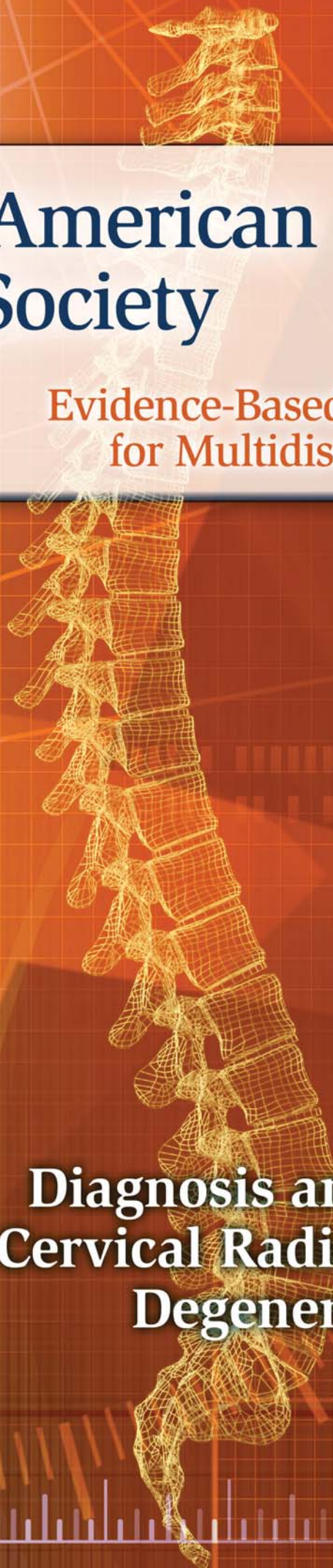
North American Spine Society

Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care



Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders

North American Spine Society

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for Multidisciplinary Spine Care

Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders

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Financial Statement

This clinical guideline was developed and funded in its entirety by the North American Spine Society (NASS). All participating authors have submitted a disclosure form relative to potential conflicts of interest which is kept on file at NASS.

Comments

Comments regarding the guideline may be submitted to the North American Spine Society and will be considered in development of future revisions of the work.

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This clinical guideline should not be construed as including all proper methods of care or excluding other acceptable methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding any specific procedure or treatment is to be made by the physician and patient in light of all circumstances presented by the patient and the needs and resources particular to the locality or institution.

I. Introduction

Objective

The objective of the North American Spine Society (NASS) Clinical Guideline for the *Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders* is to provide evidence-based recommendations to address key clinical questions surrounding the diagnosis and treatment of cervical radiculopathy from degenerative disorders. The guideline is intended to reflect contemporary treatment concepts for cervical radiculopathy from degenerative disorders as reflected in the highest quality clinical literature available on this subject as of May 2009. The goals of the guideline recommendations are to assist in delivering optimum, efficacious treatment and functional recovery from this spinal disorder.

Scope, Purpose and Intended User

This document was developed by the North American Spine Society Evidence-Based Guideline Development Committee as an educational tool to assist practitioners who treat patients with cervical radiculopathy from degenerative disorders. The goal is to provide a tool that assists practitioners in improving the quality and efficiency of care delivered to patients with cervical radiculopathy from degenerative disorders. The NASS *Clinical Guideline for the Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders* provides a definition and explanation of the natural history of cervical radiculopathy from degenerative disorders, outlines a reasonable evaluation of patients suspected to have cervical radiculopathy from degenerative disorders and outlines treatment options for adult patients with a diagnosis of cervical radiculopathy from degenerative disorders.

THIS GUIDELINE DOES NOT REPRESENT A "STANDARD OF CARE," nor is it intended as a fixed treatment protocol. It is anticipated that there will be patients who will require less or more treatment than the average. It is also acknowledged that in atypical cases, treatment falling outside this guideline will sometimes be necessary. This guideline should not be seen as prescribing the type, frequency or duration of intervention. Treatment should be based on the individual patient's need and physician's professional judgment. This document is designed to function as a guideline and should not be used as the sole reason for denial of treatment and services. This guideline is not intended to expand or restrict a health care provider's scope of practice or to supersede applicable ethical standards or provisions of law.

Patient Population

The patient population for this guideline encompasses adults (18 years or older) with a chief complaint of pain in a radicular pattern in one or both upper extremities related to compression and/or irritation of one or more cervical nerve roots.

II. Guideline Development Methodology

Through objective evaluation of the evidence and transparency in the process of making recommendations, it is NASS' goal to develop evidence-based clinical practice guidelines for the diagnosis and treatment of adult patients with various spinal conditions. These guidelines are developed for educational purposes to assist practitioners in their clinical decision-making processes. It is anticipated that where evidence is very strong in support of recommendations, these recommendations will be operationalized into performance measures.

Multidisciplinary Collaboration

With the goal of ensuring the best possible care for adult patients suffering with spinal disorders, NASS is committed to multidisciplinary involvement in the process of guideline and performance measure development. To this end, NASS has ensured that representatives from medical, interventional and surgical spine specialties have participated in the development and review of all NASS guidelines. It is also important that primary care providers and musculoskeletal specialists who care for patients with spinal complaints are represented in the development and review of guidelines that address treatment by first contact physicians, and NASS has involved these providers in the development process as well. To ensure broad-based representation, NASS has invited and welcomes input from other societies and specialties.

Evidence Analysis Training of All NASS Guideline Developers

NASS has initiated, in conjunction with the University of Alberta's Centre for Health Evidence, an online training program geared toward educating guideline developers about evidence analysis and guideline development. All participants in guideline development for NASS have completed the training prior to participating in the guideline development program at NASS. This training includes a series of readings and exercises, or interactivities, to prepare guideline developers for systematically evaluating literature and developing evidence-based guidelines. The online course takes approximately 15-30 hours to complete, and participants have been awarded CME credit upon completion of the course.

Disclosure of Potential Conflicts of Interest

All participants involved in guideline development have disclosed their relationships with other entities and potential conflicts of interest to their colleagues and their potential conflicts have been documented for future reference. They will not be published in any guideline, but kept on file for reference, if needed. Participants have been asked to update their disclosures regularly throughout the guideline development process.

Levels of Evidence and Grades of Recommendation

NASS has adopted standardized levels of evidence *(Appendix B)* and grades of recommendation *(Appendix C)* to assist practitioners in easily understanding the strength of the evidence and recommendations within the guidelines. The levels of evidence range from Level I (high quality randomized controlled trial) to Level V (expert consensus). Grades of recommendation indicate the strength of the recommendations made in the guideline based on the quality of the literature.

Grades of Recommendation:

A: Good evidence (Level I studies with consistent findings) for or against recommending intervention.

B: Fair evidence (Level II or III studies with consistent findings) for or against recommending intervention.

C: Poor quality evidence (Level IV or V studies) for or against recommending intervention.

I: Insufficient or conflicting evidence not allowing a recommendation for or against intervention.

Guideline recommendations are written utilizing a standard language that indicates the strength of the recommendation. "A" recommendations indicate a test or intervention is "recommended"; "B" recommendations "suggest" a test or intervention and "C" recommendations indicate a test or intervention "may be considered" or "is an option." "I" or "Insufficient Evidence" statements clearly indicate that "there is insufficient evidence to make a recommendation for or against" a test or intervention. Work group consensus statements clearly state that "in the absence of reliable evidence, it is the work group's opinion that" a test or intervention may be appropriate.

The levels of evidence and grades of recommendation implemented in this guideline have also been adopted by the J*ournal of Bone and Joint Surgery*, the American Academy of Orthopaedic Surgeons, Clinical Orthopaedics and Related Research, the journal *Spine* and the Pediatric Orthopaedic Society of North America.

In evaluating studies as to levels of evidence for this guideline, the study design was interpreted as establishing only a potential level of evidence. As an example, a therapeutic study designed as a randomized controlled trial would be considered a potential Level I study. The study would then be further analyzed as to how well the study design was implemented and significant short comings in the execution of the study would be used to downgrade the levels of evidence for the study's conclusions. In the example cited previously, reasons to downgrade the results of a potential Level I randomized controlled trial to a Level II study would include, among other possibilities: an underpowered study (patient sample too small, variance too high), inadequate randomization or masking of the group assignments and lack of validated outcome measures.

In addition, a number of studies were reviewed several times in answering different questions within this guideline. How a given question was asked might influence how a study was evaluated and interpreted as to its level of evidence in answering that particular question. For example, a randomized control trial reviewed to evaluate the differences between the outcomes of surgically treated versus untreated patients with lumbar spinal stenosis might be a well designed and implemented Level I therapeutic study. This same study, however, might be classified as giving Level II prognostic evidence if the data for the untreated controls were extracted and evaluated prognostically.

Guideline Development Process

■ Step 1: Identification of Clinical Questions

Trained guideline participants were asked to submit a list of clinical questions that the guideline should address. The lists were compiled into a master list, which was then circulated to each member with a request that they independently rank the questions in order of importance for consideration in the guideline. The most highly ranked questions, as determined by the participants, served to focus the guideline.

■ Step 2: Identification of Work Groups

Multidisciplinary teams were assigned to work groups and assigned specific clinical questions to address. Because NASS is comprised of surgical, medical and interventional specialists, it is imperative to the guideline development process that a cross-section of NASS membership is represented on each group. This also helps to ensure that the potential for inadvertent biases in evaluating the literature and formulating recommendations is minimized.

■ Step 3: Identification of Search Terms and Parameters

One of the most crucial elements of evidence analysis to support development of recommendations for appropriate clinical care is the comprehensive litera-

ture search. Thorough assessment of the literature is the basis for the review of existing evidence and the formulation of evidence-based recommendations. In order to ensure a thorough literature search, NASS has instituted a Literature Search Protocol *(Appendix D)* which has been followed to identify literature for evaluation in guideline development. In keeping with the Literature Search Protocol, work group members have identified appropriate search terms and parameters to direct the literature search.

Specific search strategies, including search terms, parameters and databases searched, are documented in the appendices *(Appendix E)*.

■ Step 4: Completion of the Literature Search

Once each work group identified search terms/parameters, the literature search was implemented by a medical/research librarian, consistent with the Literature Search Protocol.

Following these protocols ensures that NASS recommendations (1) are based on a thorough review of relevant literature; (2) are truly based on a uniform, comprehensive search strategy; and (3) represent the current best research evidence available. NASS maintains a search history in Endnote, for future use or reference.

■ Step 5: Review of Search Results/ Identification of Literature to Review

Work group members reviewed all abstracts yielded from the literature search and identified the literature they will review in order to address the clinical questions, in accordance with the Literature Search Protocol. Members have identified the best research evidence available to answer the targeted clinical questions. That is, if Level I, II and or III literature is available to answer specific questions, the work group was not required to review Level IV or V studies. Work group members reviewed the evidence on the topic of cervical radiculopathy, and studies eligible for review were required to address radiculopathy alone or include a subgroup analysis of patients with radiculopathy. Many of the studies considered for potential inclusion in this guideline included groups of patients with myelopathy, without appropriate subgroup analyses of those patients with cervical radiculopathy alone. For this reason, in the absence of subgroup analyses, a large number of studies were excluded from consideration in addressing the questions and formulating recommendations. These studies, having been reviewed, are included in the reference sections.

■ Step 6: Evidence Analysis

Members have independently developed evidentiary tables summarizing study conclusions, identifying strengths and weaknesses and assigning levels of evidence. In order to systematically control for potential biases, at least two work group members have reviewed each article selected and independently assigned levels of evidence to the literature using the NASS levels of evidence. Any discrepancies in scoring have been addressed by two or more reviewers. The consensus level (the level upon which two-thirds of reviewers were in agreement) was then assigned to the article.

As a final step in the evidence analysis process, members have identified and documented gaps in the evidence to educate guideline readers about where evidence is lacking and help guide further needed research by NASS and other societies.

■ Step 7: Formulation of Evidence-Based Recommendations and Incorporation of Expert Consensus

Work groups held webcasts to discuss the evidence-based answers to the clinical questions, the grades of recommendations and the incorporation of expert consensus. Expert consensus has been incorporated only where Level I-IV evidence is insufficient and the work group has deemed that a recommendation is warranted. Transparency in the incorporation of consensus is crucial, and all consensus-based rec-

ommendations made in this guideline very clearly indicate that Level I-IV evidence is insufficient to support a recommendation and that the recommendation is based only on expert consensus.

Consensus Development Process
Voting on guideline recommendations was conducted using a modification of the nominal group technique in which each work group member independently and anonymously ranked a recommendation on a scale ranging from 1 ("extremely inappropriate") to 9 ("extremely appropriate"). Consensus was obtained when at least 80% of work group members ranked the recommendation as 7, 8 or 9. When the 80% threshold was not attained, up to three rounds of discussion and voting were held to resolve disagreements. If disagreements were not resolved after these rounds, no recommendation was adopted.

After the recommendations were established, work group members developed the guideline content, addressing the literature which supports the recommendations.

■ Step 8: Submission of the Draft Guidelines for Review/Comment

Guidelines were submitted to the full Evidence-Based Guideline Development Committee and the Research Council Director for review and comment. Revisions to recommendations were considered for incorporation only when substantiated by a preponderance of appropriate level evidence.

■ Step 9: Submission for Board Approval

Once any evidence-based revisions were incorporated, the drafts were prepared for NASS Board review and approval. Edits and revisions to recommendations and any other content were considered for incorporation only when substantiated by a preponderance of appropriate level evidence.

■ Step 10: Submission for Endorsement, Publication and National Guideline Clearinghouse (NGC) Inclusion

Following NASS Board approval, the guidelines have been slated for publication, submitted for endorsement to all appropriate societies and submitted for inclusion in the National Guidelines Clearinghouse (NGC). No revisions were made at this point in the process, but comments have been and will be saved for the next iteration.

■ Step 11: Identification and Development of Performance Measures

The recommendations will be reviewed by a group experienced in performance measure development (eg, the AMA Physician's Consortium for Performance Improvement) to identify those recommendations rigorous enough for measure development. All relevant medical specialties involved in the guideline development and at the Consortium will be invited to collaborate in the development of evidence-based performance measures related to spine care.

■ Step 12: Review and Revision Process

The guideline recommendations will be reviewed every three years by an EBM-trained multidisciplinary team and revised as appropriate based on a thorough review and assessment of relevant literature published since the development of this version of the guideline.

Use of Acronyms

Throughout the guideline, readers will see many acronyms with which they may not be familiar. A glossary of acronyms is available in *Appendix A*.

Nomenclature for Medical/Interventional Treatment

Throughout the guideline, readers will see that what has traditionally been referred to as "nonoperative," "nonsurgical" or "conservative" care is now referred to as "medical/interventional care." The term medical/interventional is meant to encompass pharmacological treatment, physical therapy, exercise therapy, manipulative therapy, modalities, various types of external stimulators and injections.

III. Definition and Natural History of Cervical Radiculopathy from Degenerative Disorders

What is the best working definition of cervical radiculopathy from degenerative disorders?

Cervical radiculopathy from degenerative disorders can be defined as pain in a radicular pattern in one or both upper extremities related to compression and/or irritation of one or more cervical nerve roots. Frequent signs and symptoms include varying degrees of sensory, motor and reflex changes as well as dysesthesias and paresthesias related to nerve root(s) without evidence of spinal cord dysfunction (myelopathy).

Work Group Consensus Statement

What is the natural history of cervical radiculopathy from degenerative disorders?

To address the natural history of cervical radiculopathy from degenerative disorders, the work group performed a comprehensive literature search and analysis. The group reviewed 31 articles that were selected from a search of MEDLINE (PubMed), Cochrane Register of Controlled Trials, Web of Science and EMBASE Drugs & Pharmacology. However, all identified studies failed to meet the guideline's inclusion criteria because they did not ade-quately present data about the natural history of cervical radiculopathy. The plurality of studies did not report results of untreated patients, thus limiting conclusions about natural history. This includes works that have been frequently cited as so-called natural history studies but are in fact reports of the results of one or more medical/interventional treatment measures.[5,12,18,22,28] In other investigations, data were reported for untreated and conservatively-treated patients together without an analysis specific to the untreated group. Other commonly cited studies did not report subgroup analyses of patients with cervical radiculopathy alone and thereby presented generalized natural history data regarding a heterogeneous cohort of patients with isolated neck pain, cervical radiculopathy or cervical myelopathy.

Because of the limitations of available literature, the work group was unable to definitively answer the question posed related to the natural history of cervical radiculopathy from degenerative disorders. In lieu of an evidence-based answer, the work group did reach consensus on the following statement addressing natural history.

It is likely that for most patients with cervical radiculopathy from degenerative disorders signs and symptoms will be self-limited and will resolve spontaneously over a variable length of time without specific treatment.

Work Group Consensus Statement

Future Directions for Research

The work group identified the following potential studies, which could generate meaningful evidence to assist in further defining the natural history of cervical radiculopathy from degenerative disorders.

Recommendation #1:
A prospective study of patients with cervical radiculopathy from degenerative disorders without treatment, notwithstanding nonprescription analgesics, would provide Level I evidence regarding the natural history of this disorder.

Recommendation #2:
A systematic study of patients with untreated cer-

vical radiculopathy from degenerative disorders would provide evidence regarding the natural history of the disease in this patient population.

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IV. Recommendations for Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders

A. Diagnosis and Imaging

What history and physical examination findings best support a diagnosis of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: It is suggested that the diagnosis of cervical radiculopathy be considered in patients with arm pain, neck pain, scapular or periscapular pain, and paresthesias, numbness and sensory changes, weakness, or abnormal deep tendon reflexes in the arm. These are the most common clinical findings seen in patients with cervical radiculopathy.

Grade of Recommendation: B

Henderson et al[30] presented findings of a retrospective observational study reporting results of PLF in the treatment of 736 patients with cervical radiculopathy. Patients included in the study reported the following symptoms: arm pain (99.4%), neck pain (79.7%), scapular pain (52.5%), anterior chest pain (17.8%) and headache (9.7%). Eleven patients presented with only left chest and arm pain ("cervical angina"). Pain or paresthesia in a dermatomal pattern was reported by 53.9% of patients, while 45.5% experienced pain or paresthesia in a diffuse or non-dermatomal pattern. No pain or paresthesia was reported by 0.6% of patients. Of patients included in the study, 85.2% reported a sensory change to pinprick, 68% had a specific motor deficit and 71.2% had a specific decrease in a DTR. One nerve root level was thought to be primarily responsible for symptoms in 87.3% of patients and two levels were felt to be equally involved for the remaining 12.7%. The correlation between pain/paresthesia, motor deficit, DTR change and the primary operative level was 73.8%, 84.8% and 83.5%, respectively. There was a 71.5% incidence of correlation between preoperative clinical findings and operative findings. Good or excellent results were reported by 91.5% of patients. Good or excellent relief of arm pain was found in 95.5% of patients, neck pain in 88.8%, scapular pain in 95.9%, chest pain in 95.4% and headache in 89.8%. Resolution of DTR abnormalities was reported in 96.9%. Residual sensory deficit was found in 20.9% of patients and motor deficit in 2.3%. In a large group of patients with cervical radiculopathy, this study elucidates the common clinical findings of pain, paresthesia, motor deficit and decreased DTRs, along with their respective frequencies. These data present evidence that the surgical site can be accurately predicted on the basis of clinical findings 71.5% of the time.

In critique, no validated outcome measures were used in the study. Thus, it provides Level II evidence that 71.5% of the time, the surgical site can be accurately predicted on the basis of clinical findings.

Jenis et al[31] described a retrospective case series reporting the results of surgical intervention in 11 cervical radiculopathy patients with neck pain from C4 radiculopathy. Pain was localized to the posterior aspect of the neck and lateralized to the side with C4 root involvement. Pain was also reported in trapezial areas and upper extremities depending on the presence of more caudal radiculopathies. Neck pain was exacerbated by flexion and extension in all patients. Decreased sensation in the C4 dermatome was present in all patients. MRI was obtained in all patients and CT scan in three patients prior to surgery. Excluding a single myelopathic patient, four patients were treated with anterior cervical discectomy and fusion (ACDF) and seven with posterior

foraminotomy (PLF). Evaluating fusion status, pain relief and level of activity based on Odom's criteria, good or excellent results were obtained in 10 of the 11 patients. The authors concluded that patients with neck pain should be evaluated for C4 radiculopathy, the examination should include C4 sensory testing, and neck pain from C4 radiculopathy can respond to surgical decompression unlike neck pain arising from degenerative disc disease.

In critique, no validated outcome measures were used and the sample size was small. This study provides Level IV evidence that neck pain with or without upper extremity clinical findings should prompt evaluation for a C4 radiculopathy and that this evaluation should include C4 sensory testing.

Post et al[38] reported a retrospective case series reviewing experience with the surgical management of a series of 10 patients with C7-T1 herniations. Symptoms included shoulder pain radiating into the lateral aspect of the hand, hand weakness and weakness in finger flexion, finger extension and intrinsic hand muscles. Sensation and DTRs were unremarkable. MRI on each patient revealed a soft disc compressing the C8 nerve root. Recovery of hand strength was noted in each patient; however, recovery was incomplete in two patients with symptoms greater than four months. In critique, no validated outcome measures were used and the sample size was small. This study provides Level IV evidence that C8 radiculopathy usually presents as weakness of the hand and pain radiating to shoulder, scapular area, and to the fourth and fifth fingers. Physical exam may reveal normal sensation and DTRs. Motor examination may show weakness of finger flexion and extension and weakness of the intrinsic muscles of the hand.

Tanaka et al[48] described a prospective observational study examining whether or not pain in the neck or scapular regions in 50 consecutive patients with cervical radiculopathy originated from a compressed nerve root, and whether the site of pain is useful for identifying the level involved. Patients underwent single level nerve root decompression using a posterior open foraminotomy. The surgical level was determined by correlation of symptoms and imaging, with selective nerve root block (SNRB) in five patients. Cervical disc herniation (CDH) was found in 20 patients and stenosis in 30. Neck or scapular pain preceeded the arm/finger symptoms in 35 patients (70%) and was relieved early in 46 (92%). When the pain was suprascapular, C5 or C6 radiculopathy was frequent; when interscapular, C7 or C8 radiculopathy was frequent; and when scapular, C8 was frequent. Arm and finger symptoms improved significantly in all groups after decompression. Sixty-one painful sites were noted before surgery: one in 39 patients and two in 11 patients. One month after surgery, 27 patients reported complete pain relief, 23 complained of pain in 24 subregions, seven of which were the same as before surgery. Seventeen pain sites were new since surgery. All but one new site were nuchal and suprascapular. At one year follow-up, 45 patients reported no pain, five patients had pain in six sites, three of which were the same as before surgery. The authors concluded that pain in the suprascapular, interscapular or scapular regions can orginate from a compressed cervical nerve root and is valuable for determing the nerve root involved.

This study provides Level I evidence that cervical radiculopathy at C5, C6, C7 and C8 frequently causes pain in suprascapular, interscapular and scapular areas and is useful in determining the level of nerve root involvement. Pain in the suprascapular region suggests C5 or C6 radiculopathy, pain in the interscapular region suggests C7 or C8 radiculopathy, and pain in the scapular region suggests C8 radiculopathy.

Yoss et al[55] conducted a retrospective observational study of 100 patients to correlate clinical findings with surgical findings when a single cervical nerve root (C5, C6, C7, C8) is compressed by a disc herniation. Symptoms included pain in the neck, shoulder,

scapular or interscapular regions, arm, forearm or hand; paresthesias in forearm, and hand; and weakness of upper extremity. Signs included diminution of triceps, biceps and brachioradialis reflexes, muscle weakness and sensory loss. Pain or paresthesia in the neck, shoulder, scapular or interscapular region were present in cases of C5, C6, C7 or C8 compression. The presence of pain in the arm corresponded to the site compression in 23% of cases. The presence of pain or paresthesia in the forearm corresponded to a single root or one of two roots in 32% and 66%, respectively. Hand pain and paresthesia corresponded to a single root or one of two roots in 70% and 27%, respectively. Subjective weakness corresponded to a single level in 22/34 (79%) cases.

When a diminution of DTR was present, the lesion could be correctly localized to a single level or one of two levels in 11% and 82%, respectively. Objective muscle weakness corresponded to a single root or one of two roots in 77% and 12%, respectively. In all cases in which the C5 and C8 nerve root was involved and objective weakness was present, the level was correctly localized. Sensory loss corresponded to a single root or one of two roots in 65% and 35%, respectively. The authors concluded that clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. A single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.

This study provides Level II evidence that clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. Single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.

RECOMMENDATION: It is suggested that the diagnosis of cervical radiculopathy be considered in patients with atypical findings such as deltoid weakness, scapular winging, weakness of the intrinsic muscles of the hand, chest or deep breast pain, and headaches. Atypical symptoms and signs are often present in patients with cervical radiculopathy, and can improve with treatment.

Grade of Recommendation: B

Henderson et al[30] presented findings of a retrospective observational study reporting results of PLF in the treatment of 736 patients with cervical radiculopathy. Patients included in the study reported the following symptoms: arm pain (99.4%), neck pain (79.7%), scapular pain (52.5%), anterior chest pain (17.8%) and headache (9.7%). Eleven patients presented with only left chest and arm pain ("cervical angina"). Pain or paresthesia in a dermatomal pattern was reported by 53.9% of patients, while 45.5% experienced pain or paresthesia in a diffuse or non-dermatomal pattern. No pain or paresthesia was reported by 0.6% of patients. Of patients included in the study, 85.2% reported a sensory change to pinprick, 68% had a specific motor deficit and 71.2% had a specific decrease in a DTR. One nerve root level was thought to be primarily responsible for symptoms in 87.3% of patients and two levels were felt to be equally involved for the remaining 12.7%. The correlation between pain/paresthesia, motor deficit, DTR change and the primary surgical level was 73.8%, 84.8% and 83.5%, respectively. There was a 71.5% incidence of correlation between presurgical clinical findings and surgical findings. Good or excellent results were reported by 91.5% of patients. Good or excellent relief of arm pain was found in 95.5% of patients, neck pain in 88.8%, scapular pain in 95.9%, chest pain in 95.4% and headache in 89.8%. Resolution of DTR abnormalities was reported in 96.9%. Residual sensory deficit was found in 20.9% of patients and motor deficit in 2.3%. In a large group of patients with cervical radiculopathy, this study elucidates the common clinical findings of pain, paresthesia, motor deficit, and decreased DTRs, along with their respective frequencies. These data present evidence that the operative site can be accurately predicted on the basis of clinical findings 71.5% of the time.

In critique, no validated outcome measures were used in the study. Thus, it provides Level II evidence that 71.5% of the time, the operative site can be accurately predicted on the basis of clinical findings.

Chang et al[13] described a retrospective case series identifying the characteristics of cervical radiculopathy causing deltoid paralysis, and reporting on the surgical outcomes of ACDF for the treatment of deltoid paralysis. All 14 patients had pain radiating to the scapula, shoulder or arm, with weakness of shoulder abduction due to paralysis of deltoid (graded 0-5). Severity of radicular pain was graded on a visual analog scale (VAS) from zero to 10. Plain radiographs and MRI were correlated with clinical findings. Surgery was performed on patients with single level CDH or cervical spondylotic radiculopathy (CSR). Patients with multilevel disease were excluded. The following lists the single levels implicated in deltoid paralysis and their respective frequencies: 1-C3-4 CDH (central), 4-C4-5 CDH, 1-C5-6 CDH, 3-C4-5 CSR, 5-C5-6 CSR. Both radiculopathy and deltoid paralysis improved significantly with surgery. The authors found that a painful cervical radiculopathy with deltoid paralysis arose from the C4-5, C5-6 and C3-4 levels in 50%, 43% and 7% of the cases, respectively. This small study provides Level IV evidence that a painful cervical radiculopathy with deltoid paralysis can arise from compressive disease at the C4-5, C5-6 or C3-4 levels.

Makin et al[34] reported a retrospective case series of six patients with scapular winging as a finding with C7 radiculopathy. Scapular winging from serratus anterior weakness was detected by pushing forward against a wall with the hands at shoulder level or with the hands at waist level. The latter method places the serratus anterior muscle at a mechanical disadvantage and reveals partial paralysis. Each case of C7 compression was confirmed by surgical findings or by CT myelography. The authors concluded that scapular winging may be a component of C7 radiculopathy and when present serves to exclude lesions of the brachial plexus or radial nerve. This small study provides Level IV evidence that scapular winging can be a feature of C7 radiculopathy.

Ozgur et al[35] described a retrospective case series of the presenting symptomatology of 241 consecutive patients following C6-7 discectomy . Of the patients, 83% had typical C7 radicular signs while 17% had atypical symptoms, 12% reporting isolated subscapular pain and 5% deep breast or chest pain. The authors reported that patients presenting with atypical symptoms had correlative pathology confirmed by surgical findings, 93% of whom experienced symptom relief. This study provides Level IV evidence that a substantial percentage of patients may present with atypical symptoms associated with C7 nerve root compression

Persson et al[37] conducted a prospective observational study to describe the frequency of headaches in patients with lower level cervical radiculopathy and its response to a selective nerve root block (SNRB). Of 275 patients, 161 suffered from daily or recurrent headaches, most often ipsilateral to the patients' radiculopathy. All patients underwent clinical exam and MRI. Patients with significantly compressed nerve roots underwent SNRB. All patients with headaches had tender points in the neck/shoulder region ipsilateral to the radiculopathy. Patients with headache had significantly more limitations in daily activities and higher pain in the neck/shoulder. Immediately before the injections, 161 (59%) of patients experienced a headache exceeding 15 on the VAS. Of these 161 patients, 101 (63%) experienced >25% headache reduction following SNRB, 93 (58%) reported greater than 50% headache reduction, and 66 experienced 100% relief (C4 3%, C5 11%, C6 52%, C7 29%, C8 5%). A significant correlation was found between reduced headache and decreased pain in the neck and shoulder region. The authors concluded that cervical nerve root compression from degenerative disease in the lower cervical spine producing radiculopathy can also result in headache. Thus, headache assessment together with muscle palpation should be part of the clinical exam for patients with cervical radiculopathy.

In critique, the study had a low (50%) threshold and lack of specificity for the injection. Because of these limitations, this potential Level II study provides Level III evidence that complaint of a headache can be a symptom with C4-C8 nerve root compression. SNRB can reduce headache in a substantial percentage of patients and may be a useful diagnostic tool.

Post et al[38] reported a retrospective case series reviewing experience with the surgical management of a series of 10 patients with C7-T1 herniations. Symptoms included shoulder pain radiating into the lateral aspect of the hand, hand weakness and weakness in finger flexion, finger extension and intrinsic hand muscles. Sensation and DTRs were unremarkable. MRI on each patient revealed a soft disc compressing the C8 nerve. Recovery of hand strength was noted in each patient; however, recovery was incomplete in two patients with symptoms greater than four months. In critique, no validated outcome measures were used and the sample size was small. This study provides Level IV evidence that C8 radiculopathy can present with weakness of the hand, and pain radiating to the shoulder, scapular area, and fourth and fifth fingers.

RECOMMENDATION: Provocative tests including the shoulder abduction and Spurling's tests may be considered in evaluating patients with clinical signs and symptoms consistent with the diagnosis of cervical radiculopathy.

Grade of Recommendation: C

Davidson et al[16] described observations from a retrospective case series of 22 patients with cervical monoradiculopathy caused by compressive disease in whom clinical signs included relief of pain with abduction of the shoulder. Twenty-two patients with arm pain had cervical extradural myelographic defects. Of the 22 patients, 15 experienced relief from their pain with shoulder abduction. Motor weakness was present in 15, paresthesias in 11 and reflex changes in nine patients. Of the 15 patients with a positive shoulder abduction sign, 13 required surgery and all achieved good results. Two of the 15 had pain relief with conservative therapy. Of the seven patients with negative shoulder abduction signs, five required surgery and two were successfully treated with traction. Of the five surgical patients, three had surgery for a central lesion and improved after surgery, two had surgery for a lateral disc fragment and only one had good results. The authors concluded that the shoulder abduction test is a reliable indicator of significant cervical extradural compressive radicular disease.

In critique, no validated outcome measures were used and the sample size was small. This study provides Level III evidence that relief from arm pain with shoulder abduction is an indicator of cervical extradural compressive radiculopathy.

Shah et al[45] conducted a prospective observational study to determine the sensitivity and specificity of the Spurling's test in predicting the diagnosis of a soft lateral CDH in 50 patients with neck and arm pain. Spurling's test with cervical extension, lateral flexion to the side of pain, and downward pressure on the head was performed on all patients. Twenty-five patients underwent surgery (Group 1) and 25 were managed conservatively (Group 2). Spurling's test was correlated with surgical findings in Group 1 and with MRI findings in Group 2. Patients with their first episode of radicular pain and minimal or no neurologic deficits, and those who refused surgery were managed conservatively. In Group 1, of the 18 patients with a positive Spurling's test, all had surgically confirmed soft disc herniations. Of seven patients with a negative Spurling's test, two had a soft disc herniation and five had a hard disc. In Group 2, of the 10 patients with a positive Spurling's test, nine had a soft disc herniation, one had a hard disc. Of the 15 patients with a negative Spurling's test, a hard disc was seen in eight, and MRI was normal in seven. The Spurling's test had a sensitivity of 92%, a specificity of 95%, a positive predictive value (PPV) of 96.4% and a negative predictive power (NPP) of 90.9% for a soft disc herniation. The authors concluded that

the high PPV of the test can be used to improve the yield of postivie MRI examinations in patients with cervical radiculopathy . This study provides Level II evidence that a positive Spurling's test improves the clinician's ability to diagnose compressive disease in patients with cervical radiculopathy.

Tong et al[49] performed a prospective comparative study to determine the sensitivity and specificity of the Spurling test for 255 patients referred for electrodiagnosis of upper extremity nerve disorders. The Spurling test was performed on all patients before electromyography (EMG). The test was scored as positive if it resulted in pain or tingling starting in the shoulder and radiating distally to the elbow. A differential diagnosis based on the history and physical exam was made prior to EMG. EMG was performed and each diagnosis in the differential was scored relative to the likelihood of its occurrence. Of the 255 patients presented, 31 had missing data, leaving 224 patients for inclusion. Of 20 patients with a positive EMG for cervical radiculopathy, the Spurling's test was positive in seven, for a sensitivity of 7/20 or 30%. Of 172 patients with no EMG evidence for radiculopathy, the Spurling's test was negative in 160, for a specificity of 160/172 or 93%. The Spurling's test was positive in 16.6% of patients with a normal EMG, in 3.4% of patients with an EMG diagnosis of a nerve problem other than radiculopathy, and in 15% of patients with nonspecific EMG findings. The odds ratio of a positive Spurling's test in a patient with a positive EMG for cervical radiculopathy is 5.71. The authors concluded that the Spurling's test is not sensitive but is specific for cervical radiculopathy as diagnosed by EMG. Although not useful as a screening test, it may be useful to confirm the diagnosis.

In critique, the study uses a poor reference standard (EMG). This study provides Level IV evidence that the Spurling's test is not sensitive but is specific for cervical radiculopathy as diagnosed by EMG. Thus, a positive Spurling's test is clinically useful in helping confirm the presence of cervical radiculopathy.

Wainner et al[51] described a prospective comparative study assessing the reliability and accuracy of individual clinical exam items and self reported instruments for the diagnosis of cervical radiculopathy in 82 patients with a goal of identifying and assessing the accuracy of an optimal cluster of test items. Consecutive patients were referred for EMG for the evaluation of cervical radiculopathy or carpal tunnel syndrome. Only patients judged by one of seven laboratory providers to have signs and symptoms compatible with CR or CTS were eligible to participate. Patients with Class 5 or 6 cervical radiculopathy findings were further classified according to the severity of their EMG findings. Self-reported items included the VAS and NDI. A standardized clinical exam was performed by two of nine physical therapists and contained 34 items. History contained six questions asked by two physical therapists. Neurological exam included strength, DTRs and sensation. Provocative tests included Spurling's test, shoulder abduction test, Valsalva maneuver, neck distraction test and the upper limb tension test (ULTT). Cervical range of motion was also measured. Fifteen patients had an EMG diagnosis of cervical radiculopathy, and five patients were diagnosed with cervical radiculopathy and carpal tunnel sydrome, one with concomitant ulnar neuropathy. One patient with combined findings dropped out of the study. Of the 19 patients reported, 13 had mild symptoms and six had moderate symptoms. Reliability of different clinical items was reported including the Spurling's A/B 0.6/0.62, shoulder abduction 0.2, valsalva 0.69, distraction 0.88, ULTT A/B 0.76/0.83. Sensitivity/specificity: Spurling's A/B 0.6/0.62, shoulder abduction 0.2, valsalva 0.69, distraction 0.88, ULTT A/B 0.76/0.83. Sensitivity/Specificity of different clinical items was reported including the Spurling's A/B - 0.5/0.86 - 0.74; shoulder abduction - 0.17/0.92; valsalva - .22/.94; distraction - 0.44/0.9; ULTT A/B - 0.72-0.97/0.22-0.33; Cluster of ULTT A, cervical rotation <60degrees, distraction, and Spurling's A - 0.24/0.99. The authors concluded that many items were found to have at least a fair level of reliability

and to have acceptable diagnostic properties. The test item cluster identified was found to be the most useful.

In critique, the small study utilized EMG as a gold standard with an apparent test selection bias. Because of these limitations, this potential Level III study provides Level IV evidence that provocative tests, including the Spurling's test, shoulder abduction test, Valsalva and distraction test had a low sensitivity but high specificity for cervical radiculopathy as diagnosed by EMG.

Bertilson et al[11] reported a prospective case series analyzing the reliability of clinical tests, including provocative maneuvers, in the assessment of neck and arm pain in 100 primary care patients. Reliability of clinical tests was poor to fair in several test categories. Only a bimanual sensitivity test reached good values. However, when the examiner knows the clinical history, the prevalence of positive findings increased in 80% of test categories. Bias was apparent in all test categories except for sensitivity. The authors concluded that sensitivity testing was the most reliable and was exempt from bias. Knowledge of the patient's history had no impact on reliability, however it increased the incidence of positive findings.

In critique, patients were not enrolled at the same point in their disease and there were only two reviewers. Because of these limitations, this potential Level I study provides Level II evidence that history and physical findings are not definitive, that the incidence of positive findings can increase with known history, and that several categories may be susceptable to bias with a suggestive clinical history.

RECOMMENDATION: Because dermatomal arm pain alone is not specific in identifying the pathologic level in patients with cervical radiculopathy, further evaluation including CT, CT myelography, or MRI is suggested prior to surgical decompression.

Grade of Recommendation: B

Henderson et al[30] presented findings of a retrospective observational study reporting results of PLF in the treatment of 736 patients with cervical radiculopathy. Patients included in the study reported the following symptoms: arm pain (99.4%), neck pain (79.7%), scapular pain (52.5%), anterior chest pain (17.8%) and headache (9.7%). Eleven patients presented with only left chest and arm pain ("cervical angina"). Pain or paresthesia in a dermatomal pattern was reported by 53.9% of patients, while 45.5% experienced pain or paresthesia in a diffuse or non-dermatomal pattern. No pain or paresthesia was reported by 0.6% of patients. Of patients included in the study, 85.2% reported a sensory change to pinprick, 68% had a specific motor deficit and 71.2% had a specific decrease in a DTR. One nerve root level was thought to be primarily responsible for symptoms in 87.3% of patients and two levels were felt to be equally involved for the remaining 12.7%. The correlation between pain/paresthesia, motor deficit, DTR change and the primary operative level was 73.8%, 84.8% and 83.5%, respectively. There was a 71.5% incidence of correlation between preoperative clinical findings and operative findings. Good or excellent results were reported by 91.5% of patients. Good or excellent relief of arm pain was found in 95.5% of patients, neck pain in 88.8%, scapular pain in 95.9%, chest pain in 95.4% and headache in 89.8%. Resolution of DTR abnormalities was reported in 96.9%. Residual sensory deficit was found in 20.9% of patients and motor deficit in 2.3%. In a large group of patients with cervical radiculopathy, this study elucidates the common clinical findings of pain, paresthesia, motor deficit, and decreased DTRs, along with their respective frequencies. These data present evidence that the surgical site can be accurately predicted on the basis of clinical findings 71.5% of the time.

In critique, no validated outcome measures were used in the study. Thus, it provides Level II evidence that 71.5% of the time, the operative site can be accurately predicted on the basis of clinical findings.

Slipman et al[46] described a prospective observational study evaluating the distribution of pain and paresthesias that result from the stimulation of specific cervical nerve roots in 87 patients with 134 selective nerve root stimulations. Mechanical stimulation of nerve roots was carried out: four at C4, 14 at C5; 43 at C6; 52 at C7; and 21 at C8. An independent observer recorded the location of provoked symptoms on a pain diagram. Visual data was compiled using a 793 body sector bit map with 43 body regions identified. Although the distribution of symptom provocation resembled the classic dermatomal maps, symptoms were frequently provoked outside the classic descriptions. The authors concluded that there was a distinct difference between the dynatomal and dermatomal maps. This study provides Level I evidence that distribution of pain and paresthesias in the arm from nerve root stimulation can be different from traditional dermatomal maps in a substantial percentage of patients making it difficult to identify the level based on pain distribution.

Yoss et al[55] conducted a retrospective observational study of 100 patients to correlate clinical findings with surgical findings when a single cervical nerve root (C5, C6, C7, C8) is compressed by a disc herniation. Symptoms included pain in the neck, shoulder, scapular or interscapular region, arm, forearm or hand; paresthesias in forearm, and hand; and weakness of upper extremity. Signs included diminution of triceps, biceps and brachioradialis reflexes, muscle weakness and sensory loss. Pain or paresthesia in the neck, shoulder, scapular or interscapular region were present in cases of C5, C6, C7, or C8 compression. The presence of pain in the arm corresponded to the site compression in 23% of cases. The presence of pain or paresthesia in the forearm corresponded to a single root or one of two roots in 32% and 66%, respectively. Hand pain and paresthesia corresponded to a single root or one of two roots in 70% and 27%, respectively. Subjective weakness corresponded to a single level in 22/34 (79%) cases.

When a diminution of DTR was present, the lesion could be correctly localized to a single level or one of two levels in 11% and 82%, respectively. Objective muscle weakness corresponded to a single root or one of two roots in 77% and 12%, respectively. In all cases in which C5 or C8 radiculopathy was accompanied by weakness, the level was correctly localized. Sensory loss corresponded to a single root or one of two roots in 65% and 35%, respectively. The authors concluded that clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. A single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.

This study provides Level II evidence that clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. Single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.

Future Directions for Research

Further studies are needed to demonstrate the PPV of specific symptoms and physical exam findings in patients with confirmed cervical radiculopathy to demonstrate their usefulness in predicting a good outcome with conservative or surgical treatment.

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What are the most appropriate diagnostic tests (including imaging and electrodiagnostics), and when are these tests indicated in the evaluation and treatment of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: MRI is suggested for the confirmation of correlative compressive lesions (disc herniation and spondylosis) in cervical spine patients who have failed a course of conservative therapy and who may be candidates for interventional or surgical treatment.

Grade of Recommendation: B

Bartlett et al[9] conducted a prospective study comparing the accuracy of gadolinium (Gd) enhanced MRI with 3D gradient recalled echo (3D GRE) images in the evaluation of cervical radiculopathy in 30 consecutive patients. The 3D GRE images had an accuracy of 87% for the diagnosis of foraminal encroachment. CTM had an accuracy of 90%. MRI with Gd conferred no additional benefit. Oblique reconstructions were less accurate than axial images. The authors concluded that MRI with 3D GRE images is an acceptable technique for the primary evaluation of cervical radiculopathy. CTM remains indicated for patients with symptoms that are incongruent with MRI findings. This study provides Level II diagnostic evidence that MRI with 3D T2 technique has an accuracy approaching that of CT myelography for the diagnosis of a compressive lesion in patients with cervical radiculopathy.

Hedberg et al[22] described a retrospective comparative study assessing the accuracy of MRI with limited flip angle (LFA) GRE technique in patients with

cervical radiculopathy. MRI was performed in 130 patients, myelography in 30, CTM in 16 and CT in five. Pathologic confirmation was obtained in 13 surgically treated patients. MRI was normal in 31 cases and neither myelography nor surgery were performed. Extradural defects were detected on MRI in 99/130 patients (52 central, 26 dorsolateral osteophyte, 4 dorsolateral disc, 17 dorsolateral disc/osteophyte). Myelography/CTM and nonenhanced CT confirmed the abnormalities in 20 and five patients, respectively. Surgical findings from 13 patients and 30 sites showed correlation with MRI on 3/3 herniations and 26/27 degenerative abnormalities. The authors concluded that MRI is sufficient for the evaluation of cervical radiculopathy and may obviate the need for more invasive tests such as myelography or CTM.

In critique, since surgical confirmation of cervical radiculopathy was obtained for only 13 patients, the relevant sample size was small. Also, the study utilized an older technique. This study provides Level III diagnostic evidence that MRI is accurate in the diagnosis of disc herniation and degenerative abnormalities in the spine.

Modic et al[34] conducted a prospective study comparing the accuracy of MRI, CTM and myelography in the evaluation of cervical radiculopathy. Of the 63 patients enrolled in the study, 52 underwent MRI, myelography and CTM, and 28 underwent surgery. Findings confirmed in surgery identified diagnostic accuracy rates of 74% for MRI, 85% for CTM, and 67% for myelography. Diagnostic agreement with surgical findings was obtained in 90% of patients when MR and CTM were used jointly, 92% when CTM and myelography were used jointly. The authors concluded that MRI is a viable alternative to myelography, and together with CT if needed, provides a thorough exam of the c-spine. MRI is as sensitive, but less specific, for type of disease. CTM is better at distinguishing bone from disc. In critique, patients were not consecutively assigned in this small study. This study provides Level III diagnostic evidence that MRI is a viable alternative to myelography, and together with CT if needed, provides a thorough exam for cervical nerve root compression.

Van de Kelft et al[54] performed a prospective comparative study describing the value of MRI on a 0.5 T system plus plain radiography in the evaluation of patients with cervical radiculopathy. One hundred patients with cervical radiculopathy and failed conservative therapy were scheduled for surgery. Of these patients, 18 with myelopathy, history of surgery and history of trauma were referred for CTM instead of MRI; 23 with spondylosis, major spurs, or instability on plain radiography were also referred for CTM. This excluded 41 from the potential study. In the 59 patients that underwent MRI, CDH was found in 55, the location corresponding to the patients' symptoms. Four patients without CDH were referred for CTM; a foraminal herniation was found in one. Of the 55 patients with CDH, 50 underwent surgery. In two patients, foraminal spurs were found, not seen on MRI. MRI correlated with surgery at a rate of 94%. The authors concluded that MRI combined with plain radiography is an accurate noninvasive technique in the evaluation of patients with cervical radiculopathy.

In critique, the patients included in this study were not consecutively assigned. This study provides Level III diagnostic evidence that early MRI techniques are reasonably accurate in diagnosing CDH in patients with radiculopathy. This emphasizes that noninvasive MRI with plain radiography can diagnose specific CDH, stenosis and nerve root compression with a high degree of useful accuracy.

Wilson et al[61] described a retrospective comparative study evaluating the accuracy of MRI in the detection of compressive lesions in patients with cervical radiculopathy. Surgical diagnoses were disc herniation in 32, spondylosis in two, and a combination of the two in six patients. MRI identified the surgical lesion in 37/40 patients (92%). Two independent 'reading radiologists' knew surgery was performed,

but were blinded to the diagnosis and the level. MRI diagnosed an HNP at the correct location in 32/38 patients and spondylosis in two. In the six cases, in which HNP was missed, the MRI was interpreted as spondylosis. In three patients MRI did not diagnose the surgical lesion. CTM was performed in 13 patients, and in five of these patients CTM was felt to add additional information. There was complete recovery in 31/40 patients, and incomplete recovery in 8/40. One patient was lost to follow-up. The authors concluded that MRI is the only preoperative test necessary in most cases of cervical radiculopathy. The authors added that CTM might be useful in patients with a negative MRI, positive EMG and neurologic deficits. In critique, the patients included in this study were not consecutively assigned and there was a significant dropout rate. Due to these limitations, this potential Level II study provides Level III diagnostic evidence that MRI is an accurate tool in the initial preoperative evaluation of patients with cervical radiculopathy.

RECOMMENDATION: In the absence of reliable evidence, it is the work group's opinion that CT may be considered as the initial study to confirm a correlative compressive lesion (disc herniation or spondylosis) in cervical spine patients who have failed a course of conservative therapy, who may be candidates for interventional or surgical treatment and who have a contraindication to MRI.

Work Group Consensus Statement

An article by Ilkko et al[26] examined the accuracy of CT, myelography and MR imaging in 120 patients. Gold standard was surgery in 37 patients. The sensitivities of CT, myelography, and MRI were 66%, 84%, and 86% however MRI was only available in 8 patients. The accuracy of CT was degraded by beam hardening artifact from the shoulders in the lower cervical spine. The authors concluded that CT was a usable alternative to MRI in selected patients. This article was excluded from the formal analysis, however, because it included patients with both radiculopathy and myelopathy without sufficient subgroup analysis.

RECOMMENDATION: CT myelography is suggested for the evaluation of patients with clinical symptoms or signs that are discordant with MRI findings (eg, foraminal compression that may not be identified on MRI). CT myelography is also suggested in patients who have a contraindication to MRI.

Grade of Recommendation: B

Bartlett et al[9] conducted a prospective study comparing the accuracy of Gd-enhanced MRI with 3D GRE images in the evaluation of cervical radiculopathy in 30 consecutive patients. 3D GRE images had an accuracy of 87% for the diagnosis of foraminal encroachment. CTM had an accuracy of 90%. MRI with Gd conferred no additional benefit. Oblique reconstructions were less accurate than axial images. The authors concluded that MRI with 3D GRE images is an acceptable technique for the primary evaluation of cervical radiculopathy. CTM remains indicated for patients with incongruent symptoms and MRI results. This study provides Level II diagnostic evidence that MRI with 3D T2 technique has an accuracy approaching that of CT myelography for the diagnosis of a compressive lesion in patients with cervical radiculopathy.

Houser et al[24] reported a retrospective case series correlating the findings on CTM with surgical and path proven cervical herniations. Over three years, 734 patients underwent CTM for cervical disc disease. At surgery, CDH was noted in 297 patients. Of the 297 patients, 280 had a diagnosis of radiculopathy and 17 of myelopathy. Surgical reports noted one or more prolapsed discs in 258, a prolapsed disc and spur in 38 and a prolapsed disc with a fracture in one. CTM corresponded to surgical findings in 260 of the 280 patients with radiculopathy and in all 17 patients with myelopathy. Surgery was performed in 22 patients on the basis of clinical symptoms alone.

Of these 22 patients, 19 had herniations not seen on CTM and three had no herniations based upon surgical findings and CTM. A soft tissue extradural deformity appeared to be present on CTM in seven patients who had no cervical abnormalities on surgical exploration. The authors concluded that imaging of CDHs continues to be difficult and the results are not always specific. CTM is the most sensitive imaging examination. In critique, patients were not consecutively assigned. This study provides Level III diagnostic evidence that CT myelography can identify 90% of cervical extruded disc herniations confirmed by surgery.

Houser et al[25] presented a retrospective case series reviewing the surgical and CTM findings in 95 patients with foraminal stenosis. CTM showed stenosis at the entrance in 70 (52%), within the canal itself in 37 (28%) and site not definitively identified in 27 (20%). At the entrance to the foramen, stenosis secondary to a cartilaginous cap was identified in 10 patients (8%), osteophyte in 17 (13%), synovial cyst in one and a combination of bone and cartilaginous cap in 42 (31%). Within the canal, small bone spurs arising from the uncovertebral process contributed to stenosis in 29 instances and from the facet joint in eight. Diagnosis on the basis of CTM was difficult because stenosis was evident as a bone spur in only 13% of cases, could not be distinguished from a disc herniation in 39%, had to be distinguished from a congenitally narrowed foramen in 27% and was missed in 20%. The authors concluded that the diagnosis of foraminal stenosis on CTM is difficult. In critique, patients included in this study were not consecutively assigned. This study provides Level III diagnostic evidence that there is limited correlation between CT myelography and foraminal stenosis as confirmed by surgical exploration.

Modic et al[34] conducted a prospective study comparing the accuracy of MRI, CTM and myelography in the evaluation of cervical radiculopathy. Of the 63 patients enrolled in the study, 52 underwent MRI, myelography and CTM, and 28 underwent surgery. Findings confirmed in surgery identified diagnostic accuracy rates of 74% for MRI, 85% for CTM and 67% for myelography. Diagnostic agreement with surgical findings was obtained in 90% of patients when MR and CTM were used jointly, 92% when CTM and myelography were used jointly. The authors concluded that MRI is a viable alternative to myelography, and together with CT if needed, provides a thorough exam of the c-spine. MRI is as sensitive, but less specific, for type of disease. CTM is better at distinguishing bone from disc. In critique, patients were not consecutively assigned in this small study. This study provides Level III diagnostic evidence that MRI is a viable alternative to myelography, and together with CT if needed, provides a thorough exam of the cervical spine.

Russell et al[45] reported on a retrospective comparative study assessing the value of CT with IV contrast in the evaluation of patients with cervical radiculopathy. Ventral epidural and intervertebral veins were consistently well visualized with CT enhanced with IV contrast. Disc protrusions were diagnosed in nine of 30 patients. A clear and definitive marginal ring blush between the disc protrusion and the enhanced venous system was seen in eight of these patients. Surgical confirmation was obtained in only five of these eight patients since only five of the eight came to surgery. Visualization of posterior displacement of the enhance epidural veins and epidural enhancement surrounding extruded disc fragments provided excellent delineation of disc extrusion and in some cases allowed demarcation of multiple discrete disc fragments. The authors concluded that although routine CT is usually diagnostic, the addition of IV contrast improves anatomic information and diagnostic certainty and may obviate the need for myelography in some patients.

In critique, patients included in this small study were not consecutively assigned. Of the nine cases that reported abnormal findings, only five went on to surgery and obtained surgical confirmation. This study provides Level III diagnostic evidence that the

technique of high dose contrast infusion with CT provides useful venous enhancement with improved visualization of the disc/epidural vein interface and improved visualization of disc herniations. Myelography for cervical discs may be unnecessary unless further spinal column delineation is required.

Van de Kelft et al[54] performed a prospective comparative study describing the value of MRI on a 0.5 T system plus plain radiography in the evaluation of patients with cervical radiculopathy. The study included 100 patients with cervical radiculopathy and failed conservative therapy scheduled for surgery. All patients underwent plain radiography. Patients with myelopathy, history of previous surgery and history of trauma (18), and patients with spondylosis, major spurs or instability on plain radiography (23) were referred for CTM. The remaining 59 patients underwent MRI. On MRI, a soft disc herniation (CDH) was found in 55 patients, the location corresponding to the patients' symptoms. The four patients without CDH were referred for CTM, and a foraminal herniation was found in one. Of the 55 patients with CDH, 50 underwent surgery. Findings on MRI correlated with surgical findings in 94%. In two patients, foraminal spurs were found, not seen on MRI. The authors concluded that MRI combined with plain radiography is an accurate noninvasive technique in the evaluation of patients with cervical radiculopathy.

In critique, the patients included in this study were not consecutively assigned. This study provides Level III diagnostic evidence that early MRI techniques are reasonably accurate in diagnosing CDH in patients with radiculopathy. This emphasizes that noninvasive MRI with plain radiography can diagnose CDHs and nerve root compression with a high degree of useful accuracy.

Wilson et al[61] described a retrospective comparative study evaluating the accuracy of MRI in the detection of compressive lesions in patients with cervical radiculopathy. Surgical diagnoses were disc herniation in 32, spondylosis in two and a combination of the two in six patients. MRI identified the surgical lesion in 37/40 patients (92%). Two independent 'reading radiologists' knew surgery was performed, but were blinded to the diagnosis and the level. MRI diagnosed an HNP at the correct location in 32/38 patients and spondylosis in two. In the six cases in which HNP was missed, the MRI was interpreted as spondylosis. In three patients MRI did not diagnose the surgical lesion. CTM was performed in 13 patients, and in five of these patients, CTM was felt to add additional information. There was complete recovery in 31/40 patients and incomplete recovery in 8/40. One patient was lost to follow-up. The authors concluded that MRI is the only preoperative test necessary in most cases of cervical radiculopathy. The author added that CTM may be useful in patients with a negative MRI, positive EMG and neurologic deficits. In critique, the patients included in this study were not consecutively assigned and there was a significant dropout rate. Due to these limitations, this potential Level II study provides Level III diagnostic evidence that MRI is an accurate tool in the initial preoperative evaluation of patients with cervical radiculopathy.

RECOMMENDATION: The evidence is insufficient to make a recommendation for or against the use of EMG for patients in whom the diagnosis of cervical radiculopathy is unclear after clinical exam and MRI.

Grade of Recommendation: I (Insufficient Evidence)

Alrawi et al[2] reported a prospective case series investigating whether preoperative EMG can help identify those most likely to benefit from intervention. The study included 20 patients with clinical manifestations of cervical radiculopathy and an MRI showing disc bulges associated with narrowing of the exiting foramina. Preoperatively, patients were divided into two groups on the basis of EMG findings. Group A consisted of eight patients with denervation changes

in the distribution of a least one cervical nerve root. Group B had 12 patients with no EMG evidence of cervical radiculopathy. Patients in Group A had better clinical outcomes and patient satisfaction from their ACDF at least 12 months postoperatively than patients in Group B. The authors concluded that preoperative neurophysiologic studies (NPS) can help identify which patients are more likely to benefit from surgery for cervical radiculopathy.

In critique, patients were not consecutively assigned to the study. This study provides Level III diagnostic evidence that patients with cervical radiculopathy and an MRI showing a disc bulge with narrowing of the exiting foramina have better clinical outcomes and patient satisfaction from ACDF if a preoperative EMG shows denervation changes.

Ashkan et al[6] reported on a retrospective case series assessing whether NPS added significant information to high resolution MRI in the evaluation of cervical radiculopathy. Of the 45 patients included in the study, three experienced bilateral symptoms. Radicular arm pain was present in all cases, parasthesias in 28, numbness in 22 and subjective weakness in 14. Following surgery, 36 patients had complete resolution of symptoms and seven experienced significant improvement in symptoms. Of patients who improved following surgery, 16 (37%) had a positive MRI and NPS; 24 (56%) had a positive MRI and negative NPS; two (5%) had a negative MRI and positive NPS; and one (2%) had negative MRI and NPS studies. In the three cases with a negative MRI, surgical plans were based on the NPS in one case and on CTM in two. In five patients with foraminal stenosis on MRI the patients did not improve. Of these five patients, four were operated on at the level indicated by MRI. Sensitivity for diagnosing cervical radiculopathy was 93% for MRI and 42% for NPS; with PPVs at 91% for MRI and 86% for NPS. NPPs were 25% for MRI and 7% for NPS. The authors concluded that in patients with clinical and MRI evidence of cervical radiculopathy, NPS has limited additional diagnostic value. In critique, the patients included in the study were not consecutive. This study provides Level III diagnostic evidence that MRI is more accurate and more sensitive than NPS in the preoperative evaluation of patients with cervical radiculopathy.

RECOMMENDATION: Selective nerve root block with specific dosing and technique protocols may be considered in the evaluation of patients with cervical radiculopathy and compressive lesions identified at multiple levels on MRI or CT myelography to discern the symptomatic level(s). Selective nerve root block may also be considered to confirm a symptomatic level in patients with discordant clinical symptoms and MRI or CT myelography findings.

Grade of Recommendation: C

Anderberg et al[4] described a prospective case series assessing the use of transforaminal SNRB in patients with cervical radiculopathy and MRI findings at two levels ipsilateral to the patient's symptoms. The study included 30 consecutive patients with cervicobrachialgia, 22 with neurologic deficits. Degenerative changes on MRI were found in close relation to nerve roots. Neuroforaminal narrowing was graded as slight, moderate or severe, without further analysis. Clinical findings were correlated with MRI findings and root block levels were determined. No analgesics were administered within 12 hours prior to the procedure, and there was no mention if sedation was given prior to the procedure. Contrast was administered to confirm perineural needle position within the foramen prior to SNRB. SNRB with 0.5 ml solution of 5 mg of Mepivacaine was administered. VAS outcomes were assessed 30 minutes and four hours after SNRB. VAS reduction of at least 50% was required to determine that the SNRB was positive; however, the authors did not indicate if this measure referred to the VAS score at 30 minutes or four hours after the SNRB, or both. In 18 patients with positive SNRB at a single level, the SNRB correlated with the

level of more marked pathology in 12, to the level determined by the neurologic deficits in eight and to the level corresponding to the sensory dermatome in seven. Eleven patients had a positive SNRB at two levels. Of 13 patients treated at one level, nine (67%) had good or excellent results. Of nine patients treated at two levels, 100% had good or excellent results. The authors concluded that clinical symptoms and signs in isolation or in combination with MRI findings are not always reliable indicators of the pain-generating nerve root. SNRB may be useful in treatment planning in patients with radiculopathy and degenerative changes at two levels ipsilateral to the patient's symptoms.

In critique, this small study did not utilize a consistently applied gold standard and surgical treatment or epidural steroid injection was performed in only 22 or the 30 patients. This study provides Level III diagnostic evidence that SNRB may be useful in the preoperative evaluation of patients with radiculopathy and findings of compressive lesion at multiple levels on MRI.

Anderberg et al[5] reviewed a prospective case series of nine patients studying the selectivity of cervical transforaminal injections and the distributions of a range of injection volumes in patients with cervical radiculopathy. Three groups of three patients received one of the following: 0.6, 1.1 or 1.7 ml of injectate via the transforaminal root technique used by Kikuchi. The groups injected with 0.6 and 1.1 ml received local anesthetic and contrast. The group injected with 1.7 ml received local anesthetic, corticosteroid and contrast. Contrast distribution was determined by a post injection CT scan. An injection was considered a successful SNRB if the contrast media surrounded an adjacent nerve root by less than half of its circumference. In all three patients receiving 0.6 ml of injectate the injections were considered selective. In 2 of 3 of patients given 1.1 ml of injectate, the injections were considered selective. None of the three patients receiving 1.7 ml of injectate were considered selective. The perineural distribution length averaged 36 mm, with no correlation to injectate volume. The authors concluded that only 0.6 ml injections should be used for SNRBs. This small case series provides Level II diagnostic evidence that transforaminal injectate volumes of 0.6 ml consistently meet the criteria for a SNRB.

Future Directions for Research

The work group identified the following recommendations that would assist in generating meaningful evidence to assist in further defining the appropriate diagnostic tests for cervical radiculopathy from degenerative disorders. Studies should assess a set of diagnostic criteria established a priori.

Recommendation #1:
Studies evaluating the accuracy of MRI, CT and CT myelography in detecting and characterizing compressive lesions in the cervical spine in patients with cervical radiculopathy should be repeated using state of the art equipment and imaging techniques and should implement surgical findings and outcomes as gold standards.

Recommendation #2:
Further studies should be done to evaluate the contribution of EMG to the evaluation of cervical radiculopathy patients with discordant MRI findings and clinical findings using surgical findings and outcomes as gold standards.

Recommendation #3:
Further studies should be done evaluating the contribution of SNRB to the evaluation of cervical radiculopathy patients with discordant MRI findings and clinical findings, and to the evaluation of cervical radiculopathy patients with findings on MRI at multiple levels ipsilateral to the patient's symptoms using surgical findings and outcomes as gold standards.

Recommendation #4:
Studies should be done evaluating the contribution of dynamic upright cervical spine MRI to the evaluation of and long term outcome of patients undergoing surgical decompression for cervical radiculopa-

thy with attention to the following question: Does the presence of dynamic central canal stenosis at an adjacent level affect the long term outcome of patients undergoing surgical decompression using an anterior approach with fusion versus a motion preserving posterior approach?

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B. Outcome Measures for Medical/Interventional and Surgical Treatment

What are the most appropriate outcome measures to evaluate the treatment of cervical radiculopathy from degenerative disorders?

Asking this question about the treatment of cervical radiculopathy from degenerative disorders is intrinsically valuable. Our review of the literature on cervical radiculopathy from degenerative disorders confirmed that outcome studies are valuable in determining the course of treatment.

When evaluating studies in terms of the use of outcome measures, the work group evaluated this literature as prognostic in nature. Prognostic studies investigate the effect of a patient characteristic on the outcome of a disease. Studies investigating outcome measures, by their design, are prognostic studies.

An appropriate clinical outcome measure must be validated. Further, the validated outcome measure must be used in a high quality, prospective outcome trial in order to be useful. The literature review yielded no validated outcome measures utilized for the subset of patients with cervical radiculopathy from degenerative disorders.

RECOMMENDATION: The Neck Disability Index (NDI), SF-36, SF-12 and VAS are recommended outcome measures for assessing treatment of cervical radiculopathy from degenerative disorders.

Grade of Recommendation: A

Anderberg et al[2] described a prospective observational study examining the correlation between SNRB and MRI findings and clinical symptoms. Of the twenty consecutively assigned patients included in the study, all received SNRB with mepivicaine and their arm and neck pain were assessed 30 minutes following the procedure using VAS. The authors reported an 86% mean reduction in VAS arm pain scores and 65% mean reduction in VAS neck pain scores, and concluded that the VAS can be used to document response to the anesthetic phase of SNRB for arm and neck pain. In critique, this study had a very small sample size and the patients included were not enrolled at the same point in their disease, with duration of symptoms ranging from one to 60 months. This study provides Level II prognostic evidence that the VAS pain scale can be used to document the immediate anesthetic response to SNRB for radicular arm pain.

