1998

Differential Diagnosis and Conservative Treatment for Cervical and Lumbar Radiculopathies

Scott Kurtz
University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation
https://commons.und.edu/pt-grad/272

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinebyousif@library.und.edu.
Differential Diagnosis and Conservative Treatment
For Cervical and Lumbar Radiculopathies

by

Scott Kurtz
Bachelor of Science in Physical Therapy
University of North Dakota, 1997

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
1998
This Independent Study, submitted by Scott J. Kurtz in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(David Pelkey
(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title  Differential Diagnosis and Conservative Treatment for Cervical and Lumbar Radiculopathies

Department  Physical Therapy

Degree  Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in his absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Independent Study Report or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature

Date 12/15/97
# TABLE OF CONTENTS

Acknowledgements ......................................................... v
Abstract ................................................................. vi
Chapter I: Introduction .................................................. 1
Chapter II: Anatomy ...................................................... 4
Chapter III: Physiology and Differential Diagnosis .................. 12
Chapter IV: Treatment .................................................. 25
Conclusion ............................................................. 37
Appendix ............................................................... 38
References ............................................................. 45
ACKNOWLEDGEMENTS

I would like to thank my family for helping and encouraging me throughout my many, many years of education. I couldn't have completed my schooling without their support. I would also like to thank Dave for reading this review again and again, and providing me with helpful insights to improve the quality of the final draft. I would like to thank Sue for getting me started on this project and the rest of the faculty and staff for making my three years of physical therapy education a positive, enjoyable, learning experience.
ABSTRACT

Back and neck pain are common afflictions affecting millions of Americans every year. The economic impact of these impairments is billions of dollars annually. Although less than 5 percent of patients with pain in the lumbar spine experience radiculopathies, patients with radiculopathies still make up a considerable number of the clients seen by physical therapists. Correct diagnosis and treatment of these disorders is vital in limiting the length of time people are disabled. In order to improve the outcomes of conservative treatment, a proper understanding of the anatomy and biomechanics of the spine is requisite along with knowledge of the pathophysiology involved in various spinal disorders.

The purpose of this study is to assimilate the information available on lumbar and cervical disorders in the form of a literature review. This review will provide a working knowledge of the anatomy and physiology of the spine along with a discussion on differential diagnosis through physical assessment. Different treatment options and approaches will also be presented in addition to the proper timing and use of the procedures for patients with radicular symptoms. The information provided in this review can be utilized by physical therapists to improve their ability to differentiate among spinal disorders as well as improve their decisions related to proper treatment of patients suffering from lumbar and cervical pain with radiculopathy.
CHAPTER I

INTRODUCTION

The neck and lower back are common sites of pain that many Americans experience throughout their lives. In fact, low back pain is the most common cause of disability in people under age 45.\(^1\) Eighty per cent of Americans experience at least one episode of low back pain in their lifetime and 7-15% suffer annually.\(^2\) This problem costs $20-50 billion annually with only 15% of the patients making up 80-90% of the cost.\(^3\)

Although low back pain can be debilitating, the prognosis is good. According to Weber,\(^4\) 80-90% of patients are relieved of their symptoms after three months with conservative treatment. There has been conflicting results regarding the success of conservative therapy for the cervical spine. Studies by Gore\(^5\) and Depalma\(^6\) found a 68% and 78% improvement in symptoms but only complete relief in 43% and 29% of their patients, respectively. Honet,\(^7\) on the other hand, reported good to excellent results in 80% of his patients treated conservatively. Conservative treatment is the preferred method of management for both the lumbar and cervical spine. One reason conservative treatment is preferred is because the outcomes of conservative and surgical treatment are not significantly different after four years.\(^4\) Additionally, there are always inherent risks whenever a patient undergoes surgery. Furthermore, surgical intervention is more costly than conservative treatment. However, if
conservative treatment does not have a positive impact on a patient then surgical intervention may be indicated.2

This review will discuss the basic anatomy of the spine and describe the various pathological processes involved in the neck and back. Moreover, a discussion on differential diagnosis and treatment will be presented. The emphasis will be on spinal syndromes that produce radicular symptoms. Although only 2-3% of patients with low back pain have radiculopathy, it is important to differentiate them so conservative therapy can be properly administered and fewer patients will need surgical intervention.8 The importance in proper diagnosis is immediately evident when comparing a posterior disc herniation to a nerve root adherence. Both disorders produce radicular symptoms with spinal flexion, but if one were to diagnose them both with a posterior disc protrusion and subsequently treat them with extension exercises, one patient would markedly improve while the other would not receive any benefits.

A radiculopathy is a “functional disturbance” in a nerve root.9 The symptoms can be caused by compression or tension on the spinal roots.10 A patient with a radiculopathy may complain of severe, shooting pain that has a burning or toothache like sensation.9 The most common cause of radiculopathy is from a herniated disc.11

A radiculopathy should always be distinguished from a myelopathy. A myelopathy involves compression of the spinal cord and presents with bilateral generalized weakness, gait disturbance, decreased fine motor skills, bowel and bladder dysfunction, as well as upper motor neuron signs including hyperreflexia, ankle clonus, and positive Babinski. Myelopathies should not be treated
conservatively and require direct physician referral because surgery has a more favorable outcome. A myelopathy is not the only disease process that a physical therapist may detect that would warrant direct physician referral. There are several others, which will be mentioned in the chapter on differential diagnosis.

Many treatments are used to help patients reduce their cervical and lumbar pain. Physical agents, exercise, aerobics, and manual therapy are treatments used by many therapists. I will be discussing these modalities along with the McKenzie, Dynamic Lumbar Stabilization, and guided exercise with equipment approaches.

The purpose of the review is to improve the physical therapist's understanding of pathophysiological processes, differential diagnosis, and treatment options for patients with radicular symptoms. In order to have a proper understanding of these concepts, a basic knowledