assess since differentiating between the two can be uncertain in a majority of cases.[116] Many epidemiologic and surgical series report a higher incidence of cervical radiculopathy secondary to spondolytic changes than cervical disc herniation,[97,98,110,116] but contrary reports exist.[12] For purposes of this paper, cervical radiculopathy is defined as a lesion or disease of the cervical nerve root, regardless of etiology. It is equally important at this point to define what a cervical radiculopathy is not. The mere presence of a cervical disc herniation, spondylosis, or osteophytic spurring of the intervertebral foramen observed on an imaging study or at surgery is not sufficient for establishing the diagnosis of cervical radiculopathy, nor is it necessary. Nerve-root compression is not painful in the absence of inflammation, and inflammation of the nerve root may occur in the absence of a compressive lesion.[121] Therefore, the concept that cervical radiculopathy is necessarily due to compressive pathology is not accurate.[31] While cervical disc herniation and spondylosis are admittedly the most common causes of cervical radiculopathy,[116] the bony and ligamentous tissues affected by these conditions are themselves pain generators and are capable of giving rise to the radicular or referred symptoms[8,21,71,81] observed in patients with nerve root pathology.

Epidemiology

Several large epidemiological studies of cervical radiculopathy published from 1976 to 1990 were located.[68,72,101,116,124] The prevalence of cervical radiculopathy has been estimated at 3.3 cases per 1000[124] with an average age-adjusted incidence rate of .8

cases per 1000 persons.[116] Peak incidence of cervical radiculopathy is most frequently reported to occur in the fourth or fifth decade of life[68,72,116,124] with an annual incidence of 2.1 cases per 1000 for this age group.[116] It is unclear whether there is a predominance based on sex. Some reports show that cervical radiculopathy is predominant in men[72,116] and other reports have shown predominance in women.[68,124]

It is generally agreed that involvement of the C6 and C7 nerve roots secondary to lesions of the C5–6 and C6–7 motion segments are most common.[1,3,31,37] However, whether the C6 or C7 is the most commonly affected nerve root depends on the case series of patients reported, with most favoring the C7[10,14,61,87,101,105,116,160,162] versus C6[43,46,85,96,110] level, based on surgical or laboratory study findings.

Diagnosis

What is the status of our current clinical acumen for the diagnosis of cervical radiculopathy? Consider the following two statements taken from seemingly authoritative sources: (1) "Cervical radiculopathy is a specific diagnostic entity that requires not only highly specific diagnostic criteria, but the exclusion of other diseases that may mimic radicular symptomatology"[31]; (2) "First, there are no well-defined diagnostic criteria for cervical radiculopathy, making a differential diagnosis from numerous other causes of neck and upper limb pain difficult."[116] These statements illustrate the fact that the diagnostic criteria for cervical radiculopathy are not well-defined and no universally accepted criteria for the diagnosis of cervical radiculopathy has been established.[116] Given the lack of definitive diagnostic criteria, what is sufficient for the diagnosis of cervical radiculopathy? Laboratory tests most commonly used to establish the diagnosis of cervical radiculopathy are imaging studies and electrophysiologic studies. While not perfect,[67,107] these tests are considered to be the most accurate means of diagnosis available and are often used to support and supplement the clinical examination primarily when the clinical examination is unclear, when other conditions need to be ruled-out, or when making a decision to intervene surgically.[32,57,82]

Although many authors state that cervical radiculopathy remains largely a clinical diagnosis,[1,3,16,37] the true diagnostic accuracy of the clinical examination for cervical radiculopathy is unknown and existing data suggest that it is not very accurate.[24,154] There are numerous clinical examination items that are purported to be useful for the diagnosis of cervical radiculopathy,[86] but it is necessary to examine the validity of these diagnostic tests and measures. Just as the randomized clinical trial provides the "best" evidence whereby causality and treatment effectiveness can be determined,[132] optimum methodological principles have been proposed to assess the validity and usefulness of diagnostic tests.[66,100,117,128] Three critical aspects that determine the validity and usefulness of a test include the standard reference criterion to which the test is compared,[28] the spectrum of patients to which the test is administered or applied,[117] and the procedures used to control bias.[66]

The degree to which each of the aforementioned principles is adhered to when assessing the diagnostic properties of a test determines the level of confidence one may place in the validity of the results for that particular test. Because laboratory procedures are expensive and not without risk, findings from the clinical examination that are referenced to a laboratory procedure "criterion standard" are most often used to establish a preliminary diagnosis and the clinical examination is increasingly relied upon in this era of medical cost cutting.[123] Following a brief discussion of differential diagnosis of cervical radiculopathy, the validity of both clinical examination and laboratory procedures will be discussed in the context of the previously mentioned issues concerning validity.[28,66,117]

Differential diagnosis Common musculoskeletal disorders and other neurological conditions that must be considered in the differential diagnosis of cervical radiculopathy include lesions of the rotator cuff and shoulder adhesive capsulitis.[24] Common neurologic disorders that must be ruled-out include myelopathy (most common)[97]; upper limb mononeuropathies of the median, ulnar, and radial nerves; and idiopathic brachial neuritis.[148] In addition, the following unusual conditions have masqueraded and have been mistaken for cervical radiculopathy: intracranial tumor[19]; axillary schwannoma[9]; epidural varicose viens[78]; glenoid cyst[147]; vertebral artery dissection[58]; and osteochondroma of the upper cervical spine.[4]

Clinical examination Complaints of neck pain with or without radiating arm pain in conjunction with findings of diminished muscle stretch reflexes, loss of sensation, and motor weakness are considered classic diagnostic findings of cervical radiculopathy.[42] This assumption must be considered in light of the available scientific evidence. The salient historical features and selected physical examination findings (primarily the standard neurologic exam consisting of reflex testing, sensation, and motor testing) in patients with cervical radiculopathy have been described in 2 early case series reports.[95,162] Since then, other studies have reported similar findings, the results of which have been repeated in various texts[86,115] and review papers[31,38] dealing with the subject. Unfortunately, in all these reports the majority of subjects demonstrated severe nerve root involvement and many eventually underwent surgery. Due to this spectrum bias, it is unknown whether the clinical examination findings reported in these studies are characteristic of patients with less severe nerve

root lesions.[117] Primary research findings related to the historical and physical examination findings are summarized below.