Fernandez-Fairen et al[19] reported a prospective, randomized controlled trial assessing the effectiveness and safety of a tantalum implant in achieving anterior cervical fusion following single level discectomy as treatment for degenerative cervical disc disease with radiculopathy. Of the 61 patients included in the study, 28 were treated with ACDF with interbody implant of tantalum and 33 received ACDF with autologous iliac bone graft and plating. At 24 months, clinical outcomes, as assessed by the NDI, VAS pain scale (arm), Odom's criteria and Zung Depression Scale were similar for both treatment groups without significant difference. The authors concluded that clinical outcome as assessed by the VAS, NDI and ZDS demonstrated that tantalum implant was equivalent to autogenous graft and anterior plate. This study provides Level I prognostic evidence that the NDI and VAS pain scale (arm) are instruments that can be used to assess the outcome of surgical intervention for cervical radiculopathy from degenerative disorders. Additionally, patient satisfaction as measured by Odom's criteria and depression as assessed by the ZDS appear useful.

Foley et al[22] conducted a prospective randomized controlled trial to determine the efficacy and safety

of pulsed electromagnetic field stimulation as an adjunct to arthrodesis after ACDF in patients with potential risk factors for nonunion. Of the 323 consecutively assigned patients, 163 received PEMF in addition to the ACDF. Clinical outcomes as assessed by the NDI, VAS (arm) and SF-12 demonstrated that there were no significant differences between the two treatments. Because less than 80% of patients were available at 12 month follow-up, this study provides Level II evidence NDI, VAS (arm) and SF-12 can be used to assess outcome after surgical intervention for cervical radiculopathy from degenerative disorders.

Hacker et al[25] described a randomized controlled trial to report clinical results with maximum 24 month follow-up of fusions performed with the BAK/C fusion cage. Of the 344 patients available at 12 month follow-up, 245 had been assigned to the BAK/C fusion cage groups and 105 were assigned to the control group. Clinical outcome as assessed with the VAS and SF-36 showed that there were similar outcomes between the ACDF group and the BAK/C group at 12 months and 24 months. The authors concluded that clinical outcomes after a cervical fusion with a threaded cage are the same as those of a conventional uninstrumented bone-only ACDF. This study provides Level I evidence that the VAS and SF-36 can be used to assess outcome following surgery for cervical radiculopathy from degenerative disorders.

Kumar et al[38] reported on a retrospective observational study designed to highlight the effectiveness and safety of cervical selective nerve root block (SNRB) using a two needle technique for treatment of radiculopathy. Although the 33 patients included in the study were followed for two years, clinical outcomes were reported only for the first year. Statistical improvements in VAS and NDI scores were seen at six weeks and 12 months following the procedure. The authors concluded that the VAS and NDI can be used to show that the two needle technique of cervical foraminal SNRB produces improved outcomes at six weeks and 12 months. This study provides Level II evidence that NDI, VAS and SF-36 can be used to assess outcome of interventional treatment of cervical radiculopathy from degenerative disorders.

Lofgren et al[41] conducted a prospective observational study to compare the clinical outcome after surgery for cervical radiculopathy from degenerative disorders to conservative treatment. Forty-three surgical patients were studied prospectively and received ACDF (Cloward, single level). Their outcomes were compared with a control group of 39 patients (two did have surgery) who were treated conservatively. The conservative treatment protocol was not described. Outcomes were assessed at three months, six months, nine months and two years. Pain reduction measured with the VAS (arm) was more pronounced among the surgically treated patients at the final follow-up for maximal neck pain ($p=0.03$) and at three months and nine months, respectively, for average neck pain ($p=0.02$, both). Initially there was no statistically significant difference in pain intensity between the surgically and conservatively treated groups. Sickness Impact Profile showed that patients scheduled for surgery had higher sickness impact in the overall index. The authors concluded that surgically treated patinets demonstrated an improvement in VAS (arm) pain and SIP scores, as well as at the clinical examination, all indicating a true improvement, although only partially maintained. This study provides Level I evidence that VAS (arm) may be a useful surgical outcome measure for patients with cervical radiculopathy from degenerative disorders.

Mummaneni et al[43] reported findings of a prospective randomized controlled trial comparing the results of cervical disc arthroplasty to ACDF. Of the 541 patients included in the study, 276 received a Prestige disc and 265 were treated with ACDF and plating. Outcomes were assessed at 1.5 months, three months, six months, 12 months and 24 months. Neck pain, arm pain and NDI scores were improved in the Prestige disc group, with statistically superior success rates at 12 and 24 months compared with

the control group. Neck pain improved in both treatment groups, but statistically significant improvements were noted in the Prestige group at six weeks, three months and 12 months. No significant intergroup differences in arm pain or return to work were noted at 24 months. The NDI score was statistically significantly higher only at three months, but tended to have higher scores than the control group. The authors concluded that the Prestige ST-cervical disc system maintained physiological segmental motion at 24 months after implanation and was associated with improved neurologic success, improved clinical outcomes (SF-36) and reduced rate of secondary surgeries compared to ACDF. In critique, this study had a 75% follow-up in the control group and provides Level II evidence that NDI and SF-36 can be used to assess the outcomes of cervical radiculpathy treated by discectomy and articifial disc replacement or fusion.

Murrey et al[45] described a prospective randomized controlled trial comparing the safety and efficacy of C-TDR with ProDisc-C to ACDF for the treatment of a symptomatic cervical disc at one level between C3 and C7. Of the 209 patients included in the study, 103 received ProDisc-C TDR and 106 were treated with single level ACDF. Outcomes were assessed at three months, six months, 12 months, 18 months and 24 months. NDI and SF-36 improved in both groups as compared to preoperative scores ($\rho<0.0001$). VAS neck and arm pain intensity and frequency were statistically lower at all follow-up time points compared with preoperatively ($\rho<0.0001$) but were no different between treatment groups. Authors concluded that neurologic success (improvement or maintenance) as determined by NDI, SF-36 and VAS neck and arm pain scores was seen in 90.9% of ProDisc-C and 88% of fusion patients ($\rho=0.638$) at 24 months. Fusion patients had a higher secondary surgery rate and higher medication usage postoperatively. This study provides Level I evidence that NDI, SF-36 and VAS are outcome tools that can be used to assess cervical disc disease, including cervical radiculopathy, following surgery.

Nunley et al[46] conducted a prospective randomized controlled trial comparing the clinical and radiographic outcomes of patients treated with one-level or multiple level ACDF using cervical plates of dynamic/slotted vs. static/fixed hole design. Of the 66 patients included in the study and treated with ACDF, 33 received static plates and 33 received dynamic plates. VAS and NDI score were lower in patients with dynamic plates than static plates. At mean follow-up of 16 months, 49 patients (73.7%) had clinical success and 56 (85%) showed radiographic fusion. In single-level fusion, no statistical difference of outcome was observed between the two groups, but multilevel fusions with dynamic plate showed significantly lower VAS and NDI scores than those with static plates ($\rho=0.050$). The authors concluded that SF-36 and NDI scores were better in patients with dynamic plates as compared to those with static plates. They stated that clinical improvement is a good predictor of successful ACDF and that radiologic evidence of fusion alone is not reliable as a parameter of success. Plate design for single-level fusion does not affect outcomes, but outcome studies indicate that multilevel fusions may have better clinical outcomes when dynamic/slotted plates are used. This study provides Level I evidence that NDI and VAS are outcome measures that can be used to assess cervical radiculopathy from degenerative disorders.

Park et al[49] described a retrospective case control study comparing the clinical and radiographic outcomes of CDR-Mobi-C to ADV-Solis cage. Of the 53 patients included in the study, 21 were treated with CDR-Mobi-C and 32 received ADF-Solis-cage. Outcomes were assessed at six weeks, three months, six months and 12 months. Mean hospital stay and interval between surgery and return to work were significantly shorter in the arthroplasty group than the fusion group. Mean NDI and extremity VAS score improved after 12 months in both groups. Although it was not significant, segmental range of motion (ROM) at adjacent levels was higher in the fusion group than the arthroplasty group. Segmental mo-

tion at the operative level in the arthroplasty group maintained more motion than preoperative values at final follow-up. The authors concluded that clinical outcomes were similar in both groups. Mean NDI and extremity VAS scores improved after 12 months in both groups. In critique, this study had a small sample size and the authors did not adequately explain how assignments to the two treatment groups were made. The two groups were not appropriately matched; the fusion group had more males, iliac crest graft was only performed in the fusion group and the fusion group had cervical orthosis for two months. Due to these limitations, this potential Level II study provides Level III evidence that NDI and VAS may be appropriate outcome measures to assess cervical radiculopathy from degenerative disorders.

Peolsson et al[51] conducted a prospective randomized controlled trial to determine the predictive factors for short-term and long-term outcome of ACDF using VAS and NDI multivariate analysis. Of the 103 consecutively assigned patients included in the study, 95 proceeded with surgical treatment. Of the 95 surgically treated patients, 52 received a cervical intervertebral fusion cage and 51 received a Cloward procedure. Outcomes were assessed at 12 months and 24 months and compared with preoperative data. Using multivariate analysis, the variables' influence on projection showed that the most important preoperative variables for predicting short-term NDI and pain intensity were: NDI, horizontal active range of motion (AROM), pain intensity, smoking, right hand strength, gender and kyphosis. Radiological finding and surgical technique except preoperative kyphosis were insignificant as predictors of both short- and long-term outcome. The authors concluded that a preoperative low neck specific disability, low pain intensity, nonsmoking status, male gender, good preoperative hand strength and neck AROM were significant predictors for a good long-term outcome of pain intensity and NDI after ACDF. Short-term outcome measures of NDI and pain intensity were better predictors of the long-term outcome than were baseline values. NDI was not only overall the most important factor in explaining short- and long-term outcomes, but also was the factor with the highest impact explaining the total prediction model. NDI may be regarded as an important outcome measurement in evaluation of ACDF. This study provides Level I evidence that NDI and VAS are good outcome measures to assess cervical radiculopathy from degenerative disorders.

Xie et al[65] performed a prospective randomized controlled trial to determine the clinical outcome of ACD, ACDF and anterior cervical discectomy and fusion with instrumentation (ACDFI). Of the 45 patients included in the study, 15 were assigned to each treatment group. Outcomes were asessed at three weeks, six weeks, three months, six months, one year and two years. SF-36 scores demonstrated a dynamic postoperative improvement followed by further gradual improvement in both physical and mental components as well as other subscale scores in all groups during the follow-up period ($\rho<0.05$). The amount of pain demonstrated by the McGill pain rating index scores significantly decreased for all three groups immediately after surgery and continued to decline, plateauing at about one year. The authors concluded that SF-36 scores improved in all three groups during the follow-up period, and McGill pain scores markedly improved immediately after surgery and continued to improve until the one year follow-up evaluation before plateauing. In critique, neither patients nor reviewers were masked to treatment group and the sample size was small. Three of the 45 patients were lost to follow-up. Patients included in the study were enrolled at different points in their disease and received surgery at single and multiple levels. Due to these limitations, this potential Level I study provides Level II evidence that SF-36 may be an appropriate outcome tool for cervical radiculopathy from degenerative disorders treated with surgery.

Zoega et al[65] described a prospective observational study of patients undergoing ACDF or ACDFI at

single or multiple levels to determine the usefulness of outcome scores in the treatment of degenerative disc disease. Of the 46 patients included in the study, 12 received single-level ACDF, 10 received two-level ACDF, 15 received single-level ACDFI and 9 received two-level ACDFI. At two years, 81% of patients were satisfied with the outcome of surgery. All scores improved in the group operated on at two-levels. VAS arm and neck pain decreased in both groups. The improvement in arm pain was significantly more pronounced in patients operated with a plate at two-levels compared to those who were operated without a plate. At two year follow-up, patients with an excellent or good result according to Odom's criteria had a lower Million Index ($\rho<0.0005$), Oswestry Index ($\rho<0.0005$) and Zung Depression Scale ($\rho=0.024$) score than the group classified as fair or poor. There was a significant correlation ($\rho<0.0001$) for all scores between the test and retest. The authors concluded that Modified Million Index and Oswestry Index are clinically useful tools in the evaluation of outcome after degenerative cervical disc disease surgery. The outcome after surgery measured with the Oswestry Index, Modified Million Index, and VAS neck and arm pain seem to correlate well with the classification of outcome by Odom. This study provides Level II evidence that VAS may be an appropriate outcome measure for cervical radiculopathy from degenerative disorders treated with surgery.

RECOMMENDATION: The Modified Prolo, Patient Specific Functional Scale (PSFS), Health Status Questionnaire, Sickness Impact Profile, Modified Million Index, McGill Pain Scores and Modified Oswestry Disability Index are suggested outcome measures for assessing treatment of cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION: B

Alrawi et al[1] reported the findings of a prospective observational study examining the utility of neurophysiological EMG to predict outcome after ACDF. Of the 20 patients included in the study, eight showed EMG evidence of nerve root involvement, while 12 did not. Patient outcomes at minimum of 12 months as measured with a modified Prolo scale were better predicted by EMG. The authors concluded that EMG can better predict outcomes as measured by a modified Prolo scale. In critique, this study had a very small sample size of nonrandomized patients who were enrolled at different points of their disease. Patients still received an operation even if they had a negative EMG. Due to these limitations, this study provides Level III evidence that the modified Prolo scale can be used to assess patient outcome after ACDF.

Cleland et al[15] described a prospective observational study examining the test-retest reliability, construct validity and minimum levels of detectable and clinically important change for the NDI and PSFS in a cohort of patients with cervical radiculopathy. All 38 patients included in the study received physical therapy and were assessed at a mean of 21.5 days. Test-retest reliability was moderate for the NDI and high for the PSFS. The PSFS was more responsive to change than the NDI. The minimal detectable change for the NDI was 10.2 and for the PSFS was 2.1. The authors concluded that the PSFS exhibits superior reliability, construct validity, and responsiveness in this cohort of patients with cervical radiculopathy compared with the NDI. This study provides Level I evidence that the PSFS may be better than the NDI for the assessment of outcomes in patients with cervical radiculopathy.

Davis et al[17] conducted a retrospective observational study assessing the outcome of posterior decompression for cervical radiculopathy. Of the 170 patients included in the study, patients who had sedentary occupations and housewives had significantly higher Prolo scores ($p<0.001$) than those who did strenuous work. In 86% of patients, outcome was good (defined as a Prolo score of 8 in 5%, 9 in 38% and 10 in 43%). The authors concluded that although outcome studies must have subjective criteria, the Prolo scale is more objective and quantitative than

currently used methods. This study provides Level II evidence that the author's modified Prolo scale may be reasonable to assess outcomes for cervical radiculopathy from degenerative disorders.

Klein et al[34] reported results from a prospective observational study assessing patient outcomes using the Health Status Questionnaire after one- or two-level ACDF. In the 28 patients included in the study, statistically significant improvements were found in postoperative scores for bodily pain ($p<0.001$), vitality ($p=0.003$), physical function ($p=0.01$), role function/physical ($p=0.0003$) and social function ($p=0.0004$). No significant differences were found for three health scales: general health, mental health and role function associated with emotional limitations. Authors concluded that the HSQ may be a good disease specific outcome tool for one- and two-level ACDF. This small study provides Level II evidence that the HSQ may be a good outcome measure for assessing treatment of cervical radiculopathy from degenerative disorders.

Lofgren et al[41] conducted a prospective observational study to follow the clinical outcome after surgery for cervical radiculopathy from degenerative disorders and to compare it with the outcome after conservative treatment. Forty-three surgical patients were studied prospectively and received ACDF (Cloward-single level). Their outcomes were compared with a control group of 39 patients (two did have surgery) who were treated conservatively. The conservative treatment protocol was not described. Outcomes were assessed at three months, six months, nine months and two years. Pain reduction measured with the VAS (arm) was more pronounced among the surgically treated patients at the final follow-up for maximal neck pain ($p=0.03$) and at three months and nine months, respectively, for average neck pain ($p=0.02$, both). Initially there was no statistically significant difference in pain intensity between the surgically and conservatively treated groups. Sickness Impact Profile showed that patients scheduled for surgery had higher sickness impact in the overall index. The authors concluded that surgically treated patients demonstrated an improvement in VAS (arm) pain and SIP scores, as well as at the clinical examination, all indicating a true improvement, although only partially maintained. This study provides Level I evidence that SIP may be a useful surgical outcome measure for patients with cervical radiculopathy from degenerative disorders.

Witzmann et al[64] described a retrospective observational study designed to determine the clinical and economic outcome of patients undergoing posterior cervical foraminotomy for the treatment of compressive radiculopathy. At mean follow-up of 3.1 years, VAS scores indicated 93% of the 67 patients included in the study were improved. Prolo scores indicated 90% of patients had an excellent economic outcome and 79% of patients returned to their prior employment. In critique, patients were enrolled at different points in their disease with 57 single-level surgeries and 10 multiple level surgeries. Less than 80% of patients were available for follow-up. Due to these limitations, this potential Level II study provides Level III evidence that the Prolo scale may be an appropriate outcome measure to assess surgical treatment results for cervical radiculopathy from degenerative disorders.

Xie et al[65] performed a prospective randomized controlled trial to determine the clinical outcome of ACD, ACDF and ACDFI. Of the 45 patients included in the study, 15 were assigned to each treatment group. Outcomes were asessed at three weeks, six weeks, three months, six months, one year and two years. SF-36 scores demonstrated a dynamic postoperative improvement followed by further gradual improvement in both physical and mental components as well as other subscale scores in all groups during the follow-up period ($\rho<0.05$). The amount of pain demonstrated by the McGill pain scores significantly decreased for all three groups immediately after surgery and continued to decline, plateauing at about one year. The authors concluded that SF-36 scores improved in all three groups during the

follow-up period. McGill pain scores markedly improved immediately after surgery and continued to improve until the one year follow-up evaluation before plateauing. In critique, neither patients nor reviewers were masked to treatment group and the sample size was small. Three of the 45 patients were lost to follow-up. Patients included in the study were enrolled at different points in their disease and received surgery at single and multiple levels. Due to these limitations, this potential Level I study provides Level II evidence that the McGill pain scores may be an appropriate outcome tool for cervical radiculopathy from degenerative disorders treated with surgery.

Zoega et al[65] described a prospective observational study of patients undergoing ACDF or ACDFI at single or multiple levels to determine the usefulness of outcome scores in the treatment of degenerative disc disease. Of the 46 patients included in the study, 12 received single-level ACDF, 10 received two-level ACDF, 15 received single-level ACDFI and 9 received two-level ACDFI. At two years, 81% of patients were satisfied with the outcome of surgery. All scores improved in the group operated on at two-levels. VAS arm and neck pain decreased in both groups. The improvement in arm pain was significantly more pronounced in patients operated with a plate at two-levels compared to those who were operated without a plate. At two year follow-up, patients with an excellent or good result according to Odom's criteria had a lower Million Index ($\rho<0.0005$), Oswestry Index ($\rho<0.0005$) and Zung Depression Scale ($\rho=0.024$) score than the group classified as fair or poor. There was a significant correlation ($\rho<0.0001$) for all scores between the test and retest. The authors concluded that Modified Million Index and Oswestry Index are clinically useful tools in the evaluation of outcome after degenerative cervical disc disease surgery. The outcome after surgery measured with the Oswestry Index, Modified Million Index, and VAS neck and arm pain seem to correlate well with the classification of outcome by Odom. This study provides Level II evidence that the Modified Million Index and Modified Oswestry Disability Index may be appropriate outcome measures for cervical radiculopathy from degenerative disorders treated with surgery.

Future Directions for Research

Disease specific outcome measures like the PSFS and the HSQ have been developed and seem to be useful in assessing outcome for the treatment of cervical radiculopathy from degenerative disorders. These measures are limited in that they have not been widely used or accepted. Outcome measures such as these need to be incorporated into Level I studies to confirm their validity and to establish themselves as acceptable research tools to quantitate outcome after cervical radiculopathy from degenerative disorders.

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C. Medical and Interventional Treatment

What is the role of pharmacological treatment in the management of cervical radiculopathy from degenerative disorders?

A systematic review of the literature yielded no studies to adequately address the role of pharmacological treatment in the management of cervical radiculopathy from degenerative disorders.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of pharmacological treatment in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:

Future studies of the effects of pharmacological treatment in the management of cervical radiculopathy from degenerative disorders should include an untreated control group when ethically possible.

Recommendation #2:

Future outcome studies including patients with cervical radiculopathy from degenerative disorders treated only with pharmacological treatment should include subgroup analysis for this patient population.

Pharmacological Treatment References

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What is the role of physical therapy/exercise in the treatment of cervical radiculopathy from degenerative disorders?

A systematic review of the literature yielded no studies to adequately address the role of physical therapy/exercise in the management of cervical radiculopathy from degenerative disorders.

RECOMMENDATION: Emotional and cognitive factors (eg, job dissatisfaction) should be considered when addressing surgical or medical/interventional treatment for patients with cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION:
I (Insufficient Evidence)

Persson et al[6] conducted a prospective randomized controlled trial comparing coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Of the 81 patients included in the study, 27 were assigned to cervical bracing, 27 to physical therapy and 27 to ACDF (Cloward technique). Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique.

Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen

after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping (cognitive reappraisal and problem solving) was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. It appeared that with intervention, especially surgery, healthy active coping strategies tended to be replaced by passive coping strategies as patients allowed themselves to become more dependent on the intervention. This also implied that the ability for active coping was present before intervention, and thus cognitive behavioral treatment started concurrently with other interventions may be particularly successful for maintaining better coping patterns. Function was significantly related to pain intensity. About 40% had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. The authors concluded that cognitive and behavioral therapy is important to include in multidisciplinary rehabilitation. Patients need to improve coping strategies, self image and mood.

In critique, neither patients nor reviewers were masked to treatment group, the sample size was small and duration of follow-up was short. Due to these limitations, this potential Level I study provides Level II evidence that there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of physical therapy/exercise in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:

Future studies of the effects of physical therapy/exercise in the management of cervical radiculopathy from degenerative disorders should include an untreated control group when ethically possible.

Recommendation #2:

Future outcome studies including patients with cervical radiculopathy from degenerative disorders treated only with physical therapy/exercise should include subgroup analysis for this patient population.

Recommendation #3:

Future studies evaluating the effects of emotional, cognitive and work-related issues would add to our understanding of how these factors affect outcomes in patients with cervical radiculopathy from degenerative disorders.

Physical Therapy/Exercise References

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What is the role of manipulation/ chiropractics in the treatment of cervical radiculopathy from degenerative disorders?

A systematic review of the literature yielded no studies to adequately address the role of manipulation/ chiropractics in the management of cervical radiculopathy from degenerative disorders. The review did identify several case reports and series describing serious vascular and nonvascular complications and adverse outcomes associated with manipulation including radiculopathy, myelopathy, disc herniation and vertebral artery compression.[9,13,14,17] The true incidence of such complications is unknown and estimates vary widely. Some complications have occurred in patients with previously unrecognized spinal metastatic disease who did not have premanipulation imaging. Most patients with serious complications of manipulation require emergent surgical treatment.

RECOMMENDATION: As the efficacy of manipulation in the treatment of cervical radiculopathy from degenerative disorders is unknown, careful consideration should be given to evidence suggesting that manipulation may lead to worsened symptoms or significant complications when considering this therapy. Premanipulation imaging may reduce the risk of complications.

Work Group Consensus Statement

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of manipulation/chiropractics in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:
Future studies of the effects of manipulation/chiropractics in the management of cervical radiculopathy from degenerative disorders should include an untreated control group when ethically possible.

Recommendation #2:
Future outcome studies including patients with cervical radiculopathy from degenerative disorders treated only with manipulation/chiropractics should include subgroup analysis for this patient population.

Recommendation #3:
Future studies of the effects of manipulation/chiropractics in the management of cervical radiculopathy from degenerative disorders should include data and discussion about any complications associated with treatment.

Manipulation/Chiropractics References

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What is the role of epidural steroid injections for the treatment of cervical radiculopathy from degenerative disorders?

A systematic review of the literature revealed limited high quality studies to address this question. There is Level IV data indicating that transforaminal epidural steroid injections may provide relief for 60% of patients, and about 25% of patients referred with clear surgical indications may obtain at least short-term pain relief negating the need for surgery. Interestingly, there is limited Level II evidence that suggests that the addition of steroid to local anesthetic does not improve pain relief in these patients at three weeks post-injection. All of the studies that qualified as at least Level IV data used transforaminal epidural injections under fluoroscopic or CT guidance as the method of treatment. For this reason, the work group was unable to make recommendations regarding the safety or efficacy of interlaminar epidural steroid injections for the treatment of cervical radiculopathy.

The literature search yielded a number of publications demonstrating that transforaminal epidural steroid injections are not without risk and the potential complications, including spinal cord injury and death, need to be considered before performing this procedure.[20,25]

RECOMMENDATION: Transforaminal epidural steroid injections using fluoroscopic or CT guidance may be considered when developing a medical/interventional treatment plan for patients with cervical radiculopathy from degenerative disorders. Due consideration should be given to the potential complications.

GRADE OF RECOMMENDATION: C

Cyteval et al[10] described a prospective case series of 30 patients treated with transforaminal epidural steroid injections under CT guidance. At six month follow-up 60% of patients obtained good or excellent pain relief. In critique of this study, this is a nonrandomized, nonconsecutive case series with a small sample size and fairly short term follow-up. This study provides Level IV evidence that 60% of patients can obtain good or excellent pain relief at up to six months following transforaminal epidural steroid injections.

Kim et al[14] retrospectively reviewed 19 patients who underwent cervical transforaminal epidural steroid injections under CT guidance. At 16 week follow-up patients noted an average 50% reduction in pain. In critique of this study, it is retrospective and excluded any patients with neurologic deficits. Further limiting the relevance of this study is the small sample size and relatively short term follow-up. This study provides Level IV evidence that, on average, patients will experience a 50% reduction in pain 16 weeks following transforaminal epidural steroid injections.

Kolstad et al[15] described a prospective case series of 21 patients with cervical radiculopathy awaiting cervical disc surgery. Two cervical transforaminal epidural steroid injections under fluoroscopic guidance were performed two weeks apart. Patients were followed for four months with approximately 25% opting to cancel surgery because of clinical improvement. In critique of this study, the sample size is small. It is difficult to make any outcome statements regarding these patients other than they opted out of surgery at four months following this treatment. This study provides Level IV evidence that 25% of patients awaiting cervical disc surgery can obtain enough pain relief at four months following two cervical transforaminal epidural steroid injections to cancel surgery.

Lin et al[17] described a retrospective case series of 70 patients considered potential surgical candidates for cervical radiculopathy. Patients underwent cervical transforaminal epidural steroid injections and were followed until they obtained satisfactory relief or underwent surgical management. Of these patients, 65% (45/70) reported good or excellent results with regard to pain relief and 63% (44/70) opted not to have surgery. In critique of this study, no validated outcome measures were used, though avoiding surgery could be considered a valid endpoint. This study provides Level IV evidence that 65% of patients with cervical radiculopathy can obtain pain relief to the level necessary to avoid surgery.

Anderberg et al[3] described a prospective randomized controlled trial of 40 patients with cervical radiculopathy. They were randomized into one group that received transforaminal epidural steroid injections and a control group that received transforaminal injections of local anesthetic. At three week follow-up, 40% (8/20) of the patients in the steroid injection group, and 35% (7/20) of the patients in the control group noted improvement in their pain on a VAS. This difference was not statistically significant. In critique of this study, no validated outcome measures were used and the sample size was very small. This potential Level I study was downgraded to a Level II study because of these shortcomings. This study provides Level II evidence that the addition of steroid to local anesthetic in transforaminal epidural injections provides no additional therapeutic benefit at three weeks post-injection.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of epidural steroid injections in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:

Future studies of the effects of epidural steroid injections in the management of cervical radiculopathy from degenerative disorders should include an untreated control group when ethically possible.

Recommendation #2:
Future outcome studies including patients with cervical radiculopathy from degenerative disorders treated only with epidural steroid injections should include subgroup analysis for this patient population.

Recommendation #3:
Future studies of the effects of epidural steroid injections in the management of cervical radiculopathy from degenerative disorders should include data and discussion about any complications associated with treatment.

Epidural Steroid Injection References

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What is the role of ancillary treatments such as bracing, traction, electrical stimulation, acupuncture and transcutaneous electrical stimulation in the treatment of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: Ozone injections, cervical halter traction and combinations of medications, physical therapy, injections and traction have been associated with improvements in patient reported pain in uncontrolled case series. Such modalities may be considered recognizing that no improvement relative to the natural history of cervical radiculopathy has been demonstrated.

Work Group Consensus Statement

Alexandre et al[1] reported results of a retrospective case series investigating the effects of intervertebral disc and paravertebral injections of ozone and oxygen in patients with CDH. The authors reported that 80% of the 252 patients experienced some degree symptom relief at some point following the injections. In critique, this case series did not utilize any validated outcome measures, report specific data or delineate a specific follow-up period. No comparison to the natural history was made. Due to these weaknesses, this potential Level IV study provides Level V evidence suggesting that approximately 80% of patients will report symptomatic relief from cervical radiculopathy at some point following ozone and oxygen injection into the intervertebral disc and paravertebral musculature.

Olivero et al[6] discussed a retrospective case series evaluating the use of halter traction and collar in patients with mild cervical radiculopathy. The authors reported that of the 81 patients included in the study, 75% of patients with mild cervical radiculopathy of approximately six weeks reported some degree of pain relief with halter traction. In critique, this case series did not utilize any validated outcome measures and had a very short follow-up period. Due to these weaknesses, this potential Level IV study provides Level V evidence suggesting that 75% of patients with mild radiculopathy may improve with traction over a six week time frame.

Saal et al[8] presented a retrospective case series evaluating the use of a multifaceted medical/interventional treatment program for 26 patients with cervical radiculopathy. Of the 26 patients who completed the program, 24 were available for follow-up at three months, with 89% (22/24) of patients reporting a good treatment outcome. In critique, this study did not utilize any validated outcome measures. This study provides Level IV evidence that a multifaceted medical/interventional treatment program is associated with good outcomes in many patients with cervical radiculopathy.

RECOMMENDATION: Emotional and cognitive factors (eg, job dissatisfaction) should be considered when addressing surgical or medical/interventional treatment for patients with cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION:
I (Insufficient Evidence)

Persson et al[7] conducted a prospective randomized controlled trial comparing coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Of the 81 patients included in the study, 27 were assigned to cervical bracing, 27 to physical therapy and 27 to ACDF (Cloward technique). Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient

in the physical therapy group and five in the collar group had surgery with Cloward technique.

Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping (cognitive reappraisal and problem solving) was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. It appeared that with intervention, especially surgery, healthy active coping strategies tended to be replaced by passive coping strategies as patients allowed themselves to become more dependent on the intervention. This also implied that the ability for active coping was present before intervention, and thus cognitive behavioral treatment started concurrently with other interventions may be particularly successful for maintaining better coping patterns. Function was significantly related to pain intensity. About 40% had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. The authors concluded that cognitive and behavioral therapy is important to include in multidisciplinary rehabilitation. Patients need to improve coping strategies, self image and mood.

In critique, neither patients nor reviewers were masked to treatment group, the sample size was small and duration of follow-up was short. Due to these limitations, this potential Level I study provides Level II evidence that there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of ancillary treatments in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:
Future studies of the effects of ancillary treatments in the management of cervical radiculopathy from degenerative disorders should include an untreated control group when ethically possible.

Recommendation #2:
Future outcome studies including patients with cervical radiculopathy from degenerative disorders treated only with ancillary treatments should include subgroup analysis for this patient population.

Recommendation #3:
Future studies evaluating the effects of emotional, cognitive and work-related issues would add to our understanding of how these factors affect outcomes in patients with cervical radiculopathy from degenerative disorders.

Ancillary Treatment References

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D. Surgical Treatment

Does surgical treatment (with or without preoperative medical/interventional treatment) result in better outcomes than medical/interventional treatment for cervical radiculopathy from degenerative disorders?

RECOMMENDATION: Surgical intervention is suggested for the rapid relief of symptoms of cervical radiculopathy from degenerative disorders when compared to medical/interventional treatment.

GRADE OF RECOMMENDATION: B

Persson et al[48] described a prospective randomized controlled trial comparing outcomes in pain, strength and sensation in three treatment groups of patients with cervical radiculopathy of a minimum of three months duration. Of the 81 patients included in the study, 27 were assigned to cervical bracing, 27 to physical therapy and 27 to ACDF (Cloward technique). Three surgical patients refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique.

Strength measurements were all performed by one physical therapist with standard protocol. Physical therapy was done for 15 visits and was not standardized. Several different collars were used and worn for three months. At four month follow-up, pain was improved in the surgical and physical therapy groups and improvement in pain scores in the surgical group was significantly better than in the collar group. After another year, the pain was about the same across groups. The surgical group improved strength a little faster, but at final follow-up strength improvement was equal across groups. At final follow-up, there was no difference between groups on the sensory exam. The authors concluded that there was no difference in outcomes after one year between patients treated with a collar, physical therapy or surgery.