History In the majority of disease states, including neurologic disorders, an accurate diagnosis can be made from information obtained from a patient's history alone over 75% of the time.[92,149,151] Many historical elements have been described as pertinent for the diagnosis of cervical radiculopathy and include location and patterns of pain, location and patterns of altered sensation or paresthesias, and motor deficits.[21,95,156] Unfortunately, historical elements were not well-defined in these studies and details related to their diagnostic accuracy are lacking.[66] Atypical pain patterns reported include chest pain (pseudoangina),[157] breast pain,[76] and jaw pain.[61] A majority of patients report radicular symptoms in the upper extremity with or without neck pain[10,95,162] although some patients may experience neck pain only.[61]

Physical examination

1. Conventional Neurologic Examination Findings. This examination includes testing of strength, muscle stretch reflexes, and sensation. A standard neurological examination of the upper extremity is indicated for patients who present with radiating neck pain and radicular symptoms.[42] However, only 1 study has assessed the reliability of the conventional neurologic examination of the upper extremity. Viikari-Juntura reported moderate interrater reliability for sensory and strength testing (Kappa .40–.64) using standardized and operationally defined test procedures.[154] In what is perhaps the most frequently cited study regarding the value of the conventional neurologic examination in patients with cervical radiculopathy, Yoss et al found that diminished muscle stretch reflexes, objective motor weakness, and diminished sensation agreed with surgical findings 82, 77, and 65% of the time, respectively.[162]

   Although the conventional neurologic examination is a standard component in the evaluation of patients with suspected cervical radiculopathy, its value for the diagnosis of cervical radiculopathy is not well established.[154]
2. Range of Motion. Cervical range of motion (ROM) is frequently assessed when examining patients with complaints of neck pain[163] and cervical ROM measurements may be used as an indicator of treatment effectiveness.[83] Cervical ROM is often impaired and may result in functional limitations in patients with cervical radiculopathy.[37] Although limited cervical flexion ROM has been described as characteristic or useful for the diagnosis of cervical radiculopathy,[40,94,120] this claim has not been substantiated by data.

   Intraclass correlation coefficient values of .84–.92 have been reported for measuring cervical range of motion in subjects who suffer from mechanical neck pain or who are asymptomatic. Measurements have been taken with a variety of devices, but most are cumbersome in nature, which often limits their clinical applicability.[60,106,163]
3. Provocative Tests. Provocation tests are procedures designed to increase or decrease a patient's symptoms and usually have a dichotomous outcome. A positive test is thought to indicate that the target disorder has a mechanical component and may be responsive to treatment.[22,88] The basis for most provocative tests used to aid in the diagnosis of cervical radiculopathy is that mechanical deformation (compression or tension) or alleviation of mechanical deformation (distraction or relaxation) of the neural elements increases or decreases, respectively, symptoms or severity of symptoms in patients with nerve root irritation.[62,99,118] Mechanical deformation results in a reproduction or increase of the patient's symptoms due to ischemia and irritation of nerve axons whose depolarization threshold is elevated (ie, more easily depolarized) due to injury.[62,84]

   Provocative tests for patients with cervical radiculopathy may induce or alleviate mechanical deformation by the following mechanisms: enlargement or narrowing of the neural foramen,[99,135] peripheral neural elements placed on slack or stretch,[25,39,122] and an increase in intrathecal pressure.[119]

   Five different provocative tests have been reported as useful for the diagnosis of cervical radiculopathy and include: Spurling's or quadrant test[135]; Shoulder Abduction test[25]; Valsalva's maneuver[119]; Neck distraction[154]; and Elvey's Upper Limb Tension Test (ULTT).[39] Unfortunately, only 1 prospective report has been published regarding the efficacy of several of these tests.[154] The operational definition of each test and, if known, its reliability and diagnostic accuracy coefficient, is listed in Table 2.

Given the paucity of evidence, the true value of the clinical examination for the diagnosis of cervical radiculopathy is unknown at this time.

Laboratory tests Diagnostic test procedures used to confirm the presence of a clinically suspected cervical radiculopathy include imaging and electrophysiologic tests. The purpose of the former is to detect anatomic abnormalities and the latter to detect neuromuscular physiologic abnormalities. As is the case for many tests used to diagnose spinal disorders,[28] the diagnostic accuracy of imaging studies (magnetic resonance imaging, computed tomography with or without contrast, and myelography) and electrophysiologic tests (primarily needle electromyography [EMG]) is not perfect.

Imaging studies Imaging studies allow representation of anatomic abnormalities. Cervical myelography was the procedure of choice in the late 1970's for

TABLE 2. Reliability and diagnostic accuracy of selected clinical examination components for the diagnosis of cervical radiculopathy.

Test/Procedure	Operational definition	Reliability	Validity
Sensory testing	Patient response to light touch and pain. Representative dermatomal areas identified and tested with fingers (light touch) and injection needle (pain). Three-level scale used: normal, hyperesthesia, hypoesthesia.	Light touch: K = .41–.62 Pain: K = .29–.68[153]	Criterion standard: myelography[154] 1 neurologic sign positive: Sn = .83, Sp = .70 2 neurologic signs or more positive: Sn = .62, Sp = .78
Motor testing	Primarily based on side to side differences of selected muscles. Determination of bilateral deficit made on basis of age and general condition. Three level scale used: normal, reduced, markedly reduced.	K = .40–.64[153]	See above
Muscle stretch reflex	Elicited from the biceps, brachioradialis, and triceps using a reflex hammer.	Has not been reported	Has not been reported
Spurling's/Quadrant sign	Patient sitting. Examiner laterally flexes, slightly rotates, and then applies ~7-kg compression force to the head. Positive test is reproduction of symptoms.	K = .61–.71[153]	Criterion standard: myelography[154]* Sn = .36, Sp = .96
Shoulder abduction sign	While sitting, the patient is instructed to place the hand of the affected extremity on the head in order to support the extremity in the scapular plane. Positive test is reduction or elimination of symptoms.	K = .21–.40[153]	Criterion standard: myelography Sn = .43, Sp = .80[154] % agreement = 68%[25†]
Valsalva maneuver	Patient is instructed to take a deep breath and hold the breath while attempting to exhale over a 2–3-second period with gradually increasing force. Positive test is the reproduction of symptoms.	Has not been reported	Has not been reported
Neck distraction	Patient lies supine and the neck comfortably positioned. Examiner securely grasps the patient's head under the occiput and chin and gradually applies an axial traction force up to ~30 lbs. A positive test is the reduction or elimination of symptoms.	K = .50[153]	Criterion standard: myelography[154] Sn = .40, Sp = 1.0
Elvey's Upper Limb Tension Test	Several modifications of Elvey's test designed to selectively stress the peripheral nerves of the upper extremity have since been proposed.[39] The reliability of an upper limb tension test similar to the one described by Elvey has been reported by Viikar-Juntura.[153] Positive test is the reproduction of symptoms.	K = .35[153]	Has not been reported

Sn indicates sensitivity; Sp, specificity.

* Reliability and validity coefficients have also been reported for this test when applied and assessed in patients with mechanical neck pain[127] and myelopathy.[145] Reliability in asymptomatic subjects has been assessed as well.[136]

† Entire sample consisted of subjects with the condition; specificity undeterminable. Percent agreement uncorrected for chance.

the evaluation of patients with cervical radiculopathy.[67] However, a number of technological advances have been made resulting in imaging procedures that are more sensitive and specific than myelography and include computed tomography with myelography, as well as magnetic resonance imaging. Although the imaging modalities described in the following paragraphs are capable of detecting clinically significant problems in many patients, technical and practical factors affect the choice of procedure and each modality has its inherent strengths and weaknesses.[67]

1. Plain Radiographs. The primary role of radiography in the diagnosis of cervical radiculopathy is to rule-out other insidious disease processes and the delineation of osteophytes when used in conjunction with magnetic resonance imaging.[12,102]
2. Myelography. This modality uses contrast medium administered intrathecally followed by x-ray. It is used to assess the effect of a space occupying lesion on the dural sac, the nerve roots, and the spinal cord.[159] However, it is difficult to distinguish the nature of the defect (cervical disc herniation or osteophyte).[67,97] Infection of the puncture site and side effects of the contrast medium are a concern. In current practice, myelography is almost always used in conjunction with computed tomography and rarely employed as a stand-alone procedure.[67]
3. Computed Tomography Scan. Particularly useful

for enhancement of bony margins. Computed tomography is more sensitive than magnetic resonance imaging to bony changes but has limited ability to detect soft-tissue lesions and the patient is subjected to ionizing radiation.[12,67,97]

4. Computed Tomography With Contrast Medium. Myelography is performed and followed by a computed tomography scan. This combination enhances the advantages of myelography to detect space occupying lesions while providing excellent resolution of bony structures.[12,97] Likewise, the patient is also subjected to the risks of both myelography and computed tomography.
5. Magnetic Resonance Imaging. Magnetic resonance imaging is noninvasive and more sensitive to changes of the disc, spinal cord, nerve root, and surrounding soft tissue structures.[67] Standard views (axial and sagittal plane) may not detect lesions involving the foramina or be able to differentiate between a lateral cervical disc herniation or osteophyte.[97,98] Magnetic resonance imaging is contraindicated for patients with certain metal implants. Patients with claustrophobia may require sedation in order to tolerate the procedure and the monetary cost is high.

Although the use of noninvasive imaging techniques such as computed tomography and magnetic resonance imaging for the diagnosis of cervical radiculopathy is appealing, large prospective[7,141] and controlled studies[44] have demonstrated that both procedures, as well as plain x-rays, support pathoanatomic diagnoses in 19%–75%[44] of *asymptomatic* subjects, depending on age. Because of this high false-positive rate, the mere presence of disc or bony abnormalities is no guarantee that they are the cause of the patient's radicular signs and symptoms. Furthermore, it is well known that most tissues comprising the spinal motion segment (including the disc) can cause referred or radicular-like symptoms[8,21,71,81] and disorders unrelated to the nerve root and can cause reflex and motor changes.[26,134] While symptomatic patients demonstrate a higher incidence of degenerative changes on x-ray[44,93] and magnetic resonance imaging[64] than asymptomatic subjects, diagnostic accuracy characteristics have not been reported, which would allow practitioners to make clinically meaningful diagnostic decisions.[66] Other types of pathology demonstrated in asymptomatic subjects by magnetic resonance imaging are not trivial and may include spinal cord impingement as well as compression.[56,141] Studies attempting to match clinical manifestations to abnormal imaging features that are verified surgically serve only to visually confirm what was recorded radiographically and are primarily concerned with the existence of the lesion and not necessarily its effects.[82,97,159] Because imaging procedures may produce a number of dramatic abnormalities that produce no signs or symptoms, interpretation of any imaging finding must be done in the context of the patient's clinical presentation.[56]

Most imaging studies have used surgical observation of lesions as a criterion standard.[12,97,98,102] Imaging studies have a role in selecting surgical candidates and clarifying diagnostic uncertainty, especially when the patient's symptoms are persistent or not responding to nonoperative treatment.[57] However, selection of the optimal radiologic screening procedure(s) remains controversial and is compromised by the inexact correlation between clinical findings and anatomic lesions.[12] Based on surgical observation, the majority of studies comparing different imaging modalities have found magnetic resonance imaging to be superior to myelography alone for differentiating cervical lesions that are thought to contribute to cervical radiculopathy (stenosis, spondylosis, and cervical disc herniation)[12,97,98,102] and computed tomography with contrast appears to be comparable or superior to magnetic resonance imaging.[67,97] Although a rigid neurodiagnostic radiology algorithm for cervical radiculopathy is not always possible and is influenced by the individual patient,[67] some authors state that magnetic resonance imaging is the imaging study of choice in patients with cervical radiculopathy,[91,102] which appears to be consistent with current practice patterns. A single, accurate radiologic screening test for patients with cervical radiculopathy remains a desirable goal.[12] The results of studies comparing the imaging modalities with findings at surgery in patients with cervical radiculopathy are presented in Table 3.

Electrophysiologic tests Although often collectively referred to as EMG, in practice the electrophysiological examination consists of both needle electromyography and a variety of evoked potential procedures. Both are discussed in the following paragraphs.