In critique, neither patients nor reviewers were masked to treatment group, the sample size was small and duration of follow-up was short. Due to these limitations, this potential Level I study provides Level II evidence that at one year, outcomes are similar for medical/interventional treatment and surgical treatment of patients with cervical radiculopathy from degenerative disorders. Due to the small sample size, one may not expect to see a difference between the groups on a statistical basis. Surgical treatment resulted in improved outcomes earlier in the postoperative treatment period when compared with the medical/interventional treatment group.

Sampath et al[53] reported results of a prospective, multicenter comparative study evaluating clinical outcomes in patients with cervical radiculopathy. Medical/interventional treatment was nonstandardized in this multicenter trial and included medications, steroids, bed rest, exercise, traction, bracing, injections, chiropractic care, acupuncture and homeopathic medicine. Surgery included foraminotomy, ACD and ACDF. Of the 246 patients with radiculopathy, 160 were nonrandomized to medical treatment and 86 received surgical treatment. Of the 246 patients, only 155 reported data at final follow-up. Of the 155 patients, 104 were medically/interventionally treated and 51 had surgery.

In general, pain scores were worse in the surgical group preoperatively than in the medical/interventional treatment group. Both groups improved significantly, with greater improvement seen in the surgical group. Patient satisfaction, neurological improvement and functional improvement were seen in both groups, with greater improvement reported in the surgical group. There was significant improvement in activities of daily living (ADL) in the surgical group. Although there was improvement, there was still significant pain in about 26% of surgical patients. The number returning to work did not differ before and after intervention in either group despite improved functional ability, implying that the most important factor for return to work was work status prior to treatment. The authors concluded that surgery appears to have more success than medical/interventional treatment, although both help. Despite this, a substantial percentage of patients continue to have severe pain, neurologic symptoms and no work activity.

In critique, this was a nonrandomized study which did not utilize validated outcome measures. There was a high attrition rate to follow-up and the length of follow-up was short. Both medical/interventional and surgical treatment protocols were nonstandardized. Due to these limitations, this potential Level II study provides Level III evidence that surgical treatment results in improved outcomes when compared with medical/interventional treatment on short term follow-up.

RECOMMENDATION: Emotional and cognitive factors (eg, job dissatisfaction) should be considered when addressing surgical or medical/interventional treatment for patients with cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION: I (Insufficient Evidence)

Persson et al[47] conducted a prospective randomized controlled trial comparing coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Of the 81 patients included in the study, 27 were assigned to cervical bracing, 27 to physical therapy and 27 to ACDF (Cloward technique). Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique.

Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping (cognitive reappraisal and problem solving) was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. It appeared that with intervention, especially surgery, healthy active coping strategies tended to be replaced by passive coping strategies as patients allowed themselves to become more dependent on the intervention. This also implied that the ability for active coping was present before in-

tervention, and thus cognitive behavioral treatment started concurrently with other interventions may be particularly successful for maintaining better coping patterns. Function was significantly related to pain intensity. About 40% had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. The authors concluded that cognitive and behavioral therapy is important to include in multidisciplinary rehabilitation. Patients need to improve coping strategies, self image and mood.

In critique, neither patients nor reviewers were masked to treatment group, the sample size was small and duration of follow-up was short. Due to these limitations, this potential Level I study provides Level II evidence that there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of medical/interventional and surgical treatment in the management of cervical radiculopathy from degenerative disorders.

Recommendation #1:

A prospective, multicenter randomized controlled trial (RCT) with minimum two year follow-up comparing surgical to medical/interventional treatment for the treatment of cervical radiculopathy from degenerative disorders would yield invaluable information regarding the relative outcomes of these two treatment options.

Recommendation #2:

Future studies evaluating the effects of emotional, cognitive and work-related issues would add to our understanding of how these factors affect outcomes in patients with cervical radiculopathy from degenerative disorders.

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Does ACDF result in better outcomes (clinical or radiographic) than ACD alone?

RECOMMENDATION: Both ACD and ACDF are suggested as comparable treatment strategies, producing similar clinical outcomes, in the treatment of single level cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION: B

Barlocher et al[3] conducted a prospective randomized controlled trial comparing outcomes of ACD to three different types of ACDF: iliac crest bone graft (ICBG), polymethylmethacrylate (PMMA) and titanium cages. All patients had single level degenerative disease. Of the 125 patients included in the study, 33 were assigned to the ACD group, 30 to ICBG, 26 to PMMA and 36 to titanium cages. At one year follow-up, 123 patients were available. The functional outcomes were grouped by good and excellent to poor and fair, with good/excellent results reported for 75% of the ACDF group, 80% for ICBG, 87% for PMMA and 94% for cage. Average reported kyphosis for ACD patients was 24 degrees, with one patient requiring revision surgery (31 degrees); 12 degrees for PMMA and about three degrees for the ICBG and cage groups. Twelve month fusion results based on flexion and extension radiographs were reported as 93% for the ACD patients, 93% for ICBG and 97% for cage. Fusion rate was faster in the cage group as well with 86% achieving fusion at six months compared with 61% in the ACD group and 65% in the ICBG group. The authors concluded that ACDF with cage did significantly better with faster and better recovery and less kyphotic deformity than ACD. ACD compared to ICBG had similar outcomes but more kyphotic deformity at medium length follow-up.

In critique, neither reviewers nor patients were masked to treatment group and the randomization process was not described. No validated outcome measures were utilized, the sample size was small and length of follow-up was short. Use of PMMA as a spacer is not standard practice. Due to these limitations, this potential Level II RCT provides Level III evidence that suggests that there are variable outcomes when comparing ACD to ACDF for the treatment of cervical radiculopathy due to single level degenerative disease. In one cohort comparing ACD to fusion with ICBG, outcomes were equivalent, while another cohort showed superiority of interbody fusion with a titanium cage and allograft versus ACD. Validity of conclusions is weakened by small sample size and short follow-up.

Hauerberg et al[9] reported results of a prospective randomized controlled trial comparing radiographic and clinical outcomes of ACD with ACDF using a titanium cage. Of the 86 patients included in the study, 46 were randomized to the ACD group and 40 to ACDF. One patient withdrew in each group. Two year follow-up data were available for 36 cage and 43 ACD patients. Early outcomes, though not statistically significant, favored ACD. At two years 63% of ACD patients and 78% of cage patients reported good outcomes (not statistically significant). Reoperation rates at the same level were reported as follows: at three months, three reoperations in ACD group, two in cage group; at one year, an additional reoperation in each group; at two years, an additional three in the ACD group. There were some additional procedures at adjacent levels that were equivalent for both groups over two years. In total, for the ACD group, 17/46 were investigated, seven had the same level reoperation and two had adjacent level operations. In the cage group, 15/40 were investigated with three having same level reoperation and three having adjacent level operations. There were no statistically significant differences reported in kyphosis

or fusion rate. The authors concluded that there was no difference in outcome at two years between ACD and ACDF with cage and local autograft bone.

In critique, the reviewers were not masked to treatment group, no validated outcome measures were used and the sample size was small. Due to these limitations, this potential Level I RCT provides Level II evidence that for cervical radiculopathy due to single level degenerative disease, clinical outcomes are similar at two years for patients undergoing ACD and ACDF with threaded titanium cage and local autograft. Fusion rates and symptomatic adjacent segment disease were also similar between the two groups.

Oktenoglu et al[16] described a prospective randomized controlled trial comparing radiographic and clinical outcomes of ACD and ACDF with plate. Of the 20 patients included in the study, 11 were assigned to the ACD group and nine to the ACDF group. Inclusion criteria required only two weeks of failed medical/interventional treatment. VAS upper extremity pain scores (dominant complaint) improved significantly in both groups, from mean 8 to 3. Although less severe initially than arm pain, VAS neck pain scores had less improvement overall, but statistically significant improvement was noted in the ACDF group. CT follow-up at one year showed disc space collapse in both groups, but significantly more in the ACD group. There was some subsidence of the graft over the first year. Final foraminal dimensions were slightly larger in ACDF group, but not significant. Reported fusion rates were 100% in the ACDF group and 45% (5/11) in the ACD group. The authors concluded that ACD alone provides satisfactory clinical outcomes when compared to ACDF with semirigid plate.

In critique, patients were not masked to treatment group and duration of symptoms for study inclusion was short. Randomization was accomplished by coin flip and the sample size was small. No validated outcome measures were utilized and follow-up was short. Due to these limitations, this potential Level II study provides Level III evidence that for cervical radiculopathy due to single level degenerative disease, ACD alone provides satisfactory clinical outcomes when compared to ACDF with allograft ICBG and semirigid plate. Radiographically, disc height is maintained significantly better with plate and fusion although the clinical significance is unknown. The validity of the conclusions is uncertain due to small sample size.

Savolainen et al[19] reported results of a prospective randomized controlled trial comparing clinical results of ACD to ACDF with or without plate. Of the 91 patients included in the study, follow-up data were reported for 88 patients. Good/excellent results were reported in 76% of ACD patients, 82% ACDF and 73% ACDFP. Of the 88 patients, 71 had long term radiographic follow-up, with slight kyphosis in 62% of ACD, 41% ACDF, 44% ACDFP and fusion achieved in 100% of ACDF and 90% of ACD patients. Complication rates were similar for all groups, with the exception of short term ICBG pain which was severe in 80% of both ACDF groups. The authors concluded that because outcomes were similar for the three groups, ACD is recommended as the procedure of choice for ease of surgery and reduced complications.

In critique, neither patients nor reviewers were masked to treatment group. The randomization process was not specified. No validated outcome measures were used and the sample size was small. Patients were seen up to six months following surgery, and then final follow-up at four years was conducted via telephone interview. Due to these limitations, this potential Level II study provides Level III evidence that for patients with cervical radiculopathy due to single level degenerative disease, ACD yields results equivalent to ACDF with or without a plate. The validity of the conclusion is uncertain due to small sample size.

Wirth et al[24] conducted a prospective randomized controlled trial comparing clinical outcomes of ACD, ACDF and posterior cervical foraminotomy for single level HNP with radiculopathy. Of the 72 consecutively assigned patients included in the study, 22 were assigned to foraminotomy, 25 to ACD and 25 to ACDF. For immediate postoperative results, surgical time, hospital stay and cost were slightly better for the ACD group. Postoperative pain was worse in the foraminotomy group. At two months, according to the non validated grading scheme implemented, all three groups were about the same. Reoperations were greater at the operative site for foraminotomy and adjacent sites for ACDF patients. Long-term follow-up was accomplished via phone interview at 53 months for the foraminotomy group (14/22 patients), 56 months for the ACD group (13/25 patients) and 69 months for the ACDF group (16/25 patients), with a loss of about 40% of patients to follow-up. Within the limits of their study design and patient capture, pain improvement remained high for all groups. Return to work was 79% for the foraminotomy group, 92% for ACD and 81% for ACDF (not statistically significant). Of the patients available at final follow-up, 100% were satisfied and would have the surgery again. The authors concluded that for single level HNP, all procedures are efficacious.

In critique, neither patients nor reviewers were masked to the treatment group and the randomization method was poor. No validated outcome measures were utilized to assess this small patient sample. Approximately 40% of patients were lost to follow-up. Because of these limitations, this potential Level II study provides Level III evidence that for single level HNP causing cervical radiculopathy, outcomes for ACD are equivalent to ACDF.

Xie et al[25] reported results of a prospective randomized controlled trial comparing clinical and radiographic outcomes of ACD, ACDF, and anterior cervical discectomy with instrumented fusion (ACDFI) for single level cervical radiculopathy. Of the 45 patients included in the study, 15 were randomly assigned to each treatment group. Three patients in the ACD group were lost to follow-up. No graft site pain was reported at two years. In general, clinical results improved to one year then plateaued. Arm pain was completely absent in 92% of ACD patients, 93% of ACDF patients and 100% of ACDFI patients. Neck pain was absent in 83%, 80% and 73%, respectively. All had significant and similar improvements in McGill Pain Questionnaire and SF-36. At two years, fusion rate on radiograph was 67%, 93%, and 100% respectively. Of patients treated with ACD, 75% had kyphosis at two years. The authors concluded that patient selection is the key to surgical success. Any of these surgeries are suitable for cervical radiculopathy due to nerve root compression. Because the long term effects of kyphosis are unknown, the potential consequences of ACD remain uncertain.

In critique, neither the patients nor reviewers were masked to treatment group, and the sample size was small. Due to these limitations, this potential Level I study provides Level II evidence that clinical outcomes for treatment of cervical radiculopathy due to single level degenerative disease are similar when comparing ACD to ACDF, with or without plating. Radiographic outcomes were worse with ACD, resulting in a significant loss of lordosis, although the clinical consequences of this are unknown. The validity of the conclusions may be compromised by a very small sample size.

RECOMMENDATION: The addition of an interbody graft for fusion is suggested to improve sagittal alignment following ACD.

GRADE OF RECOMMENDATION: B

Barlocher et al[3] conducted a prospective randomized controlled trial comparing outcomes of ACD to three different types of ACDF: ICBG, PMMA and titanium cages. All patients had one level disease. Of the 125 patients included in the study, 33 were assigned to the ACD group, 30 to ICBG, 26 to PMMA

and 36 to titanium cages. At one year follow-up, 123 patients were available. The functional outcomes were grouped by good and excellent to poor and fair, with good/excellent results reported for 75% of the ACDF group, 80% for ICBG, 87% for PMMA and 94% for cage. Average reported kyphosis for ACD patients was 24 degrees, with one patient requiring revision surgery (31 degrees); 12 degrees for PMMA and about three degrees for the ICBG and cage groups. Twelve month fusion results were reported as 93% for the ACD patients, 93% for ICBG and 97% for cage. Fusion rate was faster in the cage group as well with 86% achieving fusion at six months compared with 61% in the ACD group and 65% in the ICBG group. The authors concluded that ACDF with cage did significantly better with faster and better recovery and less kyphotic deformity than ACD. ACD compared to ICBG had similar outcomes at medium length follow-up.

In critique, neither reviewers nor patients were masked to treatment group and the randomization process was not described. No validated outcome measures were utilized, the sample size was small and length of follow-up was short. Use of PMMA as a spacer is not standard practice. Due to these limitations, this potential Level II RCT provides Level III evidence that suggests that there are variable outcomes when comparing ACD to ACDF for the treatment of cervical radiculopathy due to single level degenerative disease. While not the primary outcome measure, radiographic sagittal alignment was clearly better with ACDF compared to ACD. Validity of conclusions are weakened by small sample size and short follow-up.

Xie et al[25] reported results of a prospective randomized controlled trial comparing clinical and radiographic outcomes of ACD, ACDF, and anterior cervical discectomy with instrumented fusion (ACDFI) for single level cervical radiculopathy. Of the 45 patients included in the study, 15 were randomly assigned to each treatment group. Three patients in the ACD group were lost to follow-up. No graft site pain was reported at two years. In general, clinical results improved to one year then plateaued. Arm pain was completely absent in 92% of ACD patients, 93% of ACDF patients and 100% of ACDFI patients. Neck pain was absent in 83%, 80% and 73%, respectively. All had significant and similar improvements in McGill Pain Questionnaire and SF-36. At two years, fusion rate on radiograph was 67%, 93%, and 100% respectively. Of patients treated with ACD, 75% had kyphosis at two years. Approximately 25% had kyphosis between 5 and 15 degrees, while the other 50% were between 0 and 5 degrees. It should be noted that 15% of the patients had some measure of preoperative kyphosis. In both the ACDF and ACDFI groups, less than 5% of patients had a kyphosis of 5 to 15 degrees at final follow up. There was 0 to 5 degrees of kyphosis in approximately 30% and 20% of the ACDF and ACDFI groups respectively. Pre operative kyphosis was noted in 20% and 30% respectively. Looking at the data more closely, there was a clear loss of kyphosis in the ACD group. In the ACDF group, alignment tended to remain close to the pre operative condition in general, with slight subsidence and minimal loss of kyphosis in a small percent of patients such that at final follow up pre and post operative sagittal alignment were generally similar. If these patients exhibited pre operative segmental kyphosis, they tended to stay that way, as did those with pre operative lordosis. In the ACDFI group, there was a trend towards improved sagittal alignment when comparing pre and post operative lordosis. The authors concluded that patient selection is the key to surgical success. Any of these surgeries are suitable for cervical radiculopathy due to nerve root compression. There was a clear advantage for maintaining sagittal alignment with either ACDF or ACDFI. Because the long term effects of kyphosis are unknown, the potential consequences of ACD remain uncertain.

In critique, neither the patients nor reviewers were masked to treatment group, and the sample size was small. Due to these limitations, this potential Level I study provides Level II evidence that clinical out-

comes for treatment of cervical radiculopathy due to single level degenerative disease are similar when comparing ACD to ACDF, with or without plating. Radiographic outcomes were worse with ACD, resulting in a significant loss of lordosis, although the clinical consequences of this are unknown. The validity of the conclusions may be compromised by a very small sample size.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in further defining the role of fusion with ACD in the surgical treatment of cervical radiculopathy from degenerative disorders.

Prospective, blinded, RCT comparing clinical outcomes and radiographic alignment of patients treated for cervical radiculopathy due to single level degenerative disease with ACD compared with ACDF with a uniform surgical technique would generate important information about the relative value of preserving normal alignment.

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Does ACDF with instrumentation result in better outcomes (clinical or radiographic) than ACDF without instrumentation?

RECOMMENDATION: Both ACDF with and without a plate are suggested as comparable treatment strategies, producing similar clinical outcomes and fusion rates, in the treatment of single level cervical radiculopathy from degenerative disorders.

GRADE OF RECOMMENDATION: B

Grob et al[5] conducted a prospective randomized controlled trial comparing clinical and radiographic outcomes of ACDF and ACDFP. Of the 50 patients available at follow-up, 24 were randomized to ACDFP and 26 to ACDF. Both groups had a statistically significant decrease in VAS pain scores and improvement in cervical spine range of motion postoperatively, but there was no significant difference between groups for either of these outcome measures. Radiographically, there was no difference in the frequency of pseudoarthrosis/nonunion. The authors defined inferior "graft quality" as ventral graft dislocation greater than 2mm and/or loss of disc height by more than 2mm. Based upon these criteria, the plate group had significantly better results (p=.04). The authors concluded that addition of an anterior cervical plate did not lead to an improved clinical outcome for patients treated for cervical radiculopathy with a one or two level anterior procedure.

In critique, patients were not masked to treatment group and no validated outcome measures were utilized to assess this small sample of patients. The authors did not indicate that the patients were consecutively assigned and utilized a questionable randomization method. Due to these limitations, this potential Level I study provides Level II evidence that the addition of a plate does not improve outcomes following ACDF for cervical radiculopathy from degenerative disorders at an average of 34 months follow up, although it does appear to improve sagittal alignment.

Mobbs et al[8] described a retrospective comparative study comparing clinical and radiographic outcomes of ACDF with ACDFP in patients with cervical radiculopathy. Of the 212 radiculopathy patients included in the study, 116 received ACDF and 96 were treated with ACDFP. Using Odom's criteria, there was no significant difference in good to excellent outcomes between the two groups (87% of the ACDF patient group and 92% of the ACDFP). On the other hand, the noninstrumented group had a statistically significantly higher frequency of poor outcomes at 7% (8/116) compared to the ACDFP group at 1% (1/96). Poor outcomes were considered to be postoperative kyphosis and nonunion. The authors concluded that excellent results were similar for both groups. There was a significantly higher rate of poor outcomes in the uninstrumented group and this lead to higher rate of second surgery.

In critique, no validated outcome measures were used and the length of follow-up was short. This study provides Level III evidence that addition of an anterior locking plate may not lead to an increased likelihood of a satisfactory clinical outcome, but it may lower the likelihood of a poor outcome and need for reoperation.

Zoega et al[16] reported results of a prospective randomized controlled trial evaluating whether the addition of a plate to a single level cervical fusion for degenerative disc disease enhances fusion rate and contributes to maintaining alignment. Of the 27patients included in the study, 15 were assigned to the ACDFP group and 12 to the ACDF group. There was a statistically significant increase in the frequency of postoperative kyphosis in the nonplated group at one year follow-up (p=.04). At two years statistical significance was lost (p=>06). There was one nonunion in the plate group; none in the ACDF group. Clinical scores were the same for both groups. The authors concluded that the plate maintains alignment, but provides no advantage for healing or for clinical outcomes

In critique, neither patients nor reviewers were masked to treatment group. No validated outcome measures were utilized in this small sample of patients. Due to these limitations, this potential Level I study provides Level II evidence that the addition of a plate to ACDF maintains alignment.

RECOMMENDATION: The addition of a cervical plate is suggested to improve sagittal alignment following ACDF.

GRADE OF RECOMMENDATION: B

Grob et al[5] conducted a prospective randomized controlled trial comparing clinical and radiographic outcomes of ACDF and ACDFP. Of the 50 patients available at follow-up, 24 were randomized to ACDFP and 26 to ACDF. Both groups had a statistically significant decrease in VAS pain scores and improvement in cervical spine range of motion postoperatively, but there was no significant difference between groups for either of these outcome measures. Radiographically, there was no difference in the frequency of pseudoarthrosis/nonunion. The authors defined inferior "graft quality" as ventral graft dislocation greater than 2mm and/or loss of disc height by more than 2mm. Based upon these criteria, the plate group had significantly better results (p=.04). The authors concluded that addition of an anterior cervical plate did not lead to an improved clinical outcome for patients treated for cervical radiculopathy with a one or two level anterior procedure.

In critique, patients were not masked to treatment group and no validated outcome measures were utilized to assess this small sample of patients. The authors did not indicate that the patients were consecutively assigned and utilized a questionable randomization method. Due to these limitations, this potential Level I study provides Level II evidence that the addition of a plate does not improve outcomes following ACDF for cervical radiculopathy from degenerative disorders at an average of 34 months follow up, although it does appear to improve sagittal alignment.

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In critique, no validated outcome measures were used and the length of follow-up was short. This study provides Level III evidence that addition of an anterior locking plate may not lead to an increased likelihood of a satisfactory clinical outcome, but it may lower the likelihood of a poor outcome and need for reoperation.

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In critique, neither patients nor reviewers were masked to treatment group. No validated outcome measures were utilized in this small sample of patients. Due to these limitations, this potential Level I study provides Level II evidence that the addition of a plate to ACDF maintains alignment.

RECOMMENDATION: While plate stabilization may be indicated in some patients undergoing multilevel ACDF, there is insufficient evidence that this practice results in significant improvement in clinical outcomes for degenerative cervical radiculopathy.

Work Group Consensus Statement

A systematic review of the literature yielded no studies to adequately compare outcomes for ACDF with and without a plate for multilevel surgeries.

Future Directions for Research

The work group identified the following suggestion for a future study which would generate meaningful evidence to assist in further defining the role of instrumentation in addition to ACDF in the surgical treatment of cervical radiculopathy from degenerative disorders.

A well designed, prospective RCT to compare radiographic and clinical outcomes following ACDF with or without a plate for degenerative cervical radiculopathy would generate meaningful data regarding the potential long term benefits of preserving or restoring sagittal alignment. There should be two cohorts, one with single level disease, and one with multilevel disease.

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Does anterior surgery result in better outcomes (clinical or radiographic) than posterior surgery in the treatment of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: Either ACDF or PLF are suggested for the treatment of single level degenerative cervical radiculopathy secondary to foraminal soft disc herniation to achieve comparably successful clinical outcomes.

GRADE OF RECOMMENDATION: B

Herkowitz et al[7] reported results of a prospective study comparing ACDF to posterior laminoforaminotomy (PLF). Of the 33 radiculopathy patients included in the study, 17 were treated with ACDF and 16 with PLF. The average age of the patients assigned to the ACDF group was 43, while the average age of the patients assigned to the PLF group was 39. Of the ACDF patients, 94% reported good (5/17) or excellent (11/17) results. Of the PLF patients, 75% reported good (6/16) or excellent (6/16) results. ACDF was not significantly better ($p<0.175$). Osteophytic changes were seen in 9/17 ACDF patients and 8/16 PLF patients. The authors concluded that both surgical procedures are effective, but ACDF tends to be better over the long term.

In critique, neither patients nor reviewers were masked to treatment group and the randomization technique employed was questionable. No validated outcome measures were utilized to assess this small patient sample. Due to these limitations, this potential Level II study provides Level III evidence that ACD with fusion and posterior laminoforaminotomy appear equally effective in improving pain and weakness.

Korinth et al[8] described a retrospective comparative study comparing clinical results of anterior and posterior surgery for cervical radiculopathy due to soft disc herniation. Of the 363 patients included in the study, 154 were treated with ACDF using PMMA for median or paramedian discs and 209 received PLF for posterolateral or foraminal discs, and 80% (292/363: 124/154 ACDF, 168/209 PLF) were available for long term follow-up via clinical outpatient examination (14.7%), questionnaire (64.4%), and/or a telephone interview (20.9%).

Complication rates, primarily related to hoarseness and dysphagia, were reported in 6.5 % of ACDF patients and 1.8% of PLF patients. Reoperation rates were reported as 2.4% for the ACDF group and 7.1% for the PLF group. Mean operating time in the ACDF

group was 112 minutes and 94.1 minutes for the PLF group (p<0.000). Of the patients in the ACDF group, 93.6% (116/124) reported good (36.3%) or excellent (59.5%) results according to Odom's criteria and 0.8% reported poor results (p<0.05). Of the patients in the PLF group, 85.1% (142/168) reported good (25.6%) or excellent (59.5%) results according to Odom's criteria and 7.2% reported poor results (p<0.05). In the ACDF group, a pure soft disc was removed in 60 cases (48.4%) and a mixture of both hard and soft disc elements was removed in 64 (51.6%). In the PLF group, a pure soft disc was removed in 148 cases (88.1%) and a mixture of both hard and soft disc elements was removed in 20 cases (11.9%) (p<0.000). Soft disc herniations did not have significantly better outcomes than the mixture of soft and hard disc, although there appeared to be a trend. In general, shorter duration of preoperative symptoms correlated with improved outcomes. The authors concluded that anterior surgery yielded statistically superior outcomes, but both were effective. The findings show a higher success rate with anterior microdiscectomy with PMMA interbody stabilization for treatment of degenerative cervical monoradiculopathy compared with PLF.

In critique, no validated outcome measures were utilized and there was a tendency for patient selection to posterior procedure for more lateral disc herniations, whereas for paramedian and central herniations, there was an anterior bias. This study excluded patients with pure hard discs and pure foraminal stenosis. This study provides Level III evidence that patients improve with both PLF and ACDF, but ACDF results in statistically significantly better outcomes. However, ACDF is associated with a higher risk of complications, primarily related to dysphagia/hoarseness. PLF is associated with a higher reoperation rate.

Wirth et al[12] reported results of a prospective randomized controlled trial comparing clinical outcomes for surgery for unilateral disc herniation causing radiculopathy. Of the 72 patients included in the study, 22 were assigned to the PLF group, 25 to ACD and 25 to ACDF. Age, gender and duration of symptoms were similar for all groups. Although not specifically stated, follow-up was inclusive. Anesthesia time, hospital stay, charges and analgesics were similar. Pain improvement was reported by more than 96% of patients in all groups. It appears that all groups had similar outcomes. Return-to-work was reported as greater than 88% in all groups and there was similar incidence of new weakness and new numbness across all groups. Reoperation rate were reported as 27% for the PLF group, 12% for ACD and 28% for ACDF. The authors concluded that although the numbers in this study were small, none of the procedures could be considered superior to the others. This study suggests that the selection of surgical procedure may reasonably be based on the preference of the surgeon and tailored to the individual patient.

In critique, neither patients nor reviewers were masked to the treatment group and no validated outcome measures were utilized. The functional outcome tools were broad and subjective. The initial clinical visit occurred at two months; the 60 month follow-up was poorly coordinated and varied. Numbers were small with poor statistical analysis. Due to these limitations, this potential Level II study provides Level III evidence that ACD, ACDF and PLF result in comparable clinical outcomes in the treatment of cervical radiculopathy from unilateral disc herniation.

RECOMMENDATION: Compared to PLF, ACDF is suggested for the treatment of single level degenerative cervical radiculopathy from central and paracentral nerve root compression and spondylotic disease.

Work Group Consensus Statement

Future Directions for Research

The work group identified the following suggestion for a future study which would generate meaningful evidence to assist in further defining the roles of PLF and ACDF in the surgical treatment of cervical

radiculopathy from degenerative disorders.

Prospective, RCT with long term follow up to evaluate clinical outcomes, perioperative complications, and long term success including need for revision surgery following treatment of degenerative cervical radiculopathy with PLF versus ACDF. The study group would consist of foraminal stenosis only and should include two separate cohorts, including "soft disc" herniation and hard disc or spondylotic disease.

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Does posterior decompression with fusion result in better outcomes (clinical or radiographic) than posterior decompression alone in the treatment of cervical radiculopathy from degenerative disorders?

A systematic review of the literature yielded no studies to adequately compare the outcomes of posterior decompression with posterior decompression with fusion in the treatment of cervical radiculopathy from degenerative disorders. Most decompression and fusion appears to be indicated for multilevel stenosis resulting in myelopathy or for instability due to trauma, tumor, or inflammatory disease. Due to limited indications and thus limited sample size, there is likely little to gain and a low probability of generating meaningful data to compare effects of posterior decompression alone to posterior decompression and fusion for degenerative disease resulting in cervical radiculopathy.

Future Directions for Research

The study of posterior decompression and fusion for radiculopathy appears inappropriate. While this procedure may be indicated occasionally, there will not be enough data to study results effectively, and it would not be an appropriate arm of a randomized

study. Thus the workgroup would not recommend further pursuit of this question.

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Does ACD and reconstruction with total disc replacement result in better outcomes (clinical or radiographic) than ACDF in the treatment of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: ACDF and total disc arthroplasty (TDA) are suggested as comparable treatments, resulting in similarly successful short term outcomes, for single level degenerative cervical radiculopathy.

GRADE OF RECOMMENDATION: B

Murrey et al[6] conducted a prospective randomized controlled trial comparing safety and efficacy of TDA to ACDF for single level symptomatic cervical disc disease with radiculopathy. Of the 209 patients included in the study, 106 were assigned to the ACDF group and 103 to TDA. There was no difference in demographics between the TDA and ACDF groups. Follow-up rates were 98% for TDA and 94% for ACDF. ACDF had statistically significantly lower smaller blood loss and operative time (although differences small). Neurological improvement was better for TDA than ACDF at six months ($p<0.05$), but no significant difference was seen at 24 months ($p=0.638$). NDI improved from baseline for each group ($p<0.0001$); however, between groups there was a significant difference at three months for TDA ($p<0.05$) but not at 24 months ($p=1.0000$). This was also true for aggregate patients who had greater than a 15 point improvement. Secondary surgical procedures were performed in 1.9% of TDA patients and 8.5% of ACDF patients. Implant revision was required in 4.7% of the ACDF patients, with 2.8% of the ACDF patients requiring supplemental fixation, while no TDA patients required revision. VAS neck pain, arm pain frequency and intensity were similar for TDA and ACDF patients at 24 months.

Success, as defined by greater than 20% improvement in VAS scores, was reported for 87.9% of TDA patients and 86.9% of ACDF patients at 24 months. At 24 months, 80.8% of TDA patients and 74.4% of ACDF patients had successful outcomes as assessed by the SF-36 physical component summary. The SF-36 mental component summary showed 71.8% of TDA and 68.9% of ACDF patients were successful. Patient satisfaction, narcotic use and adverse events were similar for both groups. The authors concluded that TDA for single level disease is safe and effective and at least as good as ACDF.

In critique, neither patients nor reviewers were masked to treatment group. This study provides Level I evidence that TDA shows equivalent outcomes to ACDF at two years for treatment of cervical radiculopathy due to single level disease.

Nabhan et al[7] reported results of a prospective randomized controlled trial comparing radiographic and clinical results of TDA to ACDF. Of the 49 patients included in the study, 25 were assigned to TDA and 24 to ACDF; however, only 20 TDA and 21 ACDF patients could be measured due to artifact. Range of motion decreased in both groups. In the TDA group, average motion decreased from 2.3 at one week to 0.8 at 52 weeks; in ACDF, it decreased from 0.6 at one week to 0.1 at 52 weeks. Comparison between

groups showed that the motion was significantly less in the ACDF group for all time points except three weeks. Preoperatively, there was no statistical difference in symptoms between both groups (P=0.1), as measured by the VAS. Both groups showed the same pattern of pain relief in arm pain at all examination times without a statistically significant difference (P=0.13). The ACDF group showed a higher post-surgical resolving ratio in neck pain relief at three weeks, although without any statistically significant differences (P=0.09). The authors concluded that disc motion was maintained by TDA at one year and was greater than ACDF, with similar clinical results to ACDF.