1. Needle EMG. A needle electrode is used to sample motor unit behavior in selected limb muscles as well as the cervical paravertebral muscles in order to detect neural pathophysiology (specifically axonal-loss injury) and localize it to a cervical nerve root or roots.[32] Nerve conduction studies are also performed in conjunction with EMG in order to rule-out other causes of symptoms such as a diffuse peripheral neuropathy or more distal mononeuropathy.[32]
2. Other Electrophysiologic Procedures. Several other electrophysiologic examination procedures for the diagnosis of radiculopathy have been advocated in an attempt to increase the sensitivity of EMG and include analysis of motor unit action potentials (MUAP) and the evaluation of evoked potential latencies (flexor carpi radialis H-reflex, median and ulnar F-waves, and dermatomal somatosensory evoked potentials).[54] Although these

TABLE 3. Accuracy of imaging procedures and electromyography (EMG) used for the diagnosis of cervical radiculopathy (based on surgical observation; uncorrected for chance agreement).

Procedure	Percent agreement with surgical observation, (95% confidence interval)	N (subjects)/N (abnormalities)	No. false positives	No. false negatives	Nature of study	Independent test interpretation*
Imaging						
MRI	91 (74–100)[102]	10/11	0	1	Prospective	Unknown
	82 (59–100)[98]	9/11	0	2	Prospective	Yes
	74 (60–88)[97]	28/39	5	5	Prospective	Yes
Contrast enhanced CT (CT/myelo.)	91 (74–100)[98]	9/11	0	1	Prospective	Yes
	85 (74–96)[97]	28/39	1	5	Prospective	Yes
	75 (50–100)[121]	?/12	0	3	Retrospective	Yes
Myelo.	67 (52–82)[97]	28/39	5	7	Prospective	Yes
	63 (34–91)[102]	10/11	0	4	Prospective	Unknown
	35 (10–60)[12]	?/14	0	9	Retrospective	Yes
CT	28 (0–61)[12]	20/24	0	4	Retrospective	
Combined findings						
CT/myelo. & myelo.	92 (83–100)[97]	—	—	—	Prospective	Yes
CT/myelo. & MRI	90 (81–99)[97]	—	—	—	Prospective	Yes
MRI & x-rays	83 (68–98)[12]	—	0	2	Retrospective	Yes
Needle EMG	54 (44–64)‡[107]	62	0	28	Retrospective	No
	100 (85–100)[131]	14	0	0	Retrospective	Yes

Myelo. indicates myelography; CT, computerized tomography; CT/myelo., computerized tomography with contrast medium; MRI, magnetic resonance imaging; and ?, not reported or unknown.

* Surgical observation and diagnosis accomplished by a person unaware of imaging or EMG findings.

† Authors indicate that this figure may underestimate percent agreement as CT with contrast was not performed in 12 patients who had obvious cervical disc herniation on MRI.

‡ In patients with symptoms lasting >3 months; 67% agreement in patients with symptoms >4 weeks, but <3 months.

additional procedures may increase the yield of abnormalities detected during the electrophysiologic examination,[80,82,107,130] abnormal spontaneous activity (ie, fibrillations and positive sharp wave potentials) observed during needle electromyography is still considered the hallmark diagnostic sign and the single most sensitive pathophysiologic method for establishing the diagnosis of both lumbar and cervical radiculopathy.[36,74,107,131,164]

Because needle EMG assesses the neurophysiologic status of muscle, comparison with an anatomic imaging study or with surgically observed abnormalities of the disc and surrounding soft-tissue structures does not provide an adequate criterion standard.[32,37] Besides observable abnormalities of the nerve (swollen, compressed, etc), there is no other procedure with which the diagnostic accuracy of EMG can be compared. Regardless, comparisons of surgically observed nonneural soft-tissue abnormalities and EMG findings have been reported.[107,131] As with imaging studies, the diagnostic accuracy of EMG cannot be validly calculated in traditional coefficients of sensitivity and specificity when surgical observation is the criterion standard; the other inherent limitations of a surgical observation criterion standard were previously mentioned and apply as well. Despite these limitations, a high percent agreement has been reported in studies assessing the accuracy of EMG for the diagnosis of cervical radiculopathy confirmed by surgical observation (Table 3). In addition, the following percent agreements (without correction for chance agreement) between imaging and EMG studies have been reported: EMG and myelography, 75% (95CI 61–95%)[104,150]; EMG and computed tomography, 67% (95CI 41–92%)[80]; and EMG and magnetic resonance imaging, 60% (95CI 46–73%).[103]

Electrophysiologic studies have been identified as an important adjunct in the diagnosis of cervical radiculopathy.[32,37,82] As with imaging studies,[67] EMG has technical limitations as well as timing considerations that can result in diagnostic error.[32] Although no firm criteria have been established regarding when to use EMG for the diagnosis of cervical radiculopathy, EMG examination is primarily used in patients with questionable neurologic involvement to rule out other peripheral neuropathic disorders, to assess axonal recovery, and to assess whether an anatomic abnormality observed on imaging is correlated with neurologic injury.[32,37,82,104] Wilbourn's statement that needle EMG is nearly 100% specific for the examination of patients with suspected radiculopathy[158] cannot be substantiated due to the methodologic limitations mentioned previously, but no one has reported a false positive EMG in patients treated surgically for cervical radiculopathy[47,57,107,121,131,139,150]; the same cannot be said for imaging studies (Table 3).[23,55,97,107]

Summary Although the diagnostic accuracy estimates of both imaging procedures and electrophysio-

logical tests for cervical radiculopathy are imprecise, they are the most definitive means of diagnosis currently available. These 2 laboratory procedures (imaging and electrophysioligical tests) are not mutually exclusive, but rather, are complimentary.[82,107] The diagnostic accuracy of these tests must be interpreted based on the construct the test purports to represent (anatomical abnormality, neural impairment, or both) and in the context of a less-than-perfect criterion standard.

Prognosis & Risk Factors

Prognosis Prognosis deals with the possible outcomes of a disease over a specified period of time and the frequency with which these outcomes can be expected to occur.[79] Prognostic factors refer to characteristics of the patient (ie, age, sex, laboratory results, etc) while risk factors are associated with external variables related to the development of the disease (ie, smoking, alcohol use, etc). There are 2 primary guides for assessing literature related prognosis.[79] The first is that a well-defined, valid diagnostic criteria is used to identify a sample of the population that has been assembled at a similar point in the course of the disease. The study of prognosis with respect to cervical radiculopathy is complicated because many tools are used where true diagnostic value is unknown and different criteria are used to diagnose cervical radiculopathy. The second is that subjects have had a sufficiently long surveillance period with few subjects lost to follow-up. Other important, but secondary guidelines include use of objective and unbiased outcome criteria, adjustment of results for important known prognostic factors, and prognostic and risk factors expressed in terms of the likelihood of the event occurring.[79]

Unfortunately, most reports whose purpose is to assess the prognosis of patients with cervical radiculopathy are plagued by the following short-comings: incomplete subject follow-up; follow-up periods that greatly vary; outcome measures that are unstandardized, potentially biased, and whose relevance is questionable; and failure to make adjustments for prognostic factors thought to be important.[13,38,43,70,87,96,125] Only one study reported results using some form of likelihood estimate.[43] In addition, the diagnostic criteria for cervical radiculopathy vary between the reported studies, which further prevents generalization of their results. Studies reporting the prognosis of patients undergoing surgical intervention or those with general neck pain were not included in this review paper.[49,50,142,160]

Laboratory study findings relating to prognosis Several reports have documented that a cervical disc herniation responsible for a patient's radicular symptoms can regress with nonoperative treatment.[13,87,96,125] It appears that larger and more laterally located herniations exhibit a greater degree of regression[87,96] although it is unclear whether the degree of regression is associated with symptom resolution.[13,38] Ferrante et al found that patients with radicular pain who were treated with cervical epidural steroid injections were less likely to have a poor outcome (odds ratio = .23), while subjects who did not have a radiographically demonstrated cervical disc herniation were more likely to have a poor outcome (odds ratio = 4.4).[43] Two studies indicate needle EMG findings may be of prognostic value in surgically treated patients with cervical radiculopathy.[107,144] Partanen et al noted that a larger percentage of patients with a negative preoperative EMG had persistent symptoms than subjects with positive preoperative EMG findings.[107] Likewise, Tullborg et al found that patients with a normal preoperative EMG had significantly worse pain ratings at one year compared with subjects with an abnormal preoperative EMG study.[144]

Clinical signs and symptoms related to prognosis Two large epidemiologic studies indicate that a majority (up to 90%)[116] of subjects will improve with conservative treatment.[116,125] There is some evidence that an active treatment approach for patients with cervical radiculopathy results in better outcomes than a passive treatment approach[122]; similar findings have also been reported for patients with nonspecific neck pain.[69] This gives added support to the conclusions of most other studies comparing treatment interventions or case series in which all nonsurgically treated groups of subjects show substantial improvement over time.[6,10,14,17,46,61,63,92,94,110,120,122,137,138,149,156,161]

In Radhakrishnan et al's population based study,[116] the risk of a patient with cervical radiculopathy progressing to surgical intervention was determined using a multivariate proportional hazards model and reported as a "surgical hazard" ratio. A surgical hazard ratio represents the odds favoring surgical intervention. The presence of objective muscle weakness and the combination of radicular pain and dermatomal sensory deficit were significantly associated with surgical intervention (hazard ratios of 6 and 2.9, respectively). The hazard ratio rose to 17.3 if radicular pain plus sensory loss and objective muscle weakness were present in combination.[116] One large random controlled trial of 468 patients reported the following 5 factors to have a statistically significant adverse affect on outcome at 6 months: (1) history of episodic occurrences of cervical radiculopathy for more than 5 years; (2) more than 3 cervical radiculopathy episodes; (3) bilateral paresthesia; (4) women over 50 years of age; and (5) symptoms that were worsening at the time of presentation.[10] As with other studies, meaningful outcomes, subjects lost to follow-up, and lack of likelihood estimates allow only limited conclusions regarding prognosis to be drawn from this randomized clinical trial. In a study of athletes,

players who demonstrated radicular signs (muscle stretch reflex, sensory, or motor abnormalties), took longer to fully return to sport (21 weeks) than those who did not (3 weeks) and 60% exhibited residual symptoms.[70]

Risk factors Several studies have assessed risk factors for the development of cervical radiculopathy.[51,68,72,101] Mundt et al used an epidemiological case-control design to assess relative risk ratios for a variety of selected sports activities and the development of cervical radiculopathy.[101] Relative risk is the ratio of the incidence rates of 2 populations (affected population and control or comparison population).[143] Risk ratios for all activities were not statistically significant; the use of free weights less than 2 times weekly and warming up less than half the time prior to a free weight work-out were the only 2 variables that could have been considered clinically significant.[101] This study had a lack of power that resulted in the imprecise estimates of risk ratios. In yet another epidemiological case-control study, Kelsey et al reported the odds ratio for several risk and prognostic factors for the development of cervical radiculopathy.[72] The 95CI of the odds ratios for all sporting activities and lifting parameters assessed in Kelsey's study as well as for smoking status included the number one and, therefore, were of no clinical significance for predicting which patients were likely to develop cervical radiculopathy. Although professional drivers in Denmark appear to be overwhelmingly predisposed to cervical disk prolapse based on a standardized hospitilization ratio (SHR = 142),[68] no association has been found between cervical radiculopathy and other work related factors.[51] The criteria for inclusion in the professional driver study was the presence of an anatomical defect and, therefore, the subject population is probably not truly reflective of cervical radiculopathy.[68]

Based on the available evidence from epidemiological and treatment intervention studies, it appears that the natural course of cervical radiculopathy is favorable as is the outcome of patients who undergo nonoperative treatment. However, many questions remain regarding outcome parameters and the ability to predict which individual patients are at risk for a poor outcome. Although some studies indicate severity of neurologic deficit, age, and duration of symptoms may have prognostic value, further work is needed to validate the true prognostic value of these variables. No risk factors for the development of cervical radiculopathy have been established at this time.