In critique, neither patients nor reviewers were masked to treatment group. No validated outcome measures were used and the sample size was small. The study utilized a good radiographic analysis tool, but investigators chose neutral and extreme extension and lateral rotation for their motion analysis. Clinical evaluation was limited and was not the emphasis. Follow-up was only one year. Also the authors concluded that motion was maintained with TDA; however, the data demonstrate that it was not. Range of motion was decreased, but significantly greater than with ACDF. Due to these limitations, this potential Level I study provides Level II evidence that compared with ACDF, patients treated with TDA have statistically significantly greater range of motion. Clinical outcomes are similar for both groups.

There were several additional studies reviewed, some of them of high quality, that could not be included in this guideline due to confounding of myelopathy grouped with radiculopathy. Due to lack of subgroup analyses in these studies, no conclusions could be reached in regards to outcomes in patients with cervical radiculopathy from degenerative disorders.

Future Directions for Research

The work group identified the following suggestions for future studies which would generate meaningful evidence to assist in comparing outcomes of ACDF and TDA in the treatment of cervical radiculopathy from degenerative disorders.

Recommendation #1:

Continued long term follow-up of patients currently enrolled in previously reported RCTs is necessary to determine if purported advantages of TDA compared with ACDF can be validated, with particular focus on validated clinical outcomes, revision surgery and adjacent segment disease. Subgroup analysis should include soft disc compared with hard disc and foraminal compared with paracentral pathology for cervical radiculopathy patients.

Recommendation #2:

Additional independent, masked, prospective RCTs comparing ACDF to TDA for the treatment of cervical radiculopathy from degenerative disorders would add substantial unbiased validation to the results of the investigational device exemption (IDE) studies.

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What is the long-term result (four+ years) of surgical management of cervical radiculopathy from degenerative disorders?

RECOMMENDATION: Surgery is an option for the treatment of single level degenerative radiculopathy to produce and maintain favorable long term (greater than four year) outcomes.

GRADE OF RECOMMENDATION: C

Hamburger et al[7] described a retrospective case series reviewing results of ACD with PMMA. Of the 319 cervical radiculopathy patients included in the study, 249 were available for final follow-up at a mean of 12.2 years. Of the 249 patients available for final follow-up, 246 had single level and 3 had two level surgery. Good or excellent results were reported by 87% of patients. Lumbar symptoms and high occupational stress were correlated with clinical failure. Patients with soft disc herniations reported the best results. Relatively worse outcomes were reported when "patients had unclear preoperative findings." The authors concluded that ACD with PMMA is a safe and reliable method for treating monosegmental radiculopathy with outcomes and complication rates similar to other published studies.

In critique, no validated outcome measures were used. This study provides Level IV evidence that for the treatment of cervical radiculopathy due to single level disease, ACD with PMMA interbody spacer results in 77% of patients reporting satisfactory clinical outcomes at 10 to 15 years following surgery.

Heidecke et al[8] reported a case series reviewing outcomes of Cloward-type fusion at mean follow-up of 6.5 years. Of the 28 radiculopathy patients included, long term outcome was reported as good for 93% and fair for 7%. No poor results were reported. Adverse events were dominated by graft site complications. The authors concluded that Cloward ACDF is a reliable and safe procedure for single level disease.

In critique, no validated outcome measures were used in the study including a small sample of radiculopathy patients. This study provides Level IV evidence that for treatment of cervical radiculopathy due to degenerative disease, ACDF with Cloward technique results in 93% satisfactory results with long term (4-10 year) follow-up.

Jagannathan et al[11] presented findings from a retrospective case series reviewing results of PLF for treatment of single level cervical radiculopathy. Of the 212 cervical radiculopathy patients included in the study, long term outcomes were reported at a mean of 78 months for the 162 patients. While NDI improved in 93% of patients, 20% developed kyphosis. Patients who developed kyphosis reported worse results overall. During the follow-up period, 3.1% (5/162) required additional procedures; two had progression of disease at the index level, two developed stenosis and one developed "instability." The authors concluded that PLF is highly successful for treating cervical radiculopathy. This study provides Level IV evidence that posterior laminoforaminotomy for the treatment of cervical radiculopathy due to degenerative disease results in significant improvement in 93% of cases at 5-15 year follow-up. There may be a trend for patients older than 60 years with initial lordosis of less than 10 degrees to be more vulnerable to development of postoperative cervical kyphosis or translational deformity, though the clinical significance of this is uncertain.

Wirth et al[21] reported results of a prospective randomized controlled trial comparing clinical outcomes for surgery for unilateral disc herniation causing radiculopathy. Of the 72 patients included in the study, 22 were assigned to the PLF group, 25 to ACD and 25 to ACDF. Age, gender and duration of symptoms were similar for all groups. Although not specifically stated, follow-up was inclusive. Anesthesia time, hospital stay, charges and analgesics were similar. Pain improvement was reported by more than 96% of patients in all groups. It appears that all groups had similar outcomes. Return-to-work was reported as greater than 88% in all groups and there was similar incidence of new weakness and new numbness across all groups. Reoperation rates were reported as 27% for the PLF group, 12% for ACD and 28% for ACDF. Of the 72 patients included in the study, 60% [13/25 (52%) for ACD, 16/25 (64%) for ACDF, and 14/22 (64%) for PLF] were available for final follow-up at a mean of 60 months via telephone interview or clinic visit. The authors concluded that ACD, ACDF or PLF are reasonable surgical choices for cervical radiculopathy due to unilateral disc herniation.

In critique, neither patients nor reviewers were masked to the treatment group and no validated outcome measures were utilized. The functional outcome tools were broad and subjective. The initial clinical visit occurred at two months; the 60 month follow-up was poorly coordinated and varied. Numbers were small with poor statistical analysis and 40% were lost to follow-up. Due to these limitations, this potential Level II study provides Level III evidence that for unilateral radiculopathy caused by CDH, ACD, ACDF or PLF result in satisfactory outcomes at five year follow-up.

Future Directions for Research

The work group identified the following suggestion for future studies which would generate meaningful evidence to assist in comparing long term outcomes of various surgical procedures to assist in defining their role in the treatment of cervical radiculopathy from degenerative disorders.

An adequately powered, prospective, comparative study of patients treated with ACDF, ACD, TDA and PLF followed for greater than four years and assessed with validated outcome measures would yield useful information about the long term outcomes of surgery for cervical radiculopathy from degenerative disorders.

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How do long-term results of single-level compare with multilevel surgical decompression for cervical radiculopathy from degenerative disorders?

A systematic review of the literature yielded no studies to adequately address the comparison of long term results of single-level compared with multilevel surgical decompression in the management of cervical radiculopathy from degenerative disorders. After this review, it is clear that most patients with true radiculopathy suffer from one level and occasionally two level disease. The incidence of multilevel disease without the additional presence of myelopathy is rare. Thus, there is likely little to gain and a low probability of generating meaningful data to answer this question.

Future Directions for Research

The work group would not recommend further pursuit of this question, but suggests limiting efforts to collecting long term data in primarily single level disease.

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V. Appendices

Appendix A: Acronyms

ACD	anterior cervical discectomy/ decompression
ACDF	anterior cervical discectomy/ decompression and fusion
ACDFI	anterior cervical discectomy/ decompression and instrumented fusion
ACDFP	anterior cervical discectomy/ decompression and fusion plus plate
ADL	activities of daily living
AROM	active range of motion
C-TDR	cervical total disc replacement
CDH	cervical disc herniation
CR	cervical radiculopathy
CSR	cervical spondylotic radiculopathy
CT	computed tomography
CTM	computed tomography myelography
CTS	carpal tunnel syndrome
DTR	deep tendon reflex
EBM	evidence-based medicine
EMG	electromyography
GRE	gradient recall echo
HAD	Hospital Anxiety and Depression
HNP	herniated nucleus pulposus
HSQ	Health Status Questionnaire
ICBG	iliac crest bone graft
LFA	limited flip angle
MMI	Modified Million Index
MR	magnetic resonance
MRI	magnetic resonance imaging
NASS	North American Spine Society
NDI	Neck Disability Index
NPS	neurophysiologic studies
NPP	negative predictive power
NSAIDs	nonsteroidal anti-inflammatory drugs
ODI	Oswestry Disability Index
PEMF	pulsed electromagnetic field
PLF	posterior laminoforaminotomy
PMMA	polymethylmethacrylate
PPV	positive predictive value
PSFS	Patient Specific Functional Scale
RCT	randomized clinical trial
ROM	range of motion
SF-12	12-Item Short Form Health Survey
SF-36	36-Item Short Form Health Survey
SIP	Sickness Impact Profile
SNRB	selective nerve root block
TDA	total disc arthroplasty
TENS	transcutaneous electrical nerve stimulation
ULTT	Upper Limb Tension Test
VAS	Visual Analog Scale
ZDS	Zung Depression Scale

Appendix B:
Levels of Evidence For Primary Research Question[1]

	Types of Studies			
	Therapeutic Studies – Investigating the results of treatment	Prognostic Studies – Investigating the effect of a patient characteristic on the outcome of disease	Diagnostic Studies – Investigating a diagnostic test	Economic and Decision Analyses – Developing an economic or decision model
Level I	• High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals • Systematic review[2] of Level I RCTs (and study results were homogenous[3])	• High quality prospective study[4] (all patients were enrolled at the same point in their disease with ≥ 80% follow-up of enrolled patients) • Systematic review[2] of Level I studies	• Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) • Systematic review[2] of Level I studies	• Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses • Systematic review[2] of Level I studies
Level II	• Lesser quality RCT (eg, < 80% follow-up, no blinding, or improper randomization) • Prospective[4] comparative study[5] Systematic review[2] of Level II studies or Level I studies with inconsistent results	• Retrospective[6] study • Untreated controls from an RCT • Lesser quality prospective study (eg, patients enrolled at different points in their disease or <80% follow-up) • Systematic review[2] of Level II studies	• Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) • Systematic review[2] of Level II studies	• Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses • Systematic review[2] of Level II studies
Level III	• Case control study[7] • Retrospective[6] comparative study[5] • Systematic review[2] of Level III studies	• Case control study[7]	• Study of nonconsecutive patients; without consistently applied reference "gold" standard • Systematic review[2] of Level III studies	• Analyses based on limited alternatives and costs; and poor estimates • Systematic review[2] of Level III studies
Level IV	Case series[8]	Case series	• Case-control study • Poor reference standard	• Analyses with no sensitivity analyses
Level V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

1. A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.
2. A combination of results from two or more prior studies.
3. Studies provided consistent results.
4. Study was started before the first patient enrolled.
5. Patients treated one way (eg, cemented hip arthroplasty) compared with a group of patients treated in another way (eg, uncemented hip arthroplasty) at the same institution.
6. The study was started after the first patient enrolled.
7. Patients identified for the study based on their outcome, called "cases" (eg, failed total arthroplasty) are compared to those who did not have outcome, called "controls" (eg, successful total hip arthroplasty).
8. Patients treated one way with no comparison group of patients treated in another way.

Appendix C:
Grades of Recommendation
for Summaries or Reviews of Studies

A: Good evidence (Level I Studies with consistent findings) for or against recommending intervention.

B: Fair evidence (Level II or III Studies with consistent findings) for or against recommending intervention.

C: Poor quality evidence (Level IV or V Studies) for or against recommending intervention.

I: Insufficient or conflicting evidence not allowing a recommendation for or against intervention.

Appendix D:
Protocol for NASS Literature Searches

One of the most crucial elements of evidence analysis to support development of recommendations for appropriate clinical care or use of new technologies is the comprehensive literature search. Thorough assessment of the literature is the basis for the review of existing evidence, which will be instrumental to these activities.

Background

It has become apparent that the number of literature searches being conducted at NASS is increasing and that they are not necessarily conducted in a consistent manner between committees/projects. Because the quality of a literature search directly affects the quality of recommendations made, a comparative literature search was undertaken to help NASS refine the process and make recommendations about how to conduct future literature searches on a NASS-wide basis.

In November-December 2004, NASS conducted a trial run at new technology assessment. As part of the analysis of that pilot process, the same literature searches were conducted by both an experienced NASS member and a medical librarian for comparison purposes. After reviewing the results of that experiment and the different strategies employed for both searches, it was the recommendation of NASS Research Staff that a protocol be developed to ensure that all future NASS searches be conducted consistently to yield the most comprehensive results. While it is recognized that some searches occur outside the Research and Clinical Care Councils, it is important that all searches conducted at NASS employ a solid search strategy, regardless of the source of the request. To this end, this protocol has been developed and NASS-wide implementation is recommended.

Protocol for NASS Literature Searches

The NASS Research Department has a relationship with Northwestern University's Galter Health Sciences Library. When it is determined that a literature search is needed, NASS research staff will work with the requesting parties and Galter to run a comprehensive search employing at a minimum the following search techniques:

1. A preliminary search of the evidence will be conducted using the following clearly defined search parameters (as determined by the content experts). The following parameters are to be provided to research staff to facilitate this search.
   - Time frames for search
   - Foreign and/or English language
   - Order of results (chronological, by journal, etc.)
   - Key search terms and connectors, with or without MeSH terms to be employed
   - Age range
   - Answers to the following questions:
     - Should duplicates be eliminated between searches?
     - Should searches be separated by term or as one large package?
     - Should human studies, animal studies or cadaver studies be included?

This preliminary search should encompass a search of the Cochrane database when access is available.

2. Search results with abstracts will be compiled by Galter in Endnote software. Galter typically responds to requests and completes the searches within two to five days. Results will be forwarded to the research staff, who will share it with the appropriate NASS staff member or requesting party(ies). (Research staff hasve access to EndNote software and will maintain a database of search results for future use/documentation.)

3. NASS staff shares the search results with an appropriate content expert (NASS Committee member or other) to assess relevance of articles and identify appropriate articles to review and on which to run a "related articles" search.

4. Based on content expert's review, NASS research staff will then coordinate with the Galter medical librarian the second level searching to identify relevant "related articles."

5. Galter will forward results to Research Staff to share with appropriate NASS staff.

6. NASS staff share related articles search results with an appropriate content expert (NASS Committee member or other) to assess relevance of this second set of articles, and identify appropriate articles to review and on which to run a second "related articles" search.

7. NASS research staff will work with Galter library to obtain the 2nd related articles search results and any necessary full-text articles for review.

8. NASS members reviewing full-text articles should also review the references at the end of each article to identify additional articles which should be reviewed, but may have been missed in the search.

Protocol for Expedited Searches

At a minimum, numbers 1, 2 and 3 should be followed for any necessary expedited search. Following #3, depending on the time frame allowed, deeper searching may be conducted as described by the full protocol or request of full-text articles may occur. If full-text articles are requested, #8 should also be included. Use of the expedited protocol or any deviation from the full protocol should be documented with explanation.

Following these protocols will help ensure that NASS recommendations are (1) based on a thorough review of relevant literature; (2) are truly based on a uniform, comprehensive search strategy; and (3) represent the current best research evidence available. Research staff will maintain a search history in EndNote for future use or reference.

Appendix E:
Literature Search Parameters

Natural History of Cervical Radiculopathy from Degenerative Disorders Search Strategies

Search Strategies by Clinical Question:

1. What is the best working definition of cervical radiculopathy from degenerative disorders?

   Reviewed book chapters (see reference section).

2. What is the natural history of cervical radiculopathy from degenerative disoders?

   ((("Radiculopathy"[Mesh] OR "Polyradiculopathy"[Mesh] OR "IntervertebralDiskDisplacement"[Mesh]) AND cervical[All Fields]) OR ("cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields] OR "cervical disc herniation"[All Fields])) AND degenerative[All Fields] AND ("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]

Databases Searched:

- MEDLINE (PubMed)
- EMBASE
- Web of Science
- Cochrane Database of Systematic reviews
- Cochrane Central Register of Controlled Trials

Diagnosis/Imaging of Cervical Radiculopathy from Degenerative Disorders Search Strategies

Search Strategies by Clinical Question:

1. What are the most appropriate historical and physical exam findings consistent with the diagnosis of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Radiculopathy/diagnosis"[Mesh] OR "Diagnosis"[Mesh:noexp] OR "Diagnosis, Differential"[Mesh] OR "Signs and Symptoms"[Mesh])

2. What are the most appropriate diagnostic tests for cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Radiculopathy/diagnosis"[Mesh] OR "Diagnosis"[Mesh] OR "Signs and Symptoms"[Mesh]) AND (accuracy[All Fields] OR reliability[All Fields] OR validity[All Fields] OR "sensitivity and specificity"[All Fields] OR "predictive value of tests"[All Fields])

Databases Searched:

- MEDLINE (PubMed)
- EMBASE
- Web of Science
- Cochrane Database of Systematic reviews
- Cochrane Central Register of Controlled Trials

Outcome Measures for Cervical Radiculopathy from Degenerative Disorders Search Strategies

Search Strategies by Clinical Question:

1. What are the appropriate outcome measures for the treatment of cervical radiculopathy from degenerative disorders?

((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("outcome assessment (health care)"[MeSH Terms] OR ("outcome"[All Fields] AND "assessment"[All Fields] AND "(health"[All Fields] AND "care)"[All Fields]) OR "outcome assessment (health care)"[All Fields] OR ("outcome"[All Fields] AND "measure"[All Fields]) OR "outcome measure"[All Fields]) OR ("outcome assessment (health care)"[MeSH Terms] OR ("outcome"[All Fields] AND "assessment"[All Fields] AND "(health"[All Fields] AND "care)"[All Fields]) OR "outcome assessment (health care)"[All Fields] OR ("outcome"[All Fields] AND "measures"[All Fields]) OR "outcome measures"[All Fields]))

Databases Searched:

- MEDLINE (PubMed)
- EMBASE
- Web of Science
- Cochrane Database of Systematic reviews
- Cochrane Central Register of Controlled Trials

Medical/Interventional Treatment of Cervical Radiculopathy from Degenerative Disorders
Search Strategies

Search Strategies by Clinical Question:

1. What is the role of pharmacological treatment in the management of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Drug Therapy"[Mesh] OR "drug therapy "[Subheading] OR ("pharmacology"[MeSH Terms] OR "pharmacology"[All Fields] OR "pharmacological"[All Fields]) OR ("pharmaceutical preparations"[MeSH Terms] OR ("pharmaceutical"[All Fields] AND "preparations"[All Fields]) OR "pharmaceutical preparations"[All Fields] OR "medication"[All Fields])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

2. What is the role of physical therapy/exercise in the treatment of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Physical Therapy Modalities"[Mesh] OR "Exercise"[Mesh] OR "Physical Exertion"[Mesh] OR "Physical Fitness"[Mesh] OR "Rehabilitation"[Mesh] OR "rehabilitation "[Subheading] OR exercise[title] OR physical therapy[title] OR rehabilitation[title] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]))

3. What is the role of manipulation/chiropractics in the treatment of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Manipulation, Chiropractic"[Mesh] OR "Manipulation, Spinal"[Mesh] OR "Manipulation, Orthopedic"[Mesh] OR "Musculoskeletal Manipulations"[Mesh] OR "Chiropractic"[Mesh] OR manipulation[All Fields] OR ("chiropractic"[MeSH Terms] OR "chiropractic"[All Fields]))

4. What is the role of epidural steroid injections for the treatment of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Injections"[Mesh] OR injections[title] OR injection[title])

5. What is the role of ancillary treatments such as bracing, traction, electrical stimulation, acupuncture and transcutaneous electrical stimulation (TENS) in the treatment of cervical radiculopathy from degenerative disorders?

((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Braces"[Mesh] OR "Traction"[Mesh] OR "Electric Stimulation"[Mesh] OR "Transcutaneous Electric Nerve Stimulation"[Mesh] OR "Acupuncture Therapy"[Mesh] OR "Acupuncture"[Mesh] OR bracing[All Fields] OR ("braces"[MeSH Terms] OR "braces"[All Fields] OR "brace"[All Fields]) OR ("braces"[MeSH Terms] OR "braces"[All Fields]) OR ("traction"[MeSH Terms] OR "traction"[All Fields]) OR "electrical stimulation"[All Fields] OR ("transcutaneous electric nerve stimulation"[MeSH Terms] OR ("transcutaneous"[All Fields] AND "electric"[All Fields] AND "nerve"[All Fields] AND "stimulation"[All Fields]) OR "transcutaneous electric nerve stimulation"[All Fields] OR "tens"[All Fields]))

Databases Searched:

- MEDLINE (PubMed)
- EMBASE
- Web of Science
- Cochrane Database of Systematic reviews
- Cochrane Central Register of Controlled Trials

Surgical Treatment of Cervical Radiculopathy from Degenerative Disorders Search Strategies

Search Strategies by Clinical Question

1. Does surgical treatment (with or without preoperative medical/interventional treatment) result in better outcomes than medical/interventional treatment for cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Surgical Procedures, Operative"[Mesh] OR "surgery "[Subheading] OR surgery[title] OR surgical[title] OR operative[title] OR operation[title] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

2. Does anterior cervical decompression with fusion result in better outcomes (clinical or radiographic) than anterior cervical decompression alone?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Decompression, Surgical"[Mesh] AND anterior[All Fields] AND cervical[All Fields]) OR (anterior[All Fields] AND cervical[All Fields] AND ("decompression"[MeSH Terms] OR "decompression"[All Fields]) OR (anterior[All Fields] AND cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields]))) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]) AND (("Nucl Eng Des/Fusion"[Journal] OR "fusion"[All Fields]) OR ("arthrodesis"[MeSH Terms] OR "arthrodesis"[All Fields]))

3. Does anterior cervical decompression and fusion with instrumentation result in better outcomes (clinical or radiographic) than anterior cervical decompression and fusion without instrumentation?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Decompression, Surgical"[Mesh] AND anterior[All Fields] AND cervical[All Fields]) OR (anterior[All Fields] AND cervical[All Fields] AND ("decompression"[MeSH Terms] OR "decompression"[All Fields]) OR ((anterior[All Fields] AND cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields])) OR (anterior[All Fields] AND cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields])))) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]) AND (("Nucl Eng Des/Fusion"[Journal] OR "fusion"[All Fields]) OR ("arthrodesis"[MeSH Terms] OR "arthrodesis"[All Fields]))) AND ("instrumentation "[Subheading] OR "Bone Plates"[Mesh] OR ("bone plates"[MeSH Terms] OR ("bone"[All Fields] AND "plates"[All Fields]) OR "bone plates"[All Fields] OR "plate"[All Fields]) OR plates[All Fields] OR plating[All Fields] OR instrumentation[title] OR ("computers"[MeSH Terms] OR "computers"[All Fields] OR "hardware"[All Fields]))

4. Does anterior surgery result in better outcomes (clinical or radiographic) than posterior surgery in the treatment of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Decompression, Surgical"[Mesh] OR "Laminectomy"[Mesh] OR "cervical decompression"[All Fields] OR "laminectomy"[title] OR "laminotomy"[title] OR foraminotomy[title] OR laminoplasty[title] OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields])) OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields]))) AND (anterior[All Fields] AND posterior[All Fields]))

5. Does posterior decompression with fusion result in better outcomes (clinical or radiographic) than posterior decompression alone in the treatment of cervical radiculopathy from degenerative disorders?

((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Decompression, Surgical"[Mesh] OR "Laminectomy"[Mesh] OR "cervical decompression"[All Fields] OR "laminectomy"[title] OR "laminotomy"[title] OR foraminotomy[title] OR laminoplasty[title] OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields])) OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields]))) AND posterior[All Fields] AND (("Nucl Eng Des/Fusion"[Journal] OR "fusion"[All Fields]) OR ("arthrodesis"[MeSH Terms] OR "arthrodesis"[All Fields]))

6. Does anterior cervical decompression and reconstruction with total disc replacement result in better outcomes (clinical or radiographic) than anterior cervical decompression and fusion in the treatment of cervical radiculopathy from degenerative disorders?

   ((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Arthroplasty"[Mesh] AND disc[All Fields]) OR disc arthroplasty[All Fields] OR disk arthroplasty[All Fields] OR disc replacement[All Fields] OR disk replacement[All Fields] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("Nucl Eng Des/Fusion"[Journal] OR "fusion"[All Fields]) OR ("arthrodesis"[MeSH Terms] OR "arthrodesis"[All Fields])) AND (("Decompression, Surgical"[Mesh] AND anterior[All Fields] AND cervical[All Fields]) OR (anterior[All Fields] AND cervical[All Fields] AND ("decompression"[MeSH Terms] OR "decompression"[All Fields]) OR (anterior[All Fields] AND cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields])))) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]))

7. What is the long-term result (four+ years) of surgical management of cervical radiculopathy from degenerative disorders?

   ("Longitudinal Studies"[Mesh:noexp] OR (long[All Fields] AND term[All Fields]) OR long-term[All Fields] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ((((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields]

OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Surgical Procedures, Operative"[Mesh] OR "surgery "[Subheading] OR surgery[title] OR surgical[title] OR operative[title] OR operation[title] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])

8. How do long-term results of single-level compare with multilevel surgical decompression for cervical radiculopathy from degenerative disorders?

   ((((("Radiculopathy"[All Fields] AND cervical[All Fields]) OR "cervical radiculopathy"[All Fields] OR "cervical radiculitis"[All Fields]) AND ("Intervertebral Disk Displacement"[Mesh] OR foraminal stenosis[All Fields] OR ("intervertebral disk degeneration"[MeSH Terms] OR ("intervertebral"[All Fields] AND "disk"[All Fields] AND "degeneration"[All Fields]) OR "intervertebral disk degeneration"[All Fields] OR ("disc"[All Fields] AND "degeneration"[All Fields]) OR "disc degeneration"[All Fields]) OR disk degeneration[All Fields] OR disk herniation[All Fields] OR disc herniation[All Fields] OR degenerative[All Fields]) AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang])) AND ("Decompression, Surgical"[Mesh] OR "Laminectomy"[Mesh] OR "cervical decompression"[All Fields] OR "laminectomy"[All Fields] OR "laminotomy"[All Fields] OR foraminotomy[All Fields] OR laminoplasty[All Fields] OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields] OR "discectomy"[All Fields])) OR (cervical[All Fields] AND ("diskectomy"[MeSH Terms] OR "diskectomy"[All Fields])))) AND ("Longitudinal Studies"[Mesh:noexp] OR (long[All Fields] AND term[All Fields]) OR long-term[All Fields] AND (("1966"[PDAT] : "3000"[PDAT]) AND "humans"[MeSH Terms] AND English[lang]))

Databases Searched:

- MEDLINE (PubMed)
- EMBASE
- Web of Science
- Cochrane Database of Systematic reviews
- Cochrane Central Register of Controlled Trials

Appendix F: Evidentiary Tables

Evidentiary Table • Cervical Radiculopathy from Degenerative Disorders, Diagnosis/Imaging

What history and physical examination findings best support a diagnosis of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Bertilson BC, Grunnesjo M, Strender LE. Reliability of clinical tests in the assessment of patients with neck/shoulder problems-impact of history. Spine (Phila Pa 1976). Oct 1 2003;28(19):2222-2231.	Level II Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: To analyze the reliability of clinical tests in the assessment of neck and arm pain in primary care patients. Number of patients: 100 patients Physical examination/diagnostic test description: 66 clinical tests divided into nine categories Results/subgroup analysis (relevant to question): Reliability of clinical tests was poor to fair. Only a bimanual sensitivity test reached good values. With known clinical history, the prevalence of positive findings increased in all test categories. Sensitivity tests remained diagnostically useful. Usually helpful tests were not as diagnostically predictable, but also had increased positive findings when history was prerecorded before an exam was performed, as opposed to exam first before history was obtained. Shoulder abduction test k w/o - with history .77 - .62, Spurling's .28-.46, traction relieves.63-.8, Author conclusions (relative to question): Sensitivity tests were the most reliable and were exempt from bias. History had no impact on reliability, however, it had an impact on the incidence of positive findings.	*Critique of methodology:* ☒Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☒Other: only two reviewers *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:history and physical findings are not definitive, and may be susceptable to bias with a suggestive clinical history.
Chang H, Park JB, Hwang JY, Song KJ. Clinical analysis of cervical radiculopathy	Level IV Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To investigate the characteristics of cervical radiculopathy causing	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used:

causing deltoid paralysis. Eur Spine J. Oct 2003;12(5):517-521.		deltoid paralysis, and to report on the surgical outcomes of anterior cervical decompression with fusion (ACDF) for the treatment of deltoid paralysis. Number of patients: 14 Physical examination/diagnostic test description: All patients had radiating pain to scapula, shoulder or arm, with weakness of shoulder abduction due to paralysis of deltoid (graded 0-5). Severity of radiculopathy graded on VAS 0-10. Plain radiographs and MRI were correlated with clinical findings. Surgery performed on patients with single level cervical disc herniation (CDH) or cervical spondylotic radiculopathy (CSR). Patients with multilevel disease were excluded. Results/subgroup analysis (relevant to question): Paralysis of the deltoid with ipsilateral scapular, shoulder or arm pain may be the result of a single level CDH or CSR. Following are the single levels implicated and their respective frequencies: 1-C3-4 CDH (central), 4-C4-5 CDH, 1-C5-6 CDH, 3-C4-5 CSR, 5-C5-6 CSR. Both radiculopathy and deltoid paralysis improved significantly with surgery. Author conclusions (relative to question): A painful cervical radiculopathy with deltoid paralysis emanates from the C4-5, C5-6 and C3-4 levels: 50%, 43% and 7% of the time respectively.	☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:A painful cervical radiculopathy with deltoid paralysis arose from compressive disease at the C4-5, C5-6 and C3-4 levels: 50%, 43% and 7% of the time respectively.
Davidson RI, Dunn EJ, Metzmaker JN. The shoulder abduction test in the diagnosis of radicular pain in cervical extradural compressive monoradiculopathies. Spine (Phila Pa 1976). Sep-Oct 1981;6(5):441-446.	Level III Type of evidence: diagnostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To report observations on a series of patients with cervical monoradiculopathy due to compressive disease in whom clinical signs included relief of pain with abduction of the shoulder. Number of patients: 22 Physical examination/diagnostic test description: Twenty-two patients with arm pain had cervical extradural myelographic defects. 15/22 patients had relief from their pain with shoulder abduction (SAR). The 15 patients in the SAR group all had extradural defects consistent with their clinical findings. Motor weakness was present in 15,	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☒No Validated outcome measures used: ☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:relief from arm pain with

		paresthesias in 11 and reflex changes in 9 patients. Results/subgroup analysis (relevant to question): Of the 15 patients with a positive shoulder abduction sign, 13 required surgery and all achieved good results. Two of the 15 had pain relief with conservative therapy. Of the seven patients with negative shoulder abduction signs, five required surgery and two were successfully treated with traction. Of the five surgical patients, three had surgery for a central lesion and improved after surgery, two had surgery for a lateral disc fragment and only one had good results. Author conclusions (relative to question): The shoulder abduction test is a reliable indicator of significant cervical extradural compressive radicular disease.	shoulder abduction is an indicator of cervical extradural compressive radiculopathy.
Henderson CM, Hennessy RG, Shuey HM, Jr., Shackelford EG. Posterior-lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: a review of 846 consecutively operated cases. Neurosurgery. Nov 1983;13(5):504-512.	Level II Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: observational Stated objective of study: Report the results of posterior foraminotomy in the treatment of cervical radiculopathy. Number of patients: 736 patients underwent one or more posterior-lateral foraminotomies for simple cervical radiculopathy. Physical examination/diagnostic test description: The following symptoms were present: arm pain 99.4%, neck pain 79.7%, scapular pain 52.5%, anterior chest pain 17.8%, and headache 9.7%. Eleven patients presented with only left chest and arm pain ("cervical angina"). 53.9% of patients had pain or paresthesia in a dermatomal pattern. In 45.5%, the pain or paresthesia was diffuse or nondermatomal. No pain or parasthesia was reported by 0.6% of patients. 85.2% of patients reported a sensory change to pinprick, 68% had a specific motor deficit, and 71.2% had a specific decrease in a deep tendon reflex (DTR). Results/subgroup analysis (relevant to question): One level was thought to be primary 87.3% of the time and two levels were felt to be equally involved 12.7% of the time. The correlation between pain/paresthesia, motor deficit, DTR change, and	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☒No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that: 71.5% of the time, the operative site can be accurately predicted on the basis of clinical findings.

		the primary operative space was 73.8%, 84.8% and 83.5%, respectively. There was a 71.5% incidence of correlation between preoperative clinical findings and operative findings. Good or excellent results were reported by 91.5% of patients. Good or excellent relief of arm pain was found in 95.5% of patients, neck pain in 88.8%, scapular pain in 95.9%, chest pain in 95.4% and headache in 89.8%. Resolution of DTRs were reported by 96.9%. Residual sensory deficit was found in 20.9% of patients, and motor deficit in 2.3%. Author conclusions (relative to question): In a large group of patients with cervical radiculopathy, the study elucidates the common clinical findings of pain, paresthesia, motor deficit, and decreased deep tendon reflexes, along with their respective frequencies. It presents evidence that the operative site can be accurately predicted on the basis of clinical findings 71.5% of the time.	
Jenis LG, An HS. Neck pain secondary to radiculopathy of the fourth cervical root: an analysis of 12 surgically treated patients. J Spinal Disord. Aug 2000;13(4):345-349.	Level IV Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To report the results of surgical intervention in a series of patients with neck pain from C4 radiculopathy. Number of patients: 12 (11 with cervical radiculopathy without myelopathy) Physical examination/diagnostic test description: Pain localized to the posterior aspect of the neck, lateralized to the side with more involvement of the C4 root. Pain also reported in trapezial areas and upper extremities depending on the presence of more caudal radiculopathies. Neck pain was exacerbated by flexion and extension in all patients. Decreased sensation in the C4 dermatome was uniformily present. MRI in all patients and CT scan in three patients were performed prior to surgery. Excluding the myelopathic patient, four patients were treated with ACDF and seven patients were treated with PLF including 3/7 PSF. Evaluation of surgical results was determined by status of fusion, pain relief and level of activity based on Odom's criteria. Follow-up data was obtain at 12-48 months.	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☒No Validated outcome measures used: ☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:Neck pain with or without upper extremity clinical findings should include evaluation for a C4 radiculopathy. The examination should include C4 sensory testing.