Treatment

As with diagnosis, there are 3 main principles used to assess the usefulness of a report about treatment efficacy.[52] The first principle deals with study design: Was this treatment responsible for the treatment effect observed? As previously mentioned, the randomized clinical trial provides the "best" evidence whereby causality and treatment effectiveness can be determined; other study designs are not adequate to establish a cause and effect relationship.[132] The second principle concerns the results of the study: If there was a treatment effect, was it clinically significant and how precise was its estimate? Finally, the third principle concerns the validity and relevance of the outcome measures used.[29,73] If the intervention satisfies these principles, then clinicians must still decide if the benefits of treatment are worth the potential risks and cost.[52]

Different paradigms for the management of patients with cervical radiculopathy exist as well as a plethora of nonsurgical active and passive interventions.[140] A large, multicenter study reported the most common treatments prescribed by neurosurgeons and orthopaedic surgeons for patients were diagnosed with cervical radiculopathy.[125] Of the 246 subjects enrolled, 86 (35%) were offered surgery at the initial visit. The remainder were managed nonoperatively with a variety of active and passive treatments; at follow-up, 33% had actually received surgery.[125] What is surprising is the relatively small percentage of patients who received some form of nonoperative intervention (24–53%) and the large percentage of patients who received bedrest (56%) prior to being seen by the surgeons.[125] There are several case series reports suggesting that even patients with severe neurologic deficits and severe pain can be managed quite successfully using a nonoperative approach.[122,137,156]

In accordance with the earlier stated purpose of this article, only studies reporting the efficacy of nonoperative treatment interventions for cervical radiculopathy were reviewed. All research reports related to nonoperative treatment effectiveness have similar deficiencies and include: different diagnostic criteria for subject entry, the lack of standardized and meaningful health-outcome measures, and few if any well-designed, randomized clinical trials.

Operative versus nonoperative intervention Only one study has compared operative and nonoperative intervention for the treatment of patients with cervical radiculopathy, the results of which have been published in several manuscripts.[109–112] This trial was a multicenter study in which all single-level surgeries were performed with an anterior cervical decompression and fusion technique.[20] The 2 nonsurgical treatment groups received either "physiotherapy" or were prescribed a semirigid cervical collar for day use and soft collar for night use. The physiotherapy group received a variety of active and passive treatments that were prescribed and administered according to therapist preference based on the patient's presentation. Among the numerous outcome measures obtained in

TABLE 4. Studies of nonoperative treatment for cervical radiculopathy.

Type of nonsurgical intervention	N = Number of studies and design	Outcomes measure(s)	Blinded assessment	Complications
"Mixed"*	N = 10: 2 RCT[†109–112,166] 2 PC[122,149] 3 PS[6,137] 3 RS[61,94,120]	SIP, MAC[111] Unstandardized nominal level rating scale[6,61,120,122,137,149] 10-m VAS,[6,109–112] McGill pain questionnaire[166] Manual muscle test, grip and pinch strength ratios, and sensation[109,110,112] Clinical neurologic exam[6] Imaging study changes[6] Cervical[110,166] and shoulder ROM[110,112] Postural sway[110] RTW[6,122] Medication[122,166] Collar use[166] Continued care[122]	Yes[122,166] No[6,61,94,120,137,149] Unknown[109–112]	None reported for any study
Epidural/nerve root steroid injection	N = 7: 2 RCT[17,46] 3 PS[14,18,155,156] 2 RS[92,133]	10-cm VAS[14,17,46] Unstandardized pain scale[92,156] or verbal report[133] Hospital days and recurrence[46] Complications[18,133,155]	Yes[14] No[17,18,92,155] Unknown[46,133,156]	6 minor complications[155] 17 minor complications[133] 50 minor complications[18]
Cervical traction	N = 5: 3 RCT[10,161,166] 1 PC[149] 1 RS[138]	McGill pain questionnaire[166] Unstandardized nominal level rating scale[149] Clinician and patient rating of symptoms (severity[10,138] and impact on work and sleep)[10] Cervical ROM[10,166] EMG reduction (C-5 paraspinals)[161] Medication[166] Collar use[166]	Yes[10,166] No[138] Unknown[149,161]	None reported for any study
Manipulation	N = 5: 2 PS[6,63] 3 SC[11,41,114]	NDI[114] 10-cm VAS[6,41,63] Unstandardized nominal level rating scale[6] Imaging study changes[6,114] Clinician and patient rating of symptoms[11] Clinical neurologic exam[11,41] RTW[11]	Yes No[6,11,63] Unknown	2 subjects had exacerbation of pain & worsening of neurologic deficits[63]
Cervical collar	N = 3: 3 RCT[†10,46,109–112]	See outcomes under "mixed" treatment heading[†111–114] Hospital days and recurrence[46] See outcomes under cervical traction treatment heading[10]	Yes[10] No Unknown[46,†111–114]	None reported for any study

RCT indicates Randomized Clinical Trial; PC, Prospective Cohort/Quasi/experimental trial; PS, Prospective Case Series; RS, Retrospective Case Series; SC, Single-Case Report; SIP, Sickness Impact Profile; MAC, Mood Adjective Checklist; NDI, Neck Disability Index; RTW, Return to Work; and VAS, visual analog scale.

* "Mixed": When 2 or more interventions are combined and considered a single intervention.

† References 111–114 are different reports based on the same data set.

this study (Table 4),[6,10,14,92,109–112,114,122,133,161,166] the surgery and physiotherapy group demonstrated significant short-term improvement (14–16 weeks) in most measures and all 3 groups had demonstrated significant improvement in most measures at the one-year follow-up.[111] Further research is required to determine the efficacy of surgical versus nonsurgical intervention for the treatment of cervical radiculopathy.

Nonoperative interventions Reports consisting of a variety of experimental designs that compared different treatments as well as case series and single case reports documenting treatment outcome in patients with cervical radiculopathy were found. The types of research design and outcome measures of nonoperative interventions are listed by type of intervention in Table 4. Evidence for each type of nonoperative treatment listed is further critiqued below.

Mixed Mixed treatment refers to 2 or more treatments that have been combined in a trial and considered as a single intervention (ie, moist heat and

ultrasound). Studies that use a mixed treatment usually refer to the interventions collectively as "physiotherapy,"[110] "physical therapy," or as conservative[94,137] or nonoperative treatment.[122] For the purpose of this review, however, if a single nonoperative intervention is identified and considered to be the primary treatment and other interventions are administered as adjunct treatments, then the intervention was not considered "mixed" (ie, moist heat prior to cervical traction).

Two randomized clinical trials comparing a mixed treatment were identified.[110,166] The results of 1 trial that compared a mixed intervention group to surgery and collar groups was described previously.[109–112] In the other randomized clinical trial, only 59% of the study sample consisted of patients diagnosed with cervical radiculopathy. In this study, the mixed group received a combination of neck ergonomic instruction, superficial heat, ROM, and relaxation exercises, and was compared with a group receiving intermittent traction. The traction group had significantly better ROM and pain scores than the mixed group at the 6-week follow up.[166]

Mixed groups in the remainder of studies most commonly consisted of: traction,[6,61,94,120,122,137,149] a variety of types of exercise,[6,61,120,122,137,149,166] superficial[61,94,120,149,166] and deep heat,[61,120,122,149] ergonomic neck instruction,[120,122,137,149,166] cold,[6,122,137,149] and medications.[61,120,122,137] Less frequently employed modalities include: cervical collar,[61,122,137] range of motion,[137,149,166] general conditioning,[6,122,137] mobilization and manipulation,[6,120,137] and massage.[94,137] Use of rest,[61,122] epidural-nerve root injection,[122,137] TENS,[122,137] cervical pillow,[137] and acupuncture[122] have also been described as modalities comprising a mixed treatment. In some reports, a uniform application of the mixed treatment was not administered to all subjects. Rather, individual components of the mixed treatment were selectively administered to patients based on the severity of their symptoms.[111,122,137] Unlike other studies of mixed interventions, Saal and colleagues selectively applied components of their mixed intervention according to a treatment algorithm that was based on the severity of the patient's symptoms and response to previous treatment.[122]

Although the majority of nonrandomized studies describing mixed intervention for the treatment of cervical radiculopathy are positive and a large number of surgical candidates respond to nonoperative treatment,[6,61,94,120,122,137,149] the results of 2 randomized clinical trials[110,166] showed no effect between groups receiving mixed treatment and various comparison groups (different modes of traction, surgery, cervical collar, or surgery). Due to the inherent heterogeneous nature of a mixed treatment group and inability to identify which treatment component is effective, further studies of this particular intervention as a primary treatment for cervical radiculopathy may not be a wise investment of resources.

Epidural-nerve root steroid injection All the studies of this second most commonly reported nonsurgical intervention for cervical radiculopathy fail to include functional outcome measures with validated psychometric properties, including the 2 randomized clinical trials.[17,46] Three studies reported pain measures using a 10-cm visual analogue scale,[14,17,46] while 3 others used either a verbal response of improvement from the patient[133] or unvalidated pain scales.[92,156] Two prospective studies merely documented complications of injection.[18,155]

Similar to the mixed treatment intervention, results for patients treated with cervical epidural-nerve root steroid injections were uniformly positive with the exception of one study.[133] Fukusaki observed a significant decrease in pain intensity and number of hospital days compared with the control group (7.4 days versus 20.3).[46] Three studies reported minor complications.[18,133,155] In Shulman's retrospective review, he documented several minor complications that occurred in 18% of his subjects. These complications included: nausea, bloating of the abdomen, shortness of breath, vomiting, and painful injection site.[133] Cicala noted the following minor complications and side effects in 35% of the 142 patients in his study: stiff neck lasting 12–24 hours and mild facial flushing with subjective fever were most common while dural puncture, upper extremity weakness, and vomiting were isolated occurrences. However, only 6 of 215 (3%) patients with cervical radiculopathy in Waldman's prospective study experienced complications: 3 subjects experienced a syncopal episode, 2 an unintentional dural puncture, and 1 a superficial infection at the injection site. The discrepancies between the Shulman, Cicala, and Waldman reports are considerable and need to be reconciled. The fact only 22% of the patients in Shulman's case series were diagnosed with cervical radiculopathy and the remainder had chronic neck pain of various etiologies could be one explanation for the types of complications when compared with the other 2 reports. Further randomized clinical trials of epidural-nerve root injections using meaningful outcome measures are required to determine the efficacy of this intervention. The complication and adverse event rates of all future studies must be reported before an accurate estimate of this parameter can be made.

Cervical traction van der Heijden et al's 1995 systematic review of the efficacy of traction for back and neck pain identified 3 randomized clinical trials[10,48,166] dealing with neck pain and concluded that a strong, valid judgment regarding cervical traction was not possible due to the poor methodological quality of available studies.[151] However, only one of these studies had a homogenous sample of patients diagnosed with cervical radiculopathy.[10] Fifty-nine

percent of the subjects in the Zylbergold and Piper study[166] were diagnosed with cervical disc disease based on radiographs. The inclusion criteria in the Goldie and Landquist[48] study were vague; subjects were required to have neck and radiating arm pain, but no other definitive diagnostic criteria were described. Very few of the subjects were reported to have paresthesias and none had motor deficits.[48]

Two additional studies of cervical traction have been published since van der Heijden's review. Wong et al conducted a randomized clinical trial comparing conventional sitting traction with traction applied concomitantly with a new EMG biofeedback device in patients with cervical radiculopathy.[161] Both groups received traction for a 20-minute period, 10 second pull-5 second rest cycle, at a 25 angle pull while moist heat was applied. The only outcome measures reported in this investigation were levels of surface EMG (recorded from the paraspinal musculature at the C-5 vertebral level). The reduction in muscle tension was significantly greater in the biofeedback group and it took significantly less time to reach the optimal treatment force of 25% bodyweight (48% versus 78% decrease in surface EMG levels and 2 versus 4 weeks, respectively).[161] The other study was a retrospective review of patients treated with an overhead home traction device. Only 10 of the 58 cases reported were diagnosed with cervical radiculopathy. The authors reported that 9 of these subjects were considered to be improved by their last visit.[138]

Only 2 of the 5 reports of cervical traction deal strictly with patients with cervical radiculopathy. The conclusion reached by van der Heijden et al in their review apply here: "To date no conclusions can be drawn about whether a specific traction modality for neck pain is effective, or more efficacious than other treatments. There are no clear indications, however, that traction is an ineffective therapy for neck pain."[151(p93)] Clearly, numerous high quality randomized clinical trials are needed to establish the efficacy of this nonsurgical intervention that is purported to be useful in the treatment of cervical radiculopathy.[22]

Manipulation The use of cervical spine manipulation for the treatment of cervical radiculopathy is sometimes considered to be contraindicated.[16,37,42] However, it has been administered as the primary treatment for patients with cervical radiculopathy by a number of authors.[6,11,41,63,114] All reports of high-velocity-low amplitude manipulation of the cervical spine as the main nonsurgical intervention have appeared in the chiropractic literature and consist of prospective case series[6,63] or single case reports.[11,41,114] No reports of mobilization or nonthrust techniques were identified.