		Results/subgroup analysis (relevant to question): Excluding the myelopathic patient, excellent, good and satisfactory relief was obtained in five, five and one patient, respectively. The three patients with isolated C4 radiculopathy had excellent results. Author conclusions (relative to question): Neck pain with or without upper extremity clinical findings should include evaluation for a C4 radiculopathy. The examination should include C4 sensory testing.	
Makin GJ, Brown WF, Ebers GC. C7 radiculopathy: importance of scapular winging in clinical diagnosis. J Neurol Neurosurg Psychiatry. Jun 1986;49(6):640-644.	Level IV Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: Report on six cases with scapular winging as a finding in some patients with C7 radiculopathy Number of patients: 6 Physical examination/diagnostic test description: Scapular winging was detected with the hands at shoulder level. In the remainder scapular winging was only evident when pushing against the wall with the hands at waist level. This latter method places the serratus anterior muscle at a mechanical disadvantage and reveals partial paralysis. Results/subgroup analysis (relevant to question): Each case confirmed by surgery or by CTM Author conclusions (relative to question): Scapular winging may be a component of C7 radiculopathy and when present serves to exclude lesions of the brachial plexus or radial nerve.	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that: scapular winging may be a feature of C7 radiculopathy in some patients and should not be misleading when present.
Ozgur BM, Marshall LF. Atypical presentation of C-7 radiculopathy. J Neurosurg. Sep 2003;99(2 Suppl):169-171.	Level IV Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: review 241 consecutive C6-7 discectomy patients for "presenting symptomatology" Number of patients: 241 Physical examination/diagnostic test description: clinical evaluation of presenting signs and	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☐Other:

		symptoms for usual and unusual findings Results/subgroup analysis (relevant to question): Most patients had usual C7 traditional radicular signs (dermatomal distribution), with 12% reporting sole complaint of subscapular pain, 5% having deep breast or chest pain. None of these 17% had the "typical" C7 presenting symptoms. Author conclusions (relative to question): Patients presenting with unusual symptoms had their complaints validated by surgical findings and 93% experienced symptom relief	*Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:a significant percentage of patients may present with atypical symptoms, in addition to or without standard symptoms (eg, scapular pain only). These patients responded well to surgical treatment.
Persson LCG, Carlsson JY, Anderberg L. Headache in patients with cervical radiculopathy: A prospective study with selective nerve root blocks in 275 patients. European Spine Journal. Jul 2007;16(7):953-959.	Level III Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To describe the frequency of headaches in patients with lower level cervical radiculopathy and its response to a selective nerve root block (SNRB). Number of patients: Of 275 total patients, 161 complained of headaches in addition to other symptoms. These are the ones studied. Physical examination/diagnostic test description: Of 275 patients, 161 suffered from daily or recurrent headaches, most often ipsilateral to the patients' radiculopathy. All patients underwent clinical exam and MRI. Patients with significantly compressed nerve root underwent SNRB. Effect on headache was evaluated with VAS. Results/subgroup analysis (relevant to question): All patients with headaches had tender points in the neck/shoulder region ipsilateral to the radiculopathy. Patients with headache had significantly more limitations in daily activites and higher pain in the neck/shoulder. Immediately before the injections, 161 (59%) of patients experienced a headache exceeding 15 on the VAS. Of the 161 patients, 101 (63%) experienced >25% headache reduction following SNRB, 93 (58%) reported greater than 50% headache reduction, 66 experienced 100% relief. (C4 3%, C5 11%, C6 52%, C7 29%, C8 5%) A significant correlation was found between reduced headache and decreased pain in the neck and shoulder region.	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☒Other: 50% threshold and lack of specificity of the injection *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:Complaint of headache is also a common symptom with C4 and lower nerve compression problems. SNRB can reduce headaches in a significant percentage of patients, and this was considered significant as a diagnostic tool.

		Author conclusions (relative to question): Cervical nerve root compression from degenerative disease in the lower cervical spine producing radiculopathy can also result in headache. The neck pain seems to restrict the patient's activity. Headache classification and assessment together with muscle palpation should be part of the neck exam for patients with cervical radiculopathy.	
Post NH, Cooper PR, Frempong-Boadu AK, Costa ME. Unique features of herniated discs at the cervicothoracic junction: Clinical presentation, imaging, operative management, and outcome after anterior decompressive operation in 10 patients. Neurosurgery. Mar 2006;58(3):497-501.	Level IV Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: Review their experience with the operative management of a series of patients with C7-T1 herniations. Number of patients: 10 Physical examination/diagnostic test description: Symptoms included shoulder pain radiating into the lateral aspect of the hand, hand weakness and weakness in finger flexion, finger extension, and intrinsic hand muscles. Sensation and DTRs were unremarkable. Results/subgroup analysis (relevant to question): MRI on each patient revealed a soft disc compressing the C8 nerve. Recovery of hand strength was noted in each patient, however, recovery was incomplete in two patients with symptoms greater than four months. Author conclusions (relative to question): None stated	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☒No Validated outcome measures used: ☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:C8 radiculopathy usually presents as weakness of the hand, and pain radiating to shoulder, scapular area, and to the fourth and fifth fingers. Physical exam may reveal normal sensory and DTR's. Motor examination may show weakness of flexors and extensors of the fingers and also weakness of intrinsic muscles of the hand.
Shah KC, Rajshekhar V. Reliability of diagnosis of soft cervical disc prolapse using Spurling's test. Br J Neurosurg. Oct 2004;18(5):480-483.	Level II Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To determine the sensitivity and specificity of the Spurling's test in predicting the diagnosis of a soft lateral cervical disc herniation in patients with neck and arm pain. Number of patients: 50	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☐Other:

		Physical examination/diagnostic test description: Spurling's test with cervical extension, lateral flexion to the side of pain, and downward pressure on the head was performed on all patients. Twenty-five patients underwent surgery (Group 1) and 25 were managed conservatively (Group 2). Spurling's test correlated with surgical findings in Group 1, and with MRI findings in Group 2. Patients with minimal or no neurologic deficits with the first episode of radicular pain and those who refused surgery were managed conservatively. Results/subgroup analysis (relevant to question): Group 1 (25 patients): 18/18 with a positive Spurling's test had a soft disc herniation. Of seven patients with a negative Spurling's test, two had a soft disc herniation and five had a hard disc. Group 2 (25 patients): Of the 10 patients with a positive Spurling's test, nine had a soft disc herniation, one had a hard disc. Of the 15 patients with a negative Spurling's test, a hard disc was seen in eight, and MRI was normal in seven. The Spurling's test had a sensitivity of 92%, a specificity of 95%, a positive predictive value (PPV) of 96.4% and a negative predictive value (NPP) of 90.9% for a soft disc herniation. Author conclusions (relative to question): The high PPV indicates that the Spurling's test can be used to increase the incidence of disease in patients undergoing MRI for cervical radiculopathy.	*Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:a positive Spurling's test can increase the incidence of compressive disease in patients undergoing evaluation for cervical radiculopathy.
Slipman CW, Plastaras CT, Palmitier RA, Huston CW, Sterenfeld EB. Symptom provocation of fluoroscopically guided cervical nerve root stimulation. Are dynatomal maps identical to dermatomal maps? Spine (Phila Pa 1976). Oct 15 1998;23(20):2235-2242.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To study the distribution of pain and parasthesias that result from the stimulation of specific cervical nerve roots. Number of patients: 87 patients, 134 selective nerve root stimulations Physical examination/diagnostic test description: Mechanical stimulation of nerve roots were carried out: 4 at C4, 14 at C5; 43 at C6; 52 at C7; and 21 at C8. An independent observer recorded the location of provoked symptoms on a pain diagram. Visual data was compiled using a 793 body sector bit map with 43 body regions identified.	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:distribution of pain and

		Results/subgroup analysis (relevant to question): Although the distribution of symptom provocation resembled the classic dermatomal maps, symptoms were frequently provoked outside the classic descriptions. Author conclusions (relative to question): There was a distinct difference between the dynatomal and dermatomal maps.	paresthesias in the arm from nerve root stimulation can be different than dermatomal maps in a significant percentage of patients, making it difficult to identify the level based on pain distribution. In some patients it explains the nondermatomal distribution of pain.
Tanaka Y, Kokubun S, Sato T, Ozawa H. Cervical roots as origin of pain in the neck or scapular regions. Spine. Aug 1 2006;31(17):E568-573.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To determine if pain in the neck or scapular regions in patients with cervical radiculopathy originates from the compressed nerve root and whether the site of pain is useful for identifying the level involved. Number of patients: 50 consecutive Physical examination/diagnostic test description: Patients who experienced pain with arm and finger symptoms underwent single level decompression. The level was determined based on correlation of symptoms and imaging, and SNRB in five patients. Cervical disc herniation was found in 20 patients and stenosis in 30. Patients underwent posterior open foraminotomy with follow-up at one month and one year after surgery. Results/subgroup analysis (relevant to question): Pain preceeded the arm/finger symptoms in 35 patients (70%) and was relieved early in 46 (92%). When the pain was suprascapular, C5 or C6 radiculopathy was frequent. When it was interscapular, C7 or C8 radiculopathy was frequent. When scapular, C8 was frequent. Arm and finger symptoms improved significantly in all groups after decompression. Sixty-one painful sites were noted before surgery: one in 39 patients, and two in 11 patients. Following surgery, 27 patients reported complete pain relief, 23 had pain in 24 regions and seven reported no change with surgery. Seventeen pain sites were new since surgery. All but one new site were nuchal and suprascapular. At one year follow-up, 45 patients reported no pain, five patients had pain in six sites, three of which were the same as before surgery. C5 pain localized to the nuchal, scapula, and	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:cervical radiculopathy at C5, C6, C7 and C8 frequently causes pain in suprascapular, interscapular and scapular areas and is useful in determining the level of nerve root involvement. Pain in the suprascapular region indicates C5 or C6 radiculopathy, the pain in the interscapular region indicates C7 or C8 radiculopathy, and pain in the scapular region indicates C8 radiculopathy.

		suprascapular areas; C6, suprascapular pain was significant; C7, interscapular pain was frequent; and C8, interscapular pain and scapular pain was frequent. Author conclusions (relative to question): Pain in the suprascapular, interscapular or scapular regions can orginate directly in the compressed root and is valuable for determing the nerve root involved.	
Tong HC, Haig AJ, Yamakawa K. The Spurling test and cervical radiculopathy. Spine (Phila Pa 1976). Jan 15 2002;27(2):156-159.	Level IV Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: comparative Stated objective of study: To determine the sensitivity and specificity of the Spurling test for cervical radiculopathy. Number of patients: 255 patients were referred for electrodiagnosis of upper extremity nerve disorders. Physical examination/diagnostic test description: The Spurling test was performed on all patients before EMG. The test was scored as positive if it resulted in pain or tingling starting in the shoulder and radiating distal to the elbow. A differential diagnosis based on the history and physical exam was made prior to EMG. EMG was performed and each diagnosis in the differential was scored relative to the likelihood of its occurrence. Results/subgroup analysis (relevant to question): Of the 255 patients presented, 31 had missing data, leaving 224 patients for inclusion. Of 20 patients with a positive EMG for cervical radiculopathy, the Spurling's test was positive in seven, for a sensitivity of 7/20 or 30%. Of 172 patients with no EMG evidence for radiculopathy, the Spurling's test was negative in 160, for a specificity of 160/172 or 93%. The Spurling's test was positive in 16.6% of patients with a normal EMG, in 3.4% of patients with an EMG diagnosis of a nerve problem other than radiculopathy, and in 15% of patients with nonspecific EMG findings. The odds ratio of a positive Spurling's test for a positive EMG for cervical radiculopathy is 5.71. Author conclusions (relative to question): Spurling's test is not sensitive, but is specific for	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☒Other: poor reference standard. *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:The Spurling's test is not sensitive, but is specific for cervical radiculopathy as diagnosed by EMG. A positive test increases the incidence of radiculopathy in patients undergoing EMG for upper extremity nerve disorders.

		cervical radiculopathy as diagnosed by EMG. Not useful as a screening test, but may be useful to confirm the diagnosis.	
Wainner RS, Fritz JM, Irrgang JJ, Boninger ML, Delitto A, Allison S. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. Spine (Phila Pa 1976). Jan 1 2003;28(1):52-62.	Level IV Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: comparative Stated objective of study: To assess the reliability and accuracy of individual clinical exam items and self reported instruments for the diagnosis of cervical radiculopathy, and to identify and assess the accuracy of an optimal cluster of test items. Number of patients: 82 Physical examination/diagnostic test description: Consecutive patients referred for EMG for the evaluation of cervical radiculopathy (CR) or carpal tunnel syndrome (CTS). Only patients judged by the laboratory provider (seven different providers) to have signs and symptoms compatible with CR or CTS were eligible to participate. Patients with Class 5 or 6 cervical radiculopathy findings were further classified according to the severity of their EMG findings. Self-reported items included the VAS and NDI. Standardized clinical exam was performed by two of nine physical therapists and contained 34 items. History contained six questions asked by two physical therapists. Neurological exam included strength, DTRs and sensation. Provocative tests included Spurling's test, shoulder abduction test, Valsalva maneuver, neck distraction test and the upper limb tension test. Cervical range of motion measured. Results/subgroup analysis (relevant to question): Fifteen patients had an EMG diagnosis of cervical radiculopathy (CR), five patients with CR and concomitant ulnar neuropathy and CTS. One patient with combined findings dropped out of the study. Of the 19 patients reported, 13 had mild symptoms and six had moderate symptoms. Reliability of different clinical items were reported including the Spurlings A/B .6/.62, shoulder abduction .2, valsalva .69, distraction .88, Upper Limb Tension Test (ULTT) A/B .76/.83. Sensitivity/specificity: Spurlings A/B .6/.62, shoulder abduction .2, valsalva .69, distraction .88, ULTT A/B .76/.83. 19 patients with CR (13 mild, 6 moderate).	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☒Small sample size ☐Lacked subgroup analysis ☒Other: EMG gold standard, also test selection bias. *Work group conclusions:* Potential level: III Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:Provocative tests, including the Spurling's test, shoulder abduction test, Valsalva and distraction test had a low sensitivity and high specificity for cervical radiculopathy as diagnosed by EMG.

		Sensitivity/Specificity: Spurling's A/B - 0.5/0.86 - 0.74; shoulder abduction - 0.17/0.92; valsalva - .22/.94; distraction - 0.44/0.9; ULTT A/B - 0.72-0.97/0.22-0.33. Cluster of ULTTA, cervical rotation <60degrees, distraction, and Spurling's A - 0.24/0.99 Author conclusions (relative to question): Many items were found to have at least a fair level of reliability, and to have acceptable diagnostic properties. The test item cluster identified was found to be the most useful.	
Yoss RE, Corbin KB, Maccarty CS, Love JG. Significance of symptoms and signs in localization of involved root in cervical disk protrusion. Neurology. Oct 1957;7(10):673-683.	Level II Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: observational Stated objective of study: To correlate clinical findings with operative findings when a single cervical nerve root (C5,C6,C7,C8) is compressed by a CDH. Number of patients: 100 Physical examination/diagnostic test description: Symptoms included pain in the neck, shoulder, scapular or interscapular region, arm, forearm or hand; paresthesias in forearm, and hand; and weakness of upper extremity. Signs included diminution of triceps, biceps and brachioradialis reflexes, muscle weakness and sensory loss. Surgically verified nerve root compression, sufficient information to support the surgeons preoperative impression, relief of symptoms following surgery. Results/subgroup analysis (relevant to question): The presence of pain or paresthesia in the neck, shoulder, scapular or interscapular region was present in cases of C5, C6, C7, C8 compression. The presence of pain in the arm corresponded to the site compression in 23% of cases. The presence of pain or paresthesia in the forearm corresponded to a single root or one of two roots in 32% and 66%, respectively. Hand pain and paresthesia corresponded to a single root or one of two roots in 70% and 27%, respectively. Subjective weakness corresponded to a single level in 22/34 (79%) cases. When a diminution of DTR was present, the lesion could be correctly localized to a single level or one	*Critique of methodology:* ☐Patients not enrolled at same point in their disease ☐<80% follow-up ☐No Validated outcome measures used: ☐Tests not uniformly applied across patients ☐Small sample size ☐Lacked subgroup analysis ☒Other: Marked testing bias *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:Clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. Single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.

		of two levels in 11% and 82%, respectively. Objective muscle weakness corresponded to a single root or one of two roots in 77% and 12%, respectively. All cases of objective weakness in which root C5 or C8 was involved, the level was correctly localized. Sensory loss corresponded to a single root or one of two roots in 65% and 35%, respectively. Author conclusions (relative to question): Clinical findings related to the fingers are the most accurate for localizing a CDH to a single level. A single level CDH may produce signs and symptoms that correspond to overlapping dermatomal levels.	

Evidentiary Table • Cervical Radiculopathy from Degenerative Disorders, Diagnosis/Imaging

What are the most appropriate diagnostic tests (including imaging and electrodiagnostics), and when are these tests indicated in the evaluation and treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Alrawi MF, Khalil NM, Mitchell P, Hughes SP. The value of neurophysiological and imaging studies in predicting outcome in the surgical treatment of cervical radiculopathy. Eur Spine J. Apr 2007;16(4):495-500.	Level III Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: Investigate whether preoperative electromyography (EMG) can help select those most likely to benefit from intervention. Diagnostic test(s) studied: ☐Clinical exam/history ☒Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☐Other: Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical outcome Number of patients: 20 Consecutively assigned? No Results/subgroup analysis (relevant to question): Study of 20 patients with clinical manifestations of cervical	*Critique of methodology:* ☒Nonconsecutive patients ☐Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:Patients with cervical radiculopathy and an MRI showing a disc bulge with narrowing of the exit foramina have better clinical outcomes and patient satisfaction from their anterior cervical decompression with fusion (ACDF) if a preoperative EMG shows denervation changes.

		radiculopathy and an magnetic resonance imaging (MRI) showing disc bulges associated with narrowing of the exit foramina. The operative level was unclear in all patients. Preoperatively patients were divided into groups A and B on the basis of an EMG. Group A had eight patients with denervation changes in the distribution of a least one cervical nerve root. Group B had 12 patients with no EMG evidence of cervical radiculopathy. Patients in group A had better clinical outcomes and patient satisfaction from their ACDF at least 12 months postoperatively than patients in group B. Author conclusions (relative to question): Preoperative neurophysiological studies (NPS) can help identify which patients are likely to benefit from surgery for cervical radiculopathy.	
Anderberg L, Annertz M, Rydholm U, Brandt L, Saveland H. Selective diagnostic nerve root block for the evaluation of radicular pain in the multilevel degenerated cervical spine. Eur Spine J. Jun 2006;15(6):794-801.	Level III Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: Assess the ability of transforaminal selective nerve root blocks (SNRB) to correlate clinical symptoms with MRI findings in patients with cervical radiculopathy and two level MRI degeneration ipsilateral to the radicular pain. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: SNRB Compared to: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram	*Critique of methodology:* ☐Nonconsecutive patients ☒Small sample size ☒No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☒Other: surgical treatment or transforminal epidural steroid injection (ESI) treatment performed in only 22/30 *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:SNRB may be useful in the preoperative evaluation of patients with radiculopathy and findings of compressive lesion at multiple levels on MRI.

		☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical outcomes Number of patients: 30 Consecutively assigned? Yes Results/subgroup analysis (relevant to question): Of 30 patients, 22 had neurologic deficits that occurred with cervical radiculopathy. Degenerative changes on MRI were found in close relation to nerve roots. Neuroforaminal narrowing was graded as slight, moderate or severe, without further analysis. Clinical findings were correlated with MRI findings and root block levels were determined. No analgesics were administered within 12 hours prior to the procedure, and there was no mention if sedation was given prior to the procedure. An unspecified volume of contrast was administered to confirm perineural needle position within the foramen prior to SNRB. SNRB with 0.5 ml solution of 5 mg of Mepivacaine was administered. VAS outcomes were assessed 30 minutes and four hours after SNRB. VAS reduction of at least 50% was required to determine that the SNRB was positive; no indication if VAS score occurred 30 minutes or 4 hours after the SNRB. In 18 patients with positive SNRB at a single level, the SNRB correlated with the level of more marked pathology in 12, to the level determined by the neurologic deficits in eight, and to the level corresponding to the sensory dermatone in seven. In 11 patients with positive SNRB at two levels, these levels corresponded to findings on MRI in 6. Of 13 patients treated at one level, 9 (67%) had good or excellent results. Of nine patients treated at two levels, 100% had good or excellent results. Author conclusions (relative to question): Clinical symptoms and signs in isolation or in combination with MRI findings are	

		not always reliable indicators of the pain generating nerve root. SNRB may be useful in treatment planning in patients with radiculopathy and degenerative changes at two levels ipsilateral to the patient's symptoms	
Anderberg L, Saveland H, Annertz M. Distribution patterns of transforaminal injections in the cervical spine evaluated by multi-slice computed tomography. European Spine Journal. Oct 2006;15(10):1465-1471.	Level II Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: Study the selectivity of cervical transforaminal injections and the distributions of a range of injection volumes in patients with cervical radiculopathy. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: SNRB Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☒CT ☐CT/Myelogram ☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: CT Number of patients: 9 Consecutively assigned? Yes Results/subgroup analysis (relevant to question): Three groups of three patients received either 0.6, 1.1 and 1.7 ml of injectate via the transforaminal root technique used by Kikuchi. The groups injected with 0.6 and 1.1 ml received local anesthetic and contrast. The group injected with 1.7 ml received local anesthetic, corticosteroid and contrast.	*Critique of methodology:* ☐Nonconsecutive patients ☒Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:transforaminal injectate volumes of 0.6 ml consistently meet the criteria for SNRB.

		Contrast distribution was determined by a postinjection CT scan. An injection was considered a SNRB if the contrast media surrounded an adjacent nerve root by less than half of its circumference. In all three patients receiving 0.6 ml of injectate, the injections were considered SNRB. In 1/3 of patients the contrast was noted in an intraspinal/epidural distribution. In 2/3 of patients given 1.1 ml of injectate the injections were considered SNRB. In both of these SNRB injections, there was spread of contrast around less than one-half the circumference of adjacent nerve roots. None of the three patients receiving 1.7 ml of injectate had a SNRB. The perineural distribution length averaged 36 mm, with no correlation to injectate volume. Author conclusions (relative to question): Only 0.6 ml injections should be accepted as SNRB.	
Ashkan K, Johnston P, Moore AJ. A comparison of magnetic resonance imaging and neurophysiological studies in the assessment of cervical radiculopathy. Br J Neurosurg. Apr 2002;16(2):146-148.	Level III Type of evidence: diagnostic	☐Prospective ☒Retrospective Study design: comparative Stated objective of study: To assess whether neurophysiologic studies (NPS) added significant information to high resolution MRI in the evaluation of cervical radiculopathy. Diagnostic test(s) studied: ☐Clinical exam/history ☒Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☒Other: nerve conduction studies Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☐Other:	*Critique of methodology:* ☒Nonconsecutive patients ☐Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:MRI is mlore accurate and more sensitive than NPS in the preoperative evaluation of patients with cervical radiculopathy.

		Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical outcomes Number of patients: 45 Consecutively assigned? No Results/subgroup analysis (relevant to question): Of the 45 patients, three experienced bilateral symptoms. Radicular arm pain was present in all cases, parasthesias in 28, numbness in 22 and subjective weakness in 14. Following surgery, 36 patients had complete resolution of symptoms and seven experienced significant improvement in symptoms. Of patients who improved following surgery, 16 (37%) had a positive MRI and NPS; 24 (56%) had a positive MRI and negative NPS; two (5%) had a negative MRI and positive NPS; and one (2%) had negative MRI and NPS studies. In the three cases with a negative MRI, surgical plans were based on the NPS in one case and on CTM in two. In five patients with foraminal stenosis on MRI the patients did not improve. Of these five patients, four were operated on at the level indicated by MRI. Sensitivity for diagnosing cervical radiculopathy was 93% for MRI and 42% for NPS; with positive predictive values at 91% for MRI and 86% for NPS. Negative predictive values were 25% for MRI, and 7% for NPS. Author conclusions (relative to question): In patients with clinical and MRI evidence of cervical radiculopathy, NPS has limited additional diagnostic value.	
Bartlett RJV, Hill CR, Gardiner E. A comparison of T₂ and gadolinium enhanced MRI with CT	Level II Type of evidence: diagnostic	☒Prospective ☐Retrospective Study design: comparative Stated objective of study: To compare the accuracy of gadolinium (Gd) enhanced MRI with 3D gradient recalled echo (3D GRE) images in the evaluation of cervical	*Critique of methodology:* ☐Nonconsecutive patients ☐Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis

myelography in cervical radiculopathy. British Journal of Radiology. Jan 1998;71(JAN.): 11-19.		radiculopathy. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☒CT/Myelogram ☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: best diagnosis reviewing all the studies Number of patients: 20 Consecutively assigned? Yes Results/subgroup analysis (relevant to question): 3D GRE images had an accuracy of 87% for the diagnosis of foraminal encroachment. CTM had an accuracy of 90%. MRI with Gd conferred no additional benefit. Oblique reconstructions were less accurate than axial images. Author conclusions (relative to question): MRI with 3D GRE images is an acceptable technique for the primary evaluation of cervical radiculopathy. CTM remains indicated for patients with incongruent symptoms and MRI results.	☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:MRI with 3D T2 technique has an accuracy approaching that of CT myelography for the diagnosis of a compressive lesion in patients with cervical radiculopathy.
Hedberg MC, Drayer BP, Flom RA, Hodak JA, Bird CR. Gradient echo (GRASS) MR imaging in	Level III Type of evidence: diagnostic	☐Prospective ☒Retrospective Study design: comparative Stated objective of study: To determine the accuracy of MRI with limited flip angle (LFA) GRE technique in patients with	*Critique of methodology:* ☐Nonconsecutive patients ☒Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied

cervical radiculopathy. AJR Am J Roentgenol. Mar 1988;150(3):683-689.		cervical radiculopathy. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Compared to: ☐Clinical exam/history ☐Electromyography ☒Myelogram ☐MRI ☐CT ☒CT/Myelogram ☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical findings Number of patients: 13/130 Consecutively assigned? Yes Results/subgroup analysis (relevant to question): MRI was performed in 130 patients, myelography in 30, CTM in 16 and CT in five. Pathologic confirmation was obtained in 13 surgically treated patients. Of the studies, 31 were normal and neither myelography nor surgery were performed. Extradural defects were detected in 99/130 patients (52 central, 26 dorsolateral osteophyte, 4 dorsolateral disc, 17 dorsolateral disc/osteophyte). Myelography/CTM and nonenhanced CT confirmed the abnormalities in 20 and five patients, respectively. Surgical findings from 13 patients and 30 sites showed correlation with MRI on 3/3 herniations and 26/27 degenerative abnormalities. Author conclusions (relative to question): MRI is sufficient for the evaluation of cervical radiculopathy and may obviate the need for more invasive myelography and CT.	☐Lacked subgroup analysis ☒Other: older technique *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:MRI is accurate in the diagnosis of disc herniation and degenerative abnormalities in the spine.

Houser OW, Onofrio BM, Miller GM, Folger WN, Smith PL. Cervical Disk Prolapse. Mayo Clinic Proceedings. Oct 1995;70(10):939-945.	Level III Type of evidence: diagnostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To correlate the findings on CTM with surgical and path proven cervical herniations. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☒CT/Myelogram ☐Other: Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☒CT ☐CT/Myelogram ☐Other: Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical findings/pathology Number of patients: 297 Consecutively assigned? No Results/subgroup analysis (relevant to question): Over three years, 734 patients underwent CTM for cervical disc disease. CTM findings identified cervical disc hernations (CDH) in 297 patients. Of the 297 patients, 280 were diagnosed with radiculopathy and 17 with myelopathy. At surgery, cervical disc hernations (CDH) were noted in 297 patients. In the 297 patients, surgical reports noted one or more prolapsed discs in 258, a prolapsed disk and spur in 38, and a prolapsed disk with a fractue in 1. CTM corresponded to surgical findings in than 260/280 patients with radiculopathy and in 17/17 patients with myelopathy. Surgery was performed in 22 patients on the basis of clinical	*Critique of methodology:* ☒Nonconsecutive patients ☐Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:CT myelography can identify 90% of cervical extruded disc herniations confirmed by surgery.

		symptoms alone. Of these 22 patients, 19 had herniations not seen on CTM and three had no herniations based upon surgical findings and CTM. A soft tissue extradural deformity appeared to be present on CTM in seven patients who had no cervical abnormalities on surgical exploration. The authors concluded that imaging of cervical disc prolapse continues to be difficult and the results are not always specific. CTM is the most sensitive imaging examination. In critique, patients were not consecutively assigned. This study provides Level III evidence that CT myelography can identify 90% of cervical extruded disc herniations confirmed by surgery. Author conclusions (relative to question): Imaging of cervical disc prolapse continues to be difficult and the results are not always specific. CTM is the most sensitive imaging examination, but the number of MRI studies were insufficient to allow a direct comparison	
Houser OW, Onofrio BM, Miller GM, Folger WN, Smith PL, Kallman DA. Cervical Neural Foraminal Canal Stenosis - Computerized Tomographic Myelography Diagnosis. Journal of Neurosurgery. Jul 1993;79(1):84-88.	Level III Type of evidence: diagnostic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To review the surgical and CTM findings in patients with foraminal stenosis. Diagnostic test(s) studied: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☒CT/Myelogram ☐Other: Compared to: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: surgical findings	*Critique of methodology:* ☒Nonconsecutive patients ☐Small sample size ☐No consistently applied gold standard ☐Poor reference standard/no gold standard applied ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:during surgical exploration, there was limited correlation between CT myelography and foraminal stenosis.

		Gold standard? ☒ Yes ☐No If "Yes," please specify: surgical findings Number of patients: 95, 134 stenotic foramina Consecutively assigned? No Results/subgroup analysis (relevant to question): CTM showed stenosis at the entrance in 70 (52%), within the canal itself in 37 (28%), and site not definitively identified in 27 (20%). At the entrance to the foramen, stenosis secondary to a cartilagenous cap was identified in 10 patients (8%), osteophyte in 17 (13%), synovial cyst in one, and a combination of bone and cartilagenous cap in 42 (31%). Within the canal, small bone spurs arising from the uncovertebral process contributed to stenosis in 29 instances, and from the facet joint in 8. Diagnosis on the basis of CTM was difficult because stenosis was evident as a bone spur in only 13% of cases, could not be distinguished from a disc prolapse in 39%, had to be distinguished from a congenitally narrowed foramen in 27% and was missed in 20%. Author conclusions (relative to question): The diagnosis of foraminal stenosis on CTM is difficult.	

Evidentiary Table • Cervical Radiculopathy from Degenerative Disorders, Outcome Measures

What are the most appropriate outcome measures to evaluate the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Alrawi MF, Khalil NM, Mitchell P, Hughes SP. The value of neurophysiological and imaging studies in predicting outcome in the surgical treatment of cervical radiculopathy. Eur Spine J. Apr 2007;16(4):495-500.	Level III Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To use neurophysiological electromyography (EMG) to predict outcome after ACDF. Type of treatment(s): ACDF with a cage Total number of patients: 20 Number of patients in relevant subgroup(s): 12 with no evidence of nerve root involvement/8 with evidence of nerve root involvement Consecutively assigned? Yes Duration/intervals of follow-up: minimum 12 months Outcome measure(s) implemented ☐ Neck Disability Index (NDI) ☐ SF-36 ☐ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☒ Other: Prolo (modified), patient satisfaction grade	*Critique of methodology:* ☒Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☐<80% follow-up ☒Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☒Other: Patients still received an operation even if they had a negative EMG. *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:the modified Prolo scale can be used to assess patient outcome after ACDF

		Results/subgroup analysis (relevant to question): Patients' outcome as measured with a modified Prolo scale was better predicted by EMG. Author conclusions (relative to question): EMG can better predict outcomes as measured by a modified Prolo scale.	
Anderberg L, Annertz M, Brandt L, Saveland H. Selective diagnostic cervical nerve root block--correlation with clinical symptoms and MRI-pathology. Acta Neurochir (Wien). Jun 2004;146(6):559-565; discussion 565.	Level II Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To correlate selective nerve root block (SNRB) with MRI findings and clinical symptoms. Type of treatment(s): SNRB with Mepivacaine Total number of patients: 20 Number of patients in relevant subgroup(s): 20 Consecutively assigned? Yes Duration/intervals of follow-up: immediate-30 minutes Outcome measure(s) implemented: ☐ Neck Disability Index (NDI) ☐ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☒ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☐ Other: Results/subgroup analysis (relevant to question): 86% mean reduction in VAS arm scores; 65% mean reduction in VAS neck scores. Author conclusions (relative to question):	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☐<80% follow-up ☒Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☒Other: Duration of symptoms 1-60 months *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:VAS pain scale can be used to document the immediate anesthetic response to SNRB for radicular arm pain.