BenEliyahu reported that 80% of 27 patients with cervical radiculopathy had a "good" outcome based on pain reduction (visual analog scale), reduction of radicular symptoms, and clinical examination findings at a mean follow-up time of 9 months.[6] Repeat magnetic resonance imaging showed disc herniation to be reduced or completely reabsorbed in 63% of patients. The frequency of patients who achieved a good clinical outcome and demonstrated regression of the herniation on repeated magnetic resonance imaging was statistically different from chance ($\chi^2 = < .001$). In addition, 78% of patients returned to work. The manipulative techniques used by BenEliyahu were not well described.[6] Although BenEliyahu reported no complications, 2 of 8 cervical radiculopathy patients treated with manipulation in the smaller case series reported by Hubka had increased pain and worsening of neurologic status following the manipulation and subsequently required surgery.[63] Hubka used a manipulative technique that involved neck flexion, sidebending toward the affected side, and rotation away from the affected side. The articular pillar of the affected segment was contacted with the manipulating hand, while the fingers of the other hand contact the chin and support the head. A longitudinally directed thrust was given once the patient was properly positioned. The 2 patients who had a worsening of status were not improved after 2–3 treatments using this technique, so Hubka subsequently performed the manipulation with rotation *toward* the side of the patients symptoms. It was after the change in manipulative technique that the patients' condition worsened. Therefore, Hubka felt that this change in manipulative technique may be responsible for the adverse outcomes.[63] Several single case studies employing a variety of manipulative techniques have reported successful outcomes and no complications.[11,41,114]

Because rare catastrophic vascular events have been associated with cervical spine manipulation,[65] this treatment is considered to be a risky or harmful procedure when used for the treatment of cervical radiculopathy. Three systematic reviews have concluded that manipulation or mobilization of the cervical spine is of some benefit for patients with mechanical neck pain.[30,55,65] However, no studies assessing the efficacy of cervical manipulation in patients with cervical radiculopathy were located with the search strategy used for this review paper. Future controlled trials assessing the efficacy of manipulation for cervical radiculopathy are needed but may be difficult to conduct because of rare catastrophic vascular events associated with manipulation of the cervical spine[30,55,65] and the inability to identify risk factors for complications.[55]

Cervical collar One randomized clinical trial comparing a cervical collar group with a physiotherapy group and surgery group in which no long-term differences were noted between the groups has been previously described.[110] Two other randomized clinical trials have been reported, both of which treated

subjects with soft cervical collars.[10,46] Although patients treated with soft collars improved significantly in both studies, the injection group in the Fukusaki et al study improved significantly faster than the collar group and had fewer hospital days.[46] No differences in improvement were noted between several different treatment groups compared in the other study (a multicenter trial).[10]

Considering the adverse effects of prolonged immobilization on tissue[2] and the fact that collar use is an entirely passive intervention, the appropriate role of a cervical collar may be strictly adjunctive for palliative purposes and not a primary treatment. There is no evidence supporting the use of soft or hard collar as a primary or adjunctive treatment for cervical radiculopathy.

Ultrasound One case series report was identified that described the effect of ultrasound in 6 patients with radiculopathy.[75] It was unclear which of the 6 patients were affected with cervical radiculopathy and which had lumbar involvement. Diagnostic criteria for inclusion were well specified as was the application of treatment directly over the paravertebral musculature of the affected root level. Qualitative assessments of pain and ROM were outcomes reported by the author and, therefore, uninterruptible. Additional studies of ultrasound therapy for the treatment of patients with cervical radiculopathy were not identified.

CONCLUSION

In many studies of cervical radiculopathy, a specific definition of the pathologic entity being studied is unclear. Some authors use the term to refer to an abnormality of the disc or vertebra while others adhere to a more precise definition that specifies involvement of the nerve root. Cervical radiculopathy is most commonly caused by a cervical disc herniation or spondylosis. A number of different entities may be responsible for or masquerade as cervical radiculopathy. Although the diagnosis of cervical radiculopathy remains primarily a clinical task, the true diagnostic values of components of the clinical examination have not been adequately studied and remain unknown. Imaging studies and EMG and are used to confirm a clinically suspected diagnosis of cervical radiculopathy in selected cases. These 2 laboratory procedures assess anatomic and physiologic abnormalities and should be considered complementary. Due to inherent methodological problems, however, the true diagnostic value of these 2 tests is difficult to assess. Each test has advantages and limitations, and no diagnostic algorithm involving their use has been established and substantiated. Few randomized clinical trials for the treatment of cervical radiculopathy involve homogenous groups of subjects and all the available reports describing the nonoperative treatment of patients with cervical radiculopathy have numerous methodological problems. There is no conclusive evidence demonstrating the effectiveness of any single nonoperative intervention for the treatment of cervical radiculopathy. The natural course of cervical radiculopathy appears to be favorable but no prognostic or risk factors related to cervical radiculopathy have been firmly established at this time.

A clear definition of terms and further research are required to establish definitive diagnostic criteria and treatment approaches for the management of patients with cervical radiculopathy. Those who administer nonoperative care should take a leading role in investigating the tools of their trade for the diagnosis and treatment of patients with cervical radiculopathy. This area appears to be ripe for investigation. In addition to a detailed description of treatment parameters and the identification of meaningful outcomes, future reports should detail the diagnostic criteria used to include subjects as well the subject characteristics. Clinicians, researchers, and clinician-researchers should all join forces to ensure that studies using sound methodological principles are carried out and that the results are published in the peer-reviewed literature.

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