		The VAS can be used to document response to anesthetic phase of SNRB for arm (and neck) pain.	
Cleland JA, Fritz JM, Whitman JM, Palmer JA. The reliability and construct validity of the Neck Disability Index and patient specific functional scale in patients with cervical radiculopathy. Spine (Phila Pa 1976). Mar 1 2006;31(5):598-602.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: Examine the test-retest reliability, construct validity and minimum levels of detectable and clinically important change for the Neck Disability Index (NDI) and Patient Specific Functional Scale (PSFS) in a cohort of patients with cervical radiculopathy. Type of treatment(s): Physical therapy Total number of patients: 38 Number of patients in relevant subgroup(s): 38 Consecutively assigned? Yes Duration/intervals of follow-up: 13-31 days. Mean 21.5 days Outcome measure(s) implemented ☒ Neck Disability Index (NDI) ☐ SF-36 ☐ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☒ Other: PSFS Results/subgroup analysis (relevant to question): Test-retest reliability was moderate for the NDI and high for the PSFS. The PSFS was more responsive to change than the NDI. The minimal detectable change for the NDI was 10.2 and for the PSFS was 2.1.	*Critique of methodology:* ☒Nonrandomized ☒Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:PSFS may be better than the NDI for the assessment of outcomes in patients with cervical radiculopathy.

		Author conclusions (relative to question): The PSFS exhibits superior reliability, construct validity, and responsiveness in this cohort of patients with cervical radiculopathy compared with the NDI.	
Davis RA. A long-term outcome study of 170 surgically treated patients with compressive cervical radiculopathy. Surg Neurol. Dec 1996;46(6):523-530; discussion 530-523.	Level II Type of evidence: prognostic ~~~~~ Notes:	☐Prospective ☒Retrospective Study design: observational Stated objective of study: To assess the outcome of posterior decompression for cervical radiculopathy. Type of treatment(s): Posterior decompression Total number of patients: 170 Number of patients in relevant subgroup(s): 170 Consecutively assigned? No Duration/intervals of follow-up: not stated Outcome measure(s) implemented ☐ Neck Disability Index (NDI) ☐ SF-36 ☐ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☒ Other: Prolo (modified) Results/subgroup analysis (relevant to question): Patients who had sedentary occupations and housewives had significantly higher Prolo scores ($p<0.001$) than those who did strenuous work. In 86% of patients, outcome was good (defined as a Prolo score of 8 in 5%, 9 in 38% and 10 in 43%).	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:the author's modified Prolo scale may be reasonable to assess outcomes for cervical radiculopathy from degenerative disorders.

		Author conclusions (relative to question): Although outcome studies must have subjective criteria, the Prolo scale is more objective and quantitative than currently used methods.	
Fernandez-Fairen M, Sala P, Dufoo M, Jr., Ballester J, Murcia A, Merzthal L. Anterior cervical fusion with tantalum implant: a prospective randomized controlled study. Spine. Mar 1 2008;33(5):465-472.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To determine the effectiveness and safety of a tantalum implant in achieving anterior cervical fusion following 1-level discectomy as treatment of degenerative cervical disc disease with radiculopathy. Type of treatment(s): Anterior cervical discectomy and fusion with interbody implant of tantalum (n=28) or by means of autologous iliac bone graft and plating (n=33). Total number of patients: 61 Number of patients in relevant subgroup(s): 28/33 Consecutively assigned? Yes Duration/intervals of follow-up: 24 months Outcome measure(s) implemented ☒ Neck Disability Index (NDI) ☐ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☒ Odom's Criteria ☒ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☐ Other: Results/subgroup analysis (relevant to question): At 24 months, radiologic and	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:NDI, VAS (arm) are instruments that can be used to assess the outcome of surgical intervention for cervical radiculopathy from degenerative disorders. Additionally, patient satisfaction as measured by Odom's criteria and depression as measured by the ZDS appears useful.

		clinical outcomes were similar for both treatments without significant difference. The safety of fusion with tantalum implant was documented Author conclusions (relative to question): Clinical outcome using the VAS, NDI and Zung Depression Scale (ZDS) showed that tantalum implant is equivalent to autogenous graft and anterior plate.	
Foley KT, Mroz TE, Arnold PM, et al. Randomized, prospective, and controlled clinical trial of pulsed electromagnetic field stimulation for cervical fusion. Spine Journal. May 2008;8(3):436-442.	Level II Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To determine the efficacy and safety of pulsed electromagnetic field (PEMF) stimulation as an adjunct to arthrodesis after ACDF in patients with potential risk factors for nonunion. Type of treatment(s): ACDF with PEMF Total number of patients: 323 Number of patients in relevant subgroup(s): 163/160 Consecutively assigned? Yes Duration/intervals of follow-up: 12 months Outcome measure(s) implemented ☒ Neck Disability Index (NDI) ☐ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☒ Adverse Event Occurrence ☐ Return to Work ☒ Other: SF-12 Results/subgroup analysis (relevant to question): Clinical outcome as measured	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☒<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:NDI, VAS (arm) and SF-12 can be used to assess outcome after surgical intervention for cervical radiculopathy from degenerative disorders.

		with the NDI, VAS (arm) and SF-12 showed that PEMF and control groups had no significant differences in outcome. Author conclusions (relative to question): Clinical outcome as measured with the NDI, VAS (arm) and SF-12 showed that PEMF and control groups had no significant differences in outcome.	
Hacker RJ, Cauthen JC, Gilbert TJ, Griffith SL. A prospective randomized multicenter clinical evaluation of an anterior cervical fusion cage. Spine. Oct 15 2000;25(20):2646-2654; discussion 2655.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To report clinical results with maximum 24-month follow-up of fusions performed with the BAK/C fusion cage. Type of treatment(s): ACDF with BAK/C cage Total number of patients: 344 Number of patients in relevant subgroup(s): 239/105 Consecutively assigned? Yes Duration/intervals of follow-up: 344 at one year, 180 at 2 years Outcome measure(s) implemented ☐ Neck Disability Index (NDI) ☒ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☐ Other: Results/subgroup analysis (relevant to question): Clinical outcome as assessed with the VAS and SF-36 showed that	*Critique of methodology:* ☒Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:VAS and SF-36 can be used to assess outcome following surgery for cervical radiculopathy.

		with the NDI, VAS (arm) and SF-12 showed that PEMF and control groups had no significant differences in outcome. Author conclusions (relative to question): Clinical outcome as measured with the NDI, VAS (arm) and SF-12 showed that PEMF and control groups had no significant differences in outcome.	
Hacker RJ, Cauthen JC, Gilbert TJ, Griffith SL. A prospective randomized multicenter clinical evaluation of an anterior cervical fusion cage. Spine. Oct 15 2000;25(20):2646-2654; discussion 2655.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To report clinical results with maximum 24-month follow-up of fusions performed with the BAK/C fusion cage. Type of treatment(s): ACDF with BAK/C cage Total number of patients: 344 Number of patients in relevant subgroup(s): 239/105 Consecutively assigned? Yes Duration/intervals of follow-up: 344 at one year, 180 at 2 years Outcome measure(s) implemented ☐ Neck Disability Index (NDI) ☒ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☐ Other: Results/subgroup analysis (relevant to question): Clinical outcome as assessed with the VAS and SF-36 showed that	*Critique of methodology:* ☒Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:VAS and SF-36 can be used to assess outcome following surgery for cervical radiculopathy.

		Results/subgroup analysis (relevant to question): Statistically significant improvements were found in postoperative scores for bodily pain (p<0.001), vitality (p=0.003), physical function (p=0.01), role function/physical (p=0.0003) and social function (p=0.0004). No significant differences were found for three health scales: general health, mental health and role function associated with emotional limitations. Author conclusions (relative to question): HSQ may be a good disease specific outcome tool for one and two level ACDF.	
Kumar N, Gowda V. Cervical foraminal selective nerve root block: a 'two-needle technique' with results. Eur Spine J. Apr 2008;17(4):576-584.	Level II Type of evidence: prognostic	☐Prospective ☒Retrospective Study design: observational Stated objective of study: To highlight the effectiveness and safety of cervical selective nerve root block using a two needle technique for treatment of radiculopathy. Type of treatment(s): SNRB Total number of patients: 33 Number of patients in relevant subgroup(s): 33 Consecutively assigned? No Duration/intervals of follow-up: 2 years, but only one year follow-up data on outcomes Outcome measure(s) implemented ☒ Neck Disability Index (NDI) ☐ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☐Other: *Work group conclusions:* Potential level: II Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:NDI, VAS and SF-36 can be used to assess outcome of cervical radiculopathy from degenerative disorders.

		☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☐ Other: Results/subgroup analysis (relevant to question): Statistical improvements in VAS score and NDI score were seen at 6 weeks and 12 months after the procedure. Author conclusions (relative to question): The VAS score and NDI can be used to show that the two-needle technique of cervical foraminal SNRB produces improved outcomes at 6 weeks and 12 months.	
Lofgren H, Johansen F, Skogar O, Levander B. Reduced pain after surgery for cervical disc protrusion/stenosis: a 2 year clinical follow-up. Disabil Rehabil. Sep 16 2003;25(18):1033-1043.	Level I Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: observational Stated objective of study: To follow the clinical outcome after surgery for cervical radiculopathy caused by cervical DDD and to compare it with the outcome after conservative treatment Type of treatment(s): ACDF (Cloward-single level), conservative treatment Total number of patients: 43 Number of patients in relevant subgroup(s): 43 ACDF-Cloward, 39 Conservative controls (2 did have surgery) Consecutively assigned? Yes Duration/intervals of follow-up: 2 year duration with follow-up at 3, 9 and 24 months Outcome measure(s) implemented ☐ Neck Disability Index (NDI) ☐ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria	*Critique of methodology:* ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☒Other: question of selection bias in group selection; conservative treatment not stated *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:SIP and VAS (arm) may be useful surgical outcome measures for patients with cervical radiculopathy.

		☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☐ Neurologic Exam ☐ Radiographic Follow-Up ☐ Device Success ☐ Adverse Event Occurrence ☐ Return to Work ☒ Other: Sickness Impact Profile (SIP) Results/subgroup analysis (relevant to question): Pain reduction measured with VAS was more pronounced among the operated patients at the final follow-up for maximal neck pain (ρ=0.03) and at 3 months and 9 months, respectively for average neck pain (ρ=0.02, both). Initially, there was no statistically significant difference in pain intensity between the surgically and conservatively treated groups. SIP scheduled for surgery had higher sickness impact in the overall index. Author conclusions (relative to question): Operated patients demonstrated an improvement in pain (VAS) and in SIP, as well as at the clinical examination, all indicating a true improvement, although it was only partially maintained.	
Mummaneni PV, Burkus JK, Haid RW, Traynelis VC, Zdeblick TA. Clinical and radiographic analysis of cervical disc arthroplasty compared with allograft fusion: a randomized controlled clinical trial. J Neurosurg Spine. Mar 2007;6(3):198-209.	Level II Type of evidence: prognostic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To compare the results of cervical disc arthroplasty to ACDF Type of treatment(s): Prestige Artificial Cervical Disc Replacement Total number of patients: 541 Number of patients in relevant subgroup(s): 276 - Prestige disc, 265 - ACDF & Plating Consecutively assigned? No Duration/intervals of follow-up: 2 year duration with follow-up at 1.5, 3, 6, 12 and 24 months	*Critique of methodology:* ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☒<80% follow-up ☐Patients enrolled at different points in their disease ☐Lacked subgroup analysis ☒Other: Use of arthrosis in ACDF&P group, <80%follow-up: 80%in Prestige treatment group, and 75% in ACDF&P control group *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:*

		Outcome measure(s) implemented: ☒ Neck Disability Index (NDI) ☒ SF-36 ☒ Visual Analog Scale (VAS), Pain ☐ Visual Analog Scale (VAS), Satisfaction ☐ Odom's Criteria ☐ Zung Depression Scale ☐ Sickness Impact Profile (SIP) ☒ Neurologic Exam ☒ Radiographic Follow-Up ☒ Device Success ☒ Adverse Event Occurrence ☒ Return to Work ☒ Other: Neck and arm pain numeric rating(VAS) Results/subgroup analysis (relevant to question): Neck pain, arm pain and NDI scores were improved in the Prestige disc group. Success rates at 12 and 24 months for Prestige were statistically superior to control group. Neck pain improved in both treatment groups, but statistically significant in Prestige group at 6 weeks, 3 months and 12 months. No significant intergroup differences in arm pain or return to work at 24 months. NDI score was statistically significantly higher only at 3 months, but tended to have higher score than control. Author conclusions (relative to question): The Prestige ST-cervical disc system maintained physiological segmental motion at 24 months after implantation and was associated with improved neurologic success, improved clinical outcomes (SF-36) and reduced rate of secondary surgeries Compared to: ACDF.	This paper provides evidence that:NDI and SF-36 can be used to assess the outcomes of cervical radiculopathy treated by discectomy and artifical disc replacement or fusion.

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Medical/Interventional Treatment

What is the role of physical therapy/exercise in the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Persson LC, Lilja A. Pain, coping, emotional state and physical function in patients with chronic radicular neck pain. A comparison between patients treated with surgery, physiotherapy or neck collar--a blinded, prospective randomized study. Disabil Rehabil. May 20 2001;23(8):325-335.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To compare coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Type of treatment(s): Cervical brace, physical therapy (PT), and anterior cervical decompression and fusion (ACDF) Total number of patients: 81 Number of patients in relevant subgroup(s): 27 in each group Consecutively assigned? Yes Duration of follow-up: 16 months Validated outcome measures used: VAS pain score, Hospital Anxiety and Depression scale (HAD), Mood Adjective Check List (MACL), general coping questionnaire, and Disability Rating Index (DRI). Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that: there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

		☐Myelogram ☒MRI ☐CT ☒CT/Myelogram ☒Other: behavioral and functional outcomes Results/subgroup analysis (relevant to question): Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique. Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. Also used less alcohol.	

		Function was significantly related to pain intensity. About 40% had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. Author conclusions (relative to question): Cognitive and behavioral therapy is important to include in multidisciplinaryy rehabilitation. Patients need to improve coping strategies, self image and mood.	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Medical/Interventional Treatment

What is the role of epidural steroid injections for the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Anderberg L, Annertz M, Persson L, Brandt L, Saveland H. Transforaminal steroid injections for the treatment of cervical radiculopathy: a prospective and randomised study. Eur Spine J. Mar 2007;16(3):321-328.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Evaluate role of transforaminal epidural steroid injections for pain relief following successful SNRB Type of treatment(s): transforaminal epidural injection with steroid/local anesthetic or saline/local anesthetic (control) Total number of patients: 40 Number of patients in relevant subgroup(s): 20 Consecutively assigned? Yes Duration of follow-up: 3 weeks Validated outcome measures used: VAS Nonvalidated outcome measures used: Follow-up questionairre Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☒Other: selective nerve root block Results/subgroup analysis (relevant to question):	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☐Nonmasked reviewers ☐Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:the addition of steroids to a local anesthetic injection provides no additional therapeutic benefit at 3 weeks post-procedure.

		Author conclusions (relative to question):	
Cyteval C, Thomas E, Decoux E, et al. Cervical radiculopathy: open study on percutaneous periradicular foraminal steroid infiltration performed under CT control in 30 patients. AJNR Am J Neuroradiol. Mar 2004;25(3):441-445.	Level IV Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: To evaluate the feasability, tolerance, and efficacy of transforaminal periganglionic steroid infiltration under CT control Type of treatment(s): transforaminal epidural steroid injection Total number of patients: 30 Number of patients in relevant subgroup(s): Consecutively assigned? Yes Duration of follow-up: 6 months Validated outcome measures used: used a modified VAS (excellent/good/fair/poor) Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☒CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): 60% of patients obtain good or excellent pain relief following a transforaminal epidural steroid injection under CT guidance Author conclusions (relative to question): CT guided transforaminal ESI provided sustained relief regardless of the cause of radiculopathy	*Critique of methodology:* ☒Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:60% of patients obtain good or excellent pain relief following a transforaminal epidural steroid injection under CT guidance
Kim H, Lee SH, Kim MH.	Level IV	☐Prospective ☒Retrospective	*Critique of methodology:* ☐Nonconsecutive patients

Multislice CT fluoroscopy-assisted cervical transforaminal injection of steroids: technical note. J Spinal Disord Tech. Aug 2007;20(6):456-461.	Type of evidence: therapeutic	Study design: case series Stated objective of study: To evaluate the feasibility and the outcome of cervical transforaminal epidural steroid injection guided by multislice CT Type of treatment(s): transforaminal epidural steroid injection Total number of patients: 19 Number of patients in relevant subgroup(s): 19 Consecutively assigned? Yes Duration of follow-up: 4 months Validated outcome measures used: VAS Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☒CT ☐CT/Myelogram ☒Other: excluded patients with neurologic deficit Results/subgroup analysis (relevant to question): No patient required more than 2 injections. Significant improvement in VAS at 2, 4, 8, 16 weeks. No serious complications. Author conclusions (relative to question): CT guided cervical transforaminal epidural steroid injections are safe and effective.	☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:cervical transforaminal steroid injections provide approximately a 50% reduction in pain which lasts for 16 weeks.
Kolstad F, Leivseth G, Nygaard OP. Transforaminal steroid injections in the treatment of	Level IV Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: case series Stated objective of study: To determine if transforaminal steroid injections applied to a cohort of patients waiting	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used:

cervical radiculopathy. A prospective outcome study. Acta Neurochir (Wien). Oct 2005;147(10):1065-1070; discussion 1070.		for cervical disc surgery, reduce the pain of cervical radiculopathy and hence reduce the need for surgical intervention. Type of treatment(s): 2 cervical transforaminal steroid injections, 2 weeks apart Total number of patients: 21 Number of patients in relevant subgroup(s): Consecutively assigned? Duration of follow-up: 4 months Validated outcome measures used: VAS Nonvalidated outcome measures used: Odom's criteria, operative indications Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☒CT/Myelogram ☐Other: Results/subgroup analysis (relative to question): Author conclusions (relative to question):	☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:about 1/4 of patients who could be considered for surgery could potentially achieve short term pain relief with 2 cervical transforaminal epidural steroid injections two weeks apart.
Lin EL, Lieu V, Halevi L, Shamie AN, Wang JC. Cervical epidural steroid injections for symptomatic disc herniations. Journal of Spinal	Level IV Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: To examine the efficacy of cervical epidural steroid injections for the treatment of symptomatic herniated cervical discs in patients considered potential surgical candidates. Type of treatment(s): cervical	*Critique of methodology:* ☐Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated

Disorders and Techniques. May 2006;19(3):183-186.		transforaminal epidural steroid injections using fluoroscopic guidance Total number of patients: 70 Number of patients in relevant subgroup(s): Consecutively assigned? Yes Duration of follow-up: 1 year Validated outcome measures used: main outcome measure was whether or not surgery was performed Nonvalidated outcome measures used: Odom's Diagnosis of cervical radiculopathy made by: ☐Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): older patients and those with shorter duration of symptoms did better with ESI Author conclusions (relative to question): Patients considering surgery may improve with a trial of ESI and avoid surgery	☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:approximately 60% of patients who are considered surgical candidates may obtain pain relief from cervical epidural steroid injections.

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Medical/Interventional Treatment

What is the role of ancillary treatments such as bracing, traction, electrical stimulation, acupuncture and transcutaneous electrical stimulation (TENS) in the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Alexandre A, Coro L, Azuelos A, et al. Intradiscal injection of oxygen-ozone gas mixture for the treatment of cervical disc herniations. Acta Neurochir Suppl. 2005;92:79-82.	Level V Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: Report the effects of intervertebral disc and paravertebral injections of ozone & oxygen in patients with cervical disc herniations Type of treatment(s): Intervertebral disc and five paravertebral injections of ozone & oxygen Total number of patients: 252 Number of patients in relevant subgroup(s): Consecutively assigned? No Duration of follow-up: possibly 7 months Validated outcome measures used: Nonvalidated outcome measures used: pain improvement, sensory dysfunction, strength improvement Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☒Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other:	*Critique of methodology:* ☐Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☒Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: No specified duration of follow-up, no data tables or speed of recovery noted. *Work group conclusions:* Potential level: IV Downgraded level: V *Conclusions relative to question:* This paper provides evidence that:Approximately 80% of patients will report symptomatic relief from cervical radiculopathy at some point following ozone and oxygen injection into the intervertebral disc and paravertebral musculature.

		Results/subgroup analysis (relevant to question): Author conclusions (relative to question): Approximately 80% of patients reported relief of symptoms at some point following the injection procedure.	
Olivero WC, Dulebohn SC. Results of halter cervical traction for the treatment of cervical radiculopathy: retrospective review of 81 patients. Neurosurg Focus. Feb 15 2002;12(2):ECP1.	Level V Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: Evaluate the use of halter traction and collar in patients with cervical radiculopathy Type of treatment(s): traction for 6 weeks - additional traction if improving; (8-12 lbs, TID for 15 minutes) cervical collar. Patients with severe symptoms excluded from study. Total number of patients: 81 Number of patients in relevant subgroup(s): Consecutively assigned? No Duration of follow-up: 6-12 weeks Validated outcome measures used: none Nonvalidated outcome measures used: patient report of pain relief Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): 63 (78%) of patients responded to traction	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: V *Conclusions relative to question:* This paper provides evidence that:75% of patients with mild radiculopathy may improve with traction over a six week time frame.

		3 patients who initially responded relapsed Author conclusions (relative to question): 75% of patients with mild cervical radiculopathy of approximately 6 weeks duration may improve with halter traction	
Persson LC, Lilja A. Pain, coping, emotional state and physical function in patients with chronic radicular neck pain. A comparison between patients treated with surgery, physiotherapy or neck collar--a blinded, prospective randomized study. Disabil Rehabil. May 20 2001;23(8):325-335.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To compare coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Type of treatment(s): Cervical brace, physical therapy (PT), and anterior cervical decompression and fusion (ACDF) Total number of patients: 81 Number of patients in relevant subgroup(s): 27 in each group Consecutively assigned? Yes Duration of follow-up: 16 months Validated outcome measures used: VAS pain score, Hospital Anxiety and Depression scale (HAD), Mood Adjective Check List (MACL), general coping questionnaire, and Disability Rating Index (DRI). Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☒CT/Myelogram ☒Other: behavioral and functional	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that: there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

		outcomes Results/subgroup analysis (relevant to question): Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique. Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. Also used less alcohol. Function was significantly related to pain intensity. About 40%	

		had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. Author conclusions (relative to question): Cognitive and behavioral therapy is important to include in multidisciplinaryy rehabilitation. Patients need to improve coping strategies, self image and mood.	
Saal JS, Saal JA, Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. Spine. Aug 15 1996;21(16):1877-1883.	Level IV Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: report success of a conservative management program for cervical radiculopathy Type of treatment(s): PT, NSAIDs, po steroids, ESI, exercise, postural training, collar, acupuncture, TENS Total number of patients: 26; 24/26 completed program Number of patients in relevant subgroup(s): Consecutively assigned? Yes Duration of follow-up: 3 months Validated outcome measures used: none Nonvalidated outcome measures used: patient questionaire, return to work Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other:	*Critique of methodology:* ☐Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☒Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:a multifaceted medical/interventional treatment program is associated with good outcomes in many patients with cervical radiculopathy.

		Results/subgroup analysis (relevant to question): 24 completed program 22/24 returned to work 89% had good/excellent response Author conclusions (relative to question): Comprehensive nonoperative treatment program was associated with favorable results in treating cervical radiculopathy	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

Does surgical treatment (with or without preoperative medical/interventional treatment) result in better outcomes than medical/interventional treatment for cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Persson LC, Lilja A. Pain, coping, emotional state and physical function in patients with chronic radicular neck pain. A comparison between patients treated with surgery, physiotherapy or neck collar--a blinded, prospective randomized study. Disabil Rehabil. May 20 2001;23(8):325-335.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To compare coping strategies, pain and emotional relationships of patients with cervical radiculopathy of at least three months duration randomly assigned to one of three treatment groups. Type of treatment(s): Cervical brace, physical therapy (PT), and anterior cervical decompression and fusion (ACDF) Total number of patients: 81 Number of patients in relevant subgroup(s): 27 in each group Consecutively assigned? Yes Duration of follow-up: 16 months Validated outcome measures used: VAS pain score, Hospital Anxiety and Depression scale (HAD), Mood Adjective Check List (MACL), general coping questionnaire, and Disability Rating Index (DRI). Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that: there is a high incidence of behavioral and emotional dysfunction in cervical radiculopathy patients. Medical/interventional and surgical treatment must include a cognitive, behavioral component for either method to be successful.

		☒MRI ☐CT ☒CT/Myelogram ☒Other: behavioral and functional outcomes Results/subgroup analysis (relevant to question): Three patients assigned to the surgical group refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique. Chronic symptoms influenced both function and mental well being such as emotional state, level of anxiety, depression, sleep and coping behavior. Pain was the most important primary stressor. Surgery reduced the pain faster, but no difference was seen after 12 months. Reoperation rate was 29%, mostly for adjacent segment disease. The low positive mood state (MACL score) did not improve over time. Patients who still had pain after treatment were more socially withdrawn and ceased to express their emotions. The Hospital Anxiety and Depression (HAD) anxiety score was especially high in patients before and after treatment. In patients with high pain intensity, low function, high depression and anxiety were seen. The group treated with surgery showed more anxiety and depression if pain continued, implying higher expectations and more disappointment if it failed. The strongest correlation between depression and pain was seen in the collar group, possibly because they received less attention overall. In general, coping strategies changed. Active coping was common before treatment, but disappeared after treatment, especially in the surgical group. Coping with pain was changed in general into a more passive/escape focused strategy. Also used less alcohol. Function was significantly related to pain	

		intensity. About 40% had anxiety only partially connected to pain. Prior to treatment, 30% of patients were depressed. After 12 months, 20% suffered from depression. Author conclusions (relative to question): Cognitive and behavioral therapy is important to include in multidisciplinaryy rehabilitation. Patients need to improve coping strategies, self image and mood.	
Persson LC, Moritz U, Brandt L, Carlsson CA. Cervical radiculopathy: pain, muscle weakness and sensory loss in patients with cervical radiculopathy treated with surgery, physiotherapy or cervical collar. A prospective, controlled study. Eur Spine J. 1997;6(4):256-266.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: To compare outcomes in pain, strength and sensation in three treatment groups of patients with cervical radiculopathy of a minimum of three months duration Type of treatment(s): Cervical brace, physical therapy (PT), and anterior cervical decompression and fusion (ACDF) (Cloward technique) Total number of patients: 81 Number of patients in relevant subgroup(s): 27 in each group. Consecutively assigned? Yes Duration of follow-up: 16 months Validated outcome measures used: VAS pain scale, muscle strength assessed by a handheld dynamometer, vigorometer and pinchometer. Sensory loss recorded Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☒CT/Myelogram ☐Other:	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:at one year, outcomes are similar for medical/interventional treatment and surgical treatment of patients with cervical radiculopathy from degenerative disorders. Due to the small sample size, one may not expect to see a difference between the groups on a statistical basis. Surgical treatment resulted in improved outcomes earlier in the postoperative treatment period when compared with the medical/interventional treatment group.

		Results/subgroup analysis (relevant to question): Three surgical patients refused the procedure and were handled in intent to treat analysis. In the surgical group, eight patients had a second operation: six on adjacent level, one infection and one plexus exploration. Eleven patients in the surgery group also received physical therapy. One patient in the physical therapy group and five in the collar group had surgery with Cloward technique. Strength measurements were all performed by one physical therapist with standard protocol. Physical therapy was done for 15 visits and was not standardized. Several different collars were used and worn for three months. At four month follow-up, pain was improved in the surgical and physical therapy groups, and improvement in pain scores in the surgical group was significantly better than in the collar group. After another year, the pain was about the same across groups. The surgical group improved strength a little faster, but at final follow-up strength improvement was equal across groups. At final follow-up, there was no difference between groups on the sensory exam. Author conclusions (relative to question): No difference in outcomes after one year between patients treated with a collar, physical therapy or surgery.	
Sampath P, Bendebba M, Davis JD, Ducker T. Outcome in patients with cervical radiculopathy. Prospective, multicenter study with independent clinical review. Spine. Mar 15 1999;24(6):591-	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: comparative Stated objective of study: Evaluated clinical outcomes in patients with cervical radiculopathy Type of treatment(s): Medical/interventional treatment was nonstandardized in this multicenter trial, and included medications, steroids, bed rest, exercise, traction, bracing, injections, chiropractic care, acupuncture and homeopathic medicine. Surgery included	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☐Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☒Inadequate length of follow-up ☒<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: high attrition rate, medical/interventional and surgical treatment protocols were

597.		foraminotomy, anterior cervical decompression (ACD), and anterior cervical decompression and fusion (ACDF). Total number of patients: 503 Number of patients in relevant subgroup(s): 246, 160 medical, 86 surgical. Nonrandomized from 41 different surgeons. Consecutively assigned? No Duration of follow-up: Mean 11 months (range: 8 to 13 months) Validated outcome measures used: Nonvalidated outcome measures used: Pain scale, satisfaction scale, neurologic score, functional scale, activities of daily living (ADL) scale. Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Imaging not stated Results/subgroup analysis (relevant to question): Of the 246 patients, only 155 reported data at final follow-up. Of the 155 patients, 104 were medically/interventionally treated and 51 had surgery. In general, pain scores were worse in the surgical group preoperatively than in the medical/interventional treatment group. Both groups improved significantly, with greater improvement seen in the surgical group. Patient satisfaction, neurological improvement and functional improvement were seen in both groups, with greater improvement reported in the surgical group. There was significant improvement in activities of daily living (ADL) in the surgical group. Although there was improvement, there	nonstandardized/variable. *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:surgical treatment results in improved outcomes when compared with medical/interventional treatment on short term follow-up.

		was still significant pain in about 26% of surgical patients. The number returning to work did not differ before and after intervention in either group despite improved functional ability, implying that the most important factor for return to work was work status prior to treatment. Author conclusions (relative to question): Surgery appears to have more success than medical/interventional treatment, although both help. Despite this, a substantial percentage of patients continue to have severe pain, neurologic symptoms and no work activity.	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

Does anterior cervical decompression with fusion result in better outcomes (clinical or radiographic) than anterior cervical decompression alone?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Barlocher CB, Barth A, Krauss JK, Binggeli R, Seiler RW. Comparative evaluation of microdiscectomy only, autograft fusion, polymethylmethacrylate interposition, and threaded titanium cage fusion for treatment of single-level cervical disc disease: a prospective randomized study in 125 patients. Neurosurg Focus. Jan 15 2002;12(1):E4.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Compare outcomes of anterior cervical decompression (ACD) to three different types of anterior cervical decompression and fusion (ACDF): iliac crest bone graft (ICBG), polymethylmethacrylate (PMMA) and titanium cages. Type of treatment(s): ACD vs ACDF Total number of patients: 125 Number of patients in relevant subgroup(s): 33 ACD, 30 ICBG, 26 PMMA, and 36 cages Consecutively assigned? Yes Duration of follow-up: 12 months Validated outcome measures used: Nonvalidated outcome measures used: Odom Criteria, VAS pain scale Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Used imaging; not specified Results/subgroup analysis (relevant to question): Of the 125 patients, 123 were	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☒Diagnostic method not stated ☒Other: Single level disease only, PMMA as spacer is not standard practice, randomization process is not described *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:suggests that there are variable outcomes when comparing ACD to ACDF for the treatment of cervical radiculopathy due to single level degenerative disease. In one cohort comparing ACD to fusion with ICBG, outcomes were equivalent, while another cohort showed superiority of interbody fusion with a titanium cage and allograft versus ACD. Validity of conclusions are weakened by small sample size and short follow-up.

		available for follow-up. The functional outcomes were grouped by good and excellent to poor and fair, with good/excellent results reported for 75% of the ACDF group, 80% for ICBG, 87% for PMMA and 94% for cage. Average reported kyphosis for ACD patients was 24 degrees, with one patient requiring revision surgery (31 degrees); 12 degrees for PMMA and about three degrees for the ICBG and cage groups. Twelve month fusion results were reported as 93% for the ACD patients, 93% for ICBG and 97% for cage . Fusion rate was faster in the cage group as well with 86% achieving fusion at six months compared with 61% in the ACD group and 65% in the ICBG group. Author conclusions (relative to question): Concluded that ACDF with cage did significantly better with faster and better recovery and less kyphotic deformity than ACD. ACD Compared to: ICBG had similar outcomes at medium length follow-up.	
Hauerberg J, Kosteljanetz M, Boge-Rasmussen T, et al. Anterior cervical discectomy with or without fusion with ray titanium cage: a prospective randomized clinical study. Spine. Mar 1 2008;33(5):458-464.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Compare radiographic and clinical outcomes of ACD with ACDF using a titanium cage. Type of treatment(s): anterior cervical discectomy (ACD), anterior cervical discectomy with fusion (ACDF) at one level only in subaxial cervical spine Total number of patients: 86 Number of patients in relevant subgroup(s): 46 ACD and 40 ACDF Consecutively assigned? Yes Duration of follow-up: minimum two years Validated outcome measures used: none Nonvalidated outcome measures used:	*Critique of methodology:* ☒Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☐Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that: for cervical radiculopathy due to single level degenerative disease, clinical outcomes are similar at two years for patients undergoing ACD and ACDF with threaded titanium cage and local

		four point scale, converted to dichotomized scale of good/excellent vs. unchanged/worse, numerical pain score, and return to work Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Imaging; not specified Results/subgroup analysis (relevant to question): One patient withdrew in each group. Two year follow-up data were available for 36 cage and 43 ACD patients. Early outcomes, though not statistically significant, favored ACD. At two years 63% of ACD patients and 78% of cage patients reported good outcomes (not statistically significant). Reoperation rates at the same level were reported as follows: at three months, three reoperations in ACD group, two in cage group; at one year, an additional reoperation in each group; at two years, an additional three in the ACD group. There were some additional procedures at adjacent levels that were equivalent for both groups over two years. In total, for the ACD group, 17/46 were investigated, seven had the same level reoperation and two had adjacent level operations. In the cage group, 15/40 were investigated with three having same level reoperation and three having adjacent level operations. There were no statistically significant differences reported in kyphosis or fusion rate. Author conclusions (relative to question): No difference in outcome between ACD and ACDF with cage and local autograft bone.	autograft. Fusion rates and symptomatic adjacent segment disease were also similar between the two groups.
Oktenoglu T, Cosar M, Ozer AF, et al. Anterior	Level III Type of evidence:	☒Prospective ☐Retrospective Study design: RCT	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☐Nonmasked reviewers

cervical microdiscectomy with or without fusion. J Spinal Disord Tech. Jul 2007;20(5):361-368.	therapeutic	Stated objective of study: Compare radiographic and clinical outcomes Type of treatment(s): anterior cervical decompression with fusion and plate (ACDFP) vs. anterior cervical decompression (ACD) Total number of patients: 20 Number of patients in relevant subgroup(s): 11 ACD and 9 ACDF Consecutively assigned? Yes Duration of follow-up: 12 to 18 months, mean 14 months Validated outcome measures used: Nonvalidated outcome measures used: VAS Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Inclusion criteria required only two weeks of failed medical/interventional treatment. VAS upper extremity pain scores (dominant complaint) improved significantly in both groups, from mean 8 to 3. Although less severe initially than arm pain, VAS neck pain scores had less improvement overall, but statistically significant improvement was noted in the ACDF group. CT follow-up at one year showed disc space collapse in both groups, but significantly more in the ACD group. There was some subsidence of the graft over the first year. Final foraminal dimensions were slightly larger in ACDF group, but not significant. Reported fusion rates were 100% in the ACDF group and 45% (5/11) in the ACD group.	☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: coin flip randomization; short duration of symptoms for inclusion criteria *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:for cervical radiculopathy due to single level degenerative disease, ACD alone provides satisfactory clinical outcomes when Compared to: ACDF with allograft ICBG and semirigid plate. Radiographically, disc height is maintained significantly better with plate and fusion although the clinical significance is unknown. The validity of the conclusions is uncertain due to small sample size.

		Author conclusions (relative to question): ACD alone provides satisfactory clinical outcomes when Compared to: ACDF with semirigid plate.	
Savolainen S, Rinne J, Hernesniemi J. A prospective randomized study of anterior single-level cervical disc operations with long-term follow-up: surgical fusion is unnecessary. Neurosurgery. Jul 1998;43(1):51-55.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Compare clinical results of anterior cervical decompression (ACD) to anterior cervical decompression and fusion (ACDF) with or without plate Type of treatment(s): ACD, ACDF, ACDFP with plate for one level disease, using autograft ICBG. Total number of patients: 91 Number of patients in relevant subgroup(s): 91; specific number in each group were not reported Consecutively assigned? Yes Duration of follow-up: 3.2 to 4.8 years, mean four years Validated outcome measures used: Nonvalidated outcome measures used: four point scale Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Radiologic studies, not specified Results/subgroup analysis (relevant to question): Follow-up data were reported for 88/91 patients. Good/excellent results were reported in 76% of ACD patients, 82% ACDF, and 73% ACDFP. Of the 88 patients, 71 had long term radiographic	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: randomization process not specified; phone follow-up at four years *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:for patients with cervical radiculopathy due to single level degenerative disease, ACD yields results equivalent to ACDF with or without a plate. The validity of the conclusions is uncertain due to small sample size.

		follow-up, with slight kyphosis in 62% of ACD, 41% ACDF, 44% ACDFP and fusion achieved in 100% of ACDF and 90% of ACD patients. Complication rates were similar for all groups, with the exception of short term ICBG pain which was severe in 80% of both ACDF groups. Author conclusions (relative to question): Because outcomes were similar for the three groups, ACD is recommended as procedure of choice for ease of surgery and reduced complications.	
Wirth FP, Dowd GC, Sanders HF, Wirth C. Cervical discectomy. A prospective analysis of three operative techniques. Surgical neurology; 2000:340-346; discussion 346-348.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Compare clinical outcomes of anterior cervical discectomy (ACD), anterior cervical discectomy with fusion (ACDF) and posterior cervical foraminomtomy for single level HNP with radiculopathy Type of treatment(s): ACD, ACDF, foraminotomy Total number of patients: 72 Number of patients in relevant subgroup(s): 22 foraminotomy, 25 ACD, 25 ACDF Consecutively assigned? Yes Duration of follow-up: Mean 60 months Validated outcome measures used: Nonvalidated outcome measures used: grading scheme incorporating length of hospitalization, radicular pain improvement, and return to work Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☒<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Poor randomization; high attrition rate for long term follow-up *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that: for single level HNP causing cervical radiculopathy, outcomes for ACD are equivalent to ACDF.

		☒Other: Imaging; not specified Results/subgroup analysis (relevant to question): In immediate postoperative results, surgical time, hospital stay and cost were slightly better for the ACD group. Postoperative pain was worse in the foraminotomy group. At two months, according to the grading scheme implemented, all three groups were about the same. Reoperations were greater at the operative site for foraminotomy and adjacent sites for ACDF patients. Long-term follow-up was accomplished via phone interview at 53 months for the foraminotomy group (14/22 patients), 56 months for the ACD group (13/25 patients) and 69 months for the ACDF group (16/25 patients), with a loss of about 40% of patients to follow-up. Within the limits of their study design and patient capture, pain improvement remained high for all groups. Return to work for was 79% for the foraminotomy group, 92% for ACD and 81% for ACDF (not statisically significant). Of the patients available at final follow-up, 100% were satisfied and would have the surgery again. Author conclusions (relative to question): For single level HNP, all procedures are efficacious.	
Xie JC, Hurlbert RJ. Discectomy versus discectomy with fusion versus discectomy with fusion and instrumentation: a prospective randomized study. Neurosurgery. Jul 2007;61(1):107-116; discussion 116-107.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: Compare clinical and radiographic outcomes of anterior cervical discectomy (ACD), anterior cervical discectomy with fusion (ACDF), and anterior cervical discectomy with instrumented fusion (ACDFI) for single level cervical radiculopathy Type of treatment(s): ACD, ACDF, ACDFI; graft was autograft iliac crest bone graft (ICBG) Total number of patients: 45 Number of patients in relevant subgroup(s): 15 ACD, 15 ADCF, 15	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:*

		ACDFI Consecutively assigned? Yes Duration of follow-up: two years Validated outcome measures used: McGill Pain Questionnaire (MPQ), SF-36, General Health Outcome Measure Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Three patients in the ACD group lost to follow-up. No graft site pain was reported at two years. In general, clinical results improved to one year then plateaued. Arm pain was completely absent in 92% of ACD patients, 93% of ACDF patients and 100% of ACDFI patients. Neck pain was absent in 83%, 80% and 73%, respectively. All had significant and similar improvements in MPQ and SF-36. At two years, fusion rate on radiograph was 67%, 93%, and 100% respectively. Of patients treated with ACD, 75% had kyphosis at two years. Author conclusions (relative to question): Patient selection is the key to surgical success. Any of these surgeries are suitable for cervical radiculopathy due to nerve root compression. Because the long term effects of kyphosis are unknown, we cannot be certain about the potential consequences of ACD.	This paper provides evidence that:clinical outcomes for treatment of cervical radiculopathy due to single level degenerative disease are similar when comparing ACD to ACDF, with or without plating. Radiographic outcomes were worse with ACD, resulting in a significant loss of lordosis, although the clinical consequences of this are unknown.The validity of the conclusions may be compromised by a very small sample size.

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

Does anterior cervical decompression and fusion with instrumentation result in better outcomes (clinical or radiographic) than anterior cervical decompression and fusion without instrumentation?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Grob D, Peyer JV, Dvorak J. The use of plate fixation in anterior surgery of the degenerative cervical spine: a comparative prospective clinical study. Eur Spine J. Oct 2001;10(5):408-413.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: compare clinical and radiographic outcomes of anterior cervical decompression and fusion (ACDF) and anterior cervical decompression and fusion plus plate (ACDFP) Type of treatment(s): ACDF, ACDFP Total number of patients: 54, 50 available for follow-up Number of patients in relevant subgroup(s): 50: 24 ACDFP, 26 ACDF Consecutively assigned? No Duration of follow-up: 22 to 46 months, average 34 months. Validated outcome measures used: Nonvalidated outcome measures used: Visual Analog Scale (VAS) - pain, neurological exam, functional (ROM) assessment, and radiographic evidence of fusion Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT	*Critique of methodology:* ☒Nonconsecutive patients ☐Nonrandomized ☐Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Not sure if patients were consecutively assigned. Questionable randomization method used. *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:use of plate in addition to anterior cervical decompression and fusion is not supported for the treatment of cervical radiculopathy from degenerative disorders.

		☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Both groups had a statistically significant decrease in VAS pain scores and improvement in cervical spine range of motion postoperatively, but there was no significant difference between groups for either of these outcome measures. Radiographically, there was no difference in the frequency of pseudoarthrosis/non-union. The authors defined inferior "graft quality" as ventral graft dislocation greater than 2mm and/or loss of disc height by more than 2mm. Based upon these criteria, the plate group had significantly better results (p=.04). Author conclusions (relative to question): Addition of an anterior cervical plate did not lead to an improved clinical outcome for patients treated for cervical radiculopathy with a one or two level anterior procedure.	
Mobbs RJ, Rao P, Chandran NK. Anterior cervical discectomy and fusion: analysis of surgical outcome with and without plating. J Clin Neurosci. Jul 2007;14(7):639-642.	Level III Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: comparative Stated objective of study: compare clinical and radiographic outcomes of anterior cervical decompression and fusion (ACDF) vs anterior cervical decompression and fusion with plate (ACDFP) in patients with cervical radiculopathy Type of treatment(s): ACDF, ACDFP Total number of patients: 242; 212 radiculopathy Number of patients in relevant subgroup(s): 212: 116 ACDF, 96 ACDFP Consecutively assigned? No Duration of follow-up: one year Validated outcome measures used: Nonvalidated outcome measures used: Odoms criteria, radiographic fusion	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☐Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:addition of an anterior locking plate may not lead to an increased likelihood of a satisfactory clinical outcome, but it may lower the likelihood of a poor outcome and need for reoperation.

		Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Imaging; not specified Results/subgroup analysis (relevant to question): Using Odom's criteria, there was no significant difference in good to excellent outcomes between the two groups (87% of the ACDF patient group and 92% of the ACDFP). On the other hand, the noninstrumented group had a statistically significantly higher frequency of poor outcomes at 7% (8/116) Compared to: the ACDFP group at 1% (1/96. Poor outcomes were considered to be postoperative kyphosis and nonunion. Author conclusions (relative to question): Excellent results were similar for both groups. There was a significantly higher rate of poor outcomes in the uninstrumented group and this lead to higher rate of second surgery.	
Zoega B, Karrholm J, Lind B. One-level cervical spine fusion. A randomized study, with or without plate fixation, using radiostereometry in 27 patients. Acta Orthop Scand. Aug 1998;69(4):363-368.	Level II Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: to evaluate whether addition of a plate to a single level cervical fusion for DDD enhances fusion rate and contributes to maintaining alignment Type of treatment(s): anterior cervical discectomy and fusion (ACDF), anterior cervical discectomy and fusion plus plate (ACDFP) Total number of patients: 27 Number of patients in relevant subgroup(s): 15 ACDFP, 12 ACDF Consecutively assigned? Yes Duration of follow-up: 24 months	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:plate maintains alignment.

		Validated outcome measures used: radiostereometry (RSA) Nonvalidated outcome measures used: VAS pain scale Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): There was a statistically significant increase in the frequency of postoperative kyphosis in the nonplated group at one year follow-up (p=.04). At two years statistical significance was lost (p=>06). There was one nonunion in the plate group; none in the ACDF group. Clinical scores were the same for both groups. Author conclusions (relative to question): Plate maintains alignment, but provides no advantage for healing or for clinical outcomes	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

Does anterior surgery result in better outcomes (clinical or radiographic) than posterior surgery in the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Herkowitz HN, Kurz LT, Overholt DP. Surgical management of cervical soft disc herniation. A comparison between the anterior and posterior approach. Spine. Oct 1990;15(10):1026-1030.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: comparative Stated objective of study: compare anterior cervical decompression and fusion (ACDF) to posterior laminoforaminotomy (PLF) Type of treatment(s): ACDF, PLF Total number of patients: 44: Type II central herniations with myelopathy (n=11), Type I lateral herniations with radiculopathy (n=17 ACDF, n = 16 PLF) Number of patients in relevant subgroup(s): 33: 17 ACDF, 16 PLF Consecutively assigned? Yes Duration of follow-up: 1.6 to 8.2 years, mean 4.2 years Validated outcome measures used: Nonvalidated outcome measures used: Odom's type criteria [Excellent (complete relief of pain and weakness), good (improvement of pain and weakness), fair, poor] Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☒Myelogram ☒MRI ☐CT ☒CT/Myelogram	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Improper randomization technique -- Randomization: Type I herniations alternated between ACDF and PLF (it did not state how the randomization was completed or how allocation was concealed). It simply states "alternated" and does not state "randomized." Uncertain how, or if, allocation was concealed from outcome observers. Also, it was uncertain if follow-up was at a similar times. *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that: anterior cervical decompression with fusion and posterior laminoforaminotomy appear equally effective in improving pain and weakness.

		☐Other: Results/subgroup analysis (relevant to question): The average age of the 17 patients assigned to the ACDF group was 43, while the average age of the 16 patients assigned to the PLF group was 39. Of the 17 ACDF patients, 94% reported good (5/17) or excellent (11/17) results. Of the 16 PLF patients, 75% reported good (6/16) or excellent (6/16) results. ACDF was not significantly better ($p<0.175$). Osteophytic changes were seen in 9/17 ACDF patients and 8/16 PLF patients. Author conclusions (relative to question): Both surgical procedures are effective, but ACDF tends to be better over long term.	
Korinth MC, Kruger A, Oertel MF, Gilsbach JM. Posterior foraminotomy or anterior discectomy with polymethyl methacrylate interbody stabilization for cervical soft disc disease: results in 292 patients with monoradiculopathy. Spine. May 15 2006;31(11):1207-1214; discussion 1215-1206.	Level III Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: comparative Stated objective of study: compare clinical results of anterior vs. posterior surgery for cervical radiculopathy due to soft disc herniation Type of treatment(s): anterior cervical decompression with fusion (ACDF) using PMMA for median or paramedian discs, posterior laminoforaminotomy (PLF) for posterolateral or foraminal discs Total number of patients: 363 Number of patients in relevant subgroup(s): 363: 154 ACDF, 209 PLF Consecutively assigned? No Duration of follow-up: mean 72 months, minimum 30 months Validated outcome measures used: Nonvalidated outcome measures used: Odoms criteria Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Tendency for patient selection to more lateral disc herniations for posterior procedure, whereas anterior for paramedian and central introduced bias. This study excluded patients with pure hard discs and pure foraminal stenosis (so not consecutively assigned). *Work group conclusions:* Potential level: III Downgraded level: III *Conclusions relative to question:*This paper provides evidence that:ACDF results in statistically significantly better outcomes than PLF; however, ACDF is associated with a higher risk

		☐Electromyography ☒Myelogram ☒MRI ☒CT ☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Of the 363 patients included in the study, 80% (292/363: 124/154 ACDF, 168/209 PLF) were available for long term follow-up via clinical outpatient examination (14.7%), questionnaire (64.4%), and/or a telephone interview (20.9%). Complication rates, primarily related to hoarseness and dysphagia, were reported in 6.5 % of ACDF patients and 1.8% of PLF patients. Reoperation rates were reported as 2.4% for the ACDF group and 7.1% for the PLF group. Mean operating time in the ACDF group was 112 minutes 94.1 minutes for the PLF group (p<0.000). Of the patients in the ACDF group, 93.6% (116/124) reported good (36.3%) or excellent (59.5%) results according to Odom's criteria and 0.8% reported poor results (p<0.05). Of the patients in the PLF group, 85.1% (142/168) reported good (25.6%) or excellent (59.5%) results according to Odom's criteria and 7.2% reported poor results (p<0.05). In the ACDF group, a pure soft disc was removed in 60 cases (48.4%) and a mixture of both hard and soft disc elements was removed in 64 (51.6%). In the PLF group, a pure soft disc was removed in 148 cases (88.1%) and a mixture of both hard and soft disc elements was removed in 20 (11.9%) (p<0.000). Soft disc herniations did not have significantly better outcomes than the mixture of soft and hard disc, although there appeared to be a trend. In general, shorter duration of preoperative symptoms correlated with improved outcomes. Author conclusions (relative to question): Anterior surgery yielded statistically superior outcomes, but both were effective. The findings show a higher	of complications, primarily related to dysphagia/hoarseness. PLF is associated with a higher reoperation rate.

		success rate with anterior microdiscectomy with PMMA interbody stabilization for treatment of degenerative cervical monoradiculopathy compared with posterior foraminotomy.	
Wirth FP, Dowd GC, Sanders HF, Wirth C. Cervical discectomy. A prospective analysis of three operative techniques. Surg Neurol. Apr 2000;53(4):340-346; discussion 346-348.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: compare clinical outcomes for surgery for unilateral disc herniation causing radiculopathy Type of treatment(s): anterior cervical decompression (ACD), anterior cervical decompression with fusion (ACDF), posterior laminoforaminotomy (PLF) Total number of patients: 72 Number of patients in relevant subgroup(s): 22 PLF, 25 ACD, 25 ACDF Consecutively assigned? Yes Duration of follow-up: 2 months scheduled visit, mean 60 months by phone or clinic visit Validated outcome measures used: Nonvalidated outcome measures used: Satisfaction; pain; perioperative demographics; complications; scoring scale for outcomes based on return to work, hospital stay, and pain relief Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Imaging; not specified Results/subgroup analysis (relevant to question): Age, gender and duration of symptoms were similar for all groups. Although not specifically stated, follow-up was inclusive. Anesthesia time, hospital	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Functional outcome tools were too broad and subjective. The initial clinical visit occurred at two months; the 60 month follow-up was poorly coordinated and varied. Numbers were small with poor statistical analysis. *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:ACD, ACDF and PLF result in comparable clinical outcomes in the treatment of cervical radiculopathy from unilateral disc herniation.

		stay, charges and analgesics were similar. Pain improvement was reported by more than 96% of patients in all groups. It appears that all groups had similar outcomes. Return-to-work was reported as greater than 88% in all groups. Similar incidence of new weakness and new numbness across all groups. Reoperation rate were reported as 27% for the PLF group, 12% for ACD and 28% for ACDF. Author conclusions (relative to question): Although the numbers in this study were small, none of the procedures could be considered superior to the others. This study suggests that the selection of surgical procedure may reasonably be based on the preference of the surgeon and tailored to the individual patient.	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

Does anterior cervical decompression and reconstruction with total disc replacement result in better outcomes (clinical or radiographic) than anterior cervical decompression and fusion in the treatment of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Murrey D, Janssen M, Delamarter R, et al. Results of the prospective, randomized, controlled multicenter Food and Drug Administration investigational device exemption study of the ProDisc-C total disc replacement versus anterior discectomy and fusion for the treatment of 1-level symptomatic cervical disc disease. Spine J. Apr 2009;9(4):275-286.	Level I Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: compare safety and efficacy of total disc arthroplasty (TDA) to anterior cervical decompression with fusion (ACDF) for single level symptomatic cervical disc disease with radiculopathy Type of treatment(s): ProDisc TDA, ACDF with allograft and plate Total number of patients: 209 Number of patients in relevant subgroup(s): 106 ACDF, 103 TDA Consecutively assigned? Yes Duration of follow-up: 2 years with follow-up intervals at 6 weeks, 3 months, 6 months, 12 months and 2 years Validated outcome measures used: Neck Disability Index (NDI), SF-36, Visual Analog Scale (VAS) pain scores Nonvalidated outcome measures used: Neurological exam, VAS satisfaction Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☒CT/Myelogram	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: I Downgraded level: I *Conclusions relative to question:* This paper provides evidence that:TDA shows equivalent outcomes to ACDF at two years for treatment of cervical radiculopathy.

		☐Other: Results/subgroup analysis (relevant to question): There was no difference in demographics between the TDA and ACDF groups. Follow-up rates were 98% for TDA and 94% for ACDF. ACDF had statistically significantly lower smaller blood loss and operative time (although differences small). Neurological improvement was better for TDA than ACDF at six months ($p<0.05$), but no significant difference was seen 24 months ($p=0.638$). NDI improved from baseline for each group ($p<0.0001$); however, between groups there was a significant difference at three months for TDA ($p<0.05$) but not at 24 months ($p=1.0000$). This was also true for aggregate patients who had greater than 15 point improvement. Secondary surgical procedure were performed in 1.9% of TDA patients and 8.5% of ACDF patients. Implant revision was required in no TDA patients, but 4.7% of the ACDF patients, with 2.8% of the ACDF patients requiring supplemental fixaton. VAS neck pain, arm pain frequency and intensity was similar for TDA and ACDF patients at 24 months. Success, as defined by greater than 20% improvement in VAS scores, was reported for 87.9% of TDA patients and 86.9% of ACDF patients at 24 months. At 24 months, 80.8% of TDA patients and 74.4% of ACDF patients had successful outcomes as assessed by the SF-36 physical component summary. The SF-36 mental component summary showed 71.8% of TDA and 68.9% of ACDF patients were successful. Patient satisfaction, narcotic use and adverse events were similar for both groups. Author conclusions (relative to question): TDA with ProDisc is safe and effective and at least as good as ACDF.	
Nabhan A, Ahlhelm F, Shariat K, et al. The ProDisc-C	Level II Type of evidence:	☒Prospective ☐Retrospective Study design: RCT	*Critique of methodology:* ☐Nonconsecutive patients ☐Nonrandomized ☒Nonmasked reviewers

prothesis - Clinical and radiological experience 1 year after surgery. Spine. Aug 2007;32(18):1935-1941.	therapeutic	Stated objective of study: compare radiographic and clinical results of total disc arthroplasty (TDA) to anterior cervical decompression with fusion (ACDF) Type of treatment(s): ProDIsc TDA, ACDF with PEEK cage and plate Total number of patients: 49 Number of patients in relevant subgroup(s): 25 TDA and 24 ACDF, all with radiculopathy; however, only 20 TDA and 21 ACDF patients could be measured due to artifact. Consecutively assigned? Yes Duration of follow-up: One year Validated outcome measures used: RSA for dynamic radiographic evaluation Nonvalidated outcome measures used: VAS pain score Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI ☐CT ☐CT/Myelogram ☒Other: Imaging; not specified Results/subgroup analysis (relevant to question): Range of motion decreased in both groups. In the TDA group, average motion decreased from 2.3 at one week to 0.8 at 52 weeks; in ACDF, it decreased from 0.6 at one week to 0.1 at 52 weeks. Comparison between groups showed that the motion was significantly less in the ACDF group for all time points except three weeks. Preoperatively, there was no statistical difference in symptoms between both groups (P=0.1), as measured by the VAS. Both groups showed the same pattern of pain relief in arm pain at all examination times without statically significant difference (P=0.13).	☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☒Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: They used a good radiographic analysis tool, but chose neutral and extreme extension and lateral rotation for their motion analysis. Clinical evaluation was limited and was not their emphasis. Follow-up of only one year. Also they conclude motion was maintained with TDA; however, it was not. Range of motion was decreased, but significantly greater than with ACDF. *Work group conclusions:* Potential level: I Downgraded level: II *Conclusions relative to question:* This paper provides evidence that:compared with ACDF, patients treated with TDA have statistically significantly greater range of motion. Clinical outcomes are similar for both groups.

		The ACDF group showed a higher postsurgical resolving ratio in neck pain relief at three weeks, although without any statistically significant differences (P=0.09). Author conclusions (relative to question): Disc motion was maintained by TDA at one year and was greater than ACDF, with similar clinical results to ACDF.	

Evidentiary Table ● Cervical Radiculopathy from Degenerative Disorders, Surgical Treatment

What is the long-term result (four+ years) of surgical management of cervical radiculopathy from degenerative disorders?

Article (Alpha by Author)	Level of evidence	Description of study	Conclusion
Hamburger C, Festenberg FV, Uhl E. Ventral discectomy with pmma interbody fusion for cervical disc disease: long-term results in 249 patients. Spine. Feb 1 2001;26(3):249-255.	Level IV Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: review results of anterior cervical decompression (ACD) with polymethylmethacralate (PMMA) Type of treatment(s): ACD with PMMA Total number of patients: 351 Number of patients in relevant subgroup(s): 319:; 249/319 available for final follow-up Consecutively assigned? No Duration of follow-up: 10 to 15 years, mean 12.2 years Validated outcome measures used: Nonvalidated outcome measures used: Odoms criteria Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☒Myelogram ☐MRI ☒CT ☐CT/Myelogram ☒Other: radiograph Results/subgroup analysis (relevant to question): Of the 249 patients available for final follow-up, 246 had single level	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:for the treatment of cervical radiculopathy due to single level disease, ACD with PMMA interbody spacer results in 77% of patients reporting satisfactory clinical outcomes at 10 to 15 years following surgery.

		and 3 had two level surgery. Good or excellent results were reported by 87% of patients. Lumbar symptoms and high occupational stress were correlated with clinical failure. Patients with soft disc herniations reported the best results. Relatively worse outcomes were reported when "patients had unclear preoperative findings." Author conclusions (relative to question): ACD with PMMA is a safe and reliable method for treating monosegmental radiculopathy with outcomes and complication rates similar to other published studies.	
Heidecke V, Rainov NG, Marx T, Burkert W. Outcome in Cloward anterior fusion for degenerative cervical spinal disease. Acta Neurochir (Wien). 2000;142(3):283-291.	Level IV Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: to review outcomes of Cloward type fusion Type of treatment(s): anterior cervical decompression with fusion (ACDF) using Cloward technique and iliac crest bone graft (ICBG) Total number of patients: 156 Number of patients in relevant subgroup(s): 28 patients with radiculopathy only Consecutively assigned? No Duration of follow-up: 4 to 10.5 years, mean 6.5 years Validated outcome measures used: Nonvalidated outcome measures used: three point scale of good, fair and poor; radiographic analysis; neurological exam. Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☒CT	*Critique of methodology:* ☒Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:for treatment of cervical radiculopathy due to degenerative disease, ACDF with Cloward technique results in 93% satisfactory results with long term (4-10 year) follow-up.

		☐CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Of the 28 radiculopathy patients included, long term outcome was reported as good for 93% and fair for 7%. No poor results were reported. Adverse events were dominated by graft site complications. Author conclusions (relative to question): Cloward ACDF is a reliable and safe procedure for single level disease.	
Jagannathan J, Sherman JH, Szabo T, Shaffrey CI, Jane JA. The posterior cervical foraminotomy in the treatment of cervical disc/osteophyte disease: a single-surgeon experience with a minimum of 5 years' clinical and radiographic follow-up. J Neurosurg Spine. Apr 2009;10(4):347-356.	Level IV Type of evidence: therapeutic	☐Prospective ☒Retrospective Study design: case series Stated objective of study: review results of posterior foraminotomy (PLF) for treatment of single level cervical radiculopathy Type of treatment(s): PLF Total number of patients: 973 Number of patients in relevant subgroup(s): 212 Consecutively assigned? Yes Duration of follow-up: 5 to 15 years, mean 78 months Validated outcome measures used: Neck Disability Index (NDI) Nonvalidated outcome measures used: Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☒MRI ☐CT ☒CT/Myelogram ☐Other: Results/subgroup analysis (relevant to question): Follow-up was reported for	*Critique of methodology:* ☐Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☐No Validated outcome measures used: ☐Small sample size ☐Inadequate length of follow-up ☐<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☐Other: *Work group conclusions:* Potential level: IV Downgraded level: IV *Conclusions relative to question:* This paper provides evidence that:posterior laminoforaminotomy for the treatment of cervical radiculopathy due to degenerative disease results in significant improvement in 93% of cases at 5-15 year follow-up. There may be a trend for patients older than 60 years with initial lordosis of less than 10 degrees to be more vulnerable to development of postoperative cervical kyphosis or translational deformity, though the clinical significance of this is uncertain.

		162/212 patients. While NDI improved in 93% of patients, 20% developed kyphosis. Patients who developed kyphosis reported worse results overall. During the follow-up period, 3.1% (5/162) required additional procedures; two had progression of disease at the index level, two developed stenosis and one developed "instability." Author conclusions (relative to question): PLF is highly successful for treating cervical radiculopathy.	
Wirth FP, Dowd GC, Sanders HF, Wirth C. Cervical discectomy. A prospective analysis of three operative techniques. Surg Neurol. Apr 2000;53(4):340-346; discussion 346-348.	Level III Type of evidence: therapeutic	☒Prospective ☐Retrospective Study design: RCT Stated objective of study: compare clinical outcomes for surgery for unilateral disc herniation causing radiculopathy Type of treatment(s): anterior cervical discectomy ACD), anterior cervical discectomy with fusion (ACDF), posterior foraminotomy Total number of patients: 72 Number of patients in relevant subgroup(s): 22 PLF, 25 ACD, 25 ACDF Consecutively assigned? Yes Duration of follow-up: 2 months scheduled visit, mean 60 months by phone or clinic visit Validated outcome measures used: Nonvalidated outcome measures used: satisfaction; pain; perioperative demographics; complications; scoring scale for outcomes based on return to work, hospital stay, and pain relief Diagnosis of cervical radiculopathy made by: ☒Clinical exam/history ☐Electromyography ☐Myelogram ☐MRI	*Critique of methodology:* ☐Nonconsecutive patients ☒Nonrandomized ☒Nonmasked reviewers ☒Nonmasked patients ☒No Validated outcome measures used: ☒Small sample size ☐Inadequate length of follow-up ☒<80% follow-up ☐Lacked subgroup analysis ☐Diagnostic method not stated ☒Other: Functional outcome tools were too broad and subjective. The initial clinical visit occurred at two months; the 60 month follow-up was poorly coordinated and varied. Numbers were small with poor statistical analysis. 40% lost to follow-up. *Work group conclusions:* Potential level: II Downgraded level: III *Conclusions relative to question:* This paper provides evidence that:for unilateral radiculopathy caused by cervical disc herniation, ACD, ACDF or posterior foraminotomy result in satisfactory outcomes at five year follow-up.

		☐CT ☐CT/Myelogram ☒Other: Imaging not stated Results/subgroup analysis (relevant to question): Age, gender and duration of symptoms were similar for all groups. Although not specifically stated, follow-up was inclusive. Anesthesia time, hospital stay, charges and analgesics were similar. Pain improvement was reported by more than 96% of patients in all groups. It appears that all groups had similar outcomes. Return-to-work was reported as greater than 88% in all groups. Similar incidence of new weakness and new numbness across all groups. Reoperation rate were reported as 27% for the PLF group, 12% for ACD and 28% for ACDF. Of the 72 patients included in the study, 60% (43/72) were available at final follow-up [13/25 (52%) for ACD, 16/25 (64%) for ACDF, and 14/22 (64%) for posterior foraminotomy]. Author conclusions (relative to question): ACD, ACDF or posterior foraminotomy are reasonable surgical choices for cervical radiculopathy due to unilateral disc herniation.	

VI. Cervical Radiculopathy from Degenerative Disorders Guideline References

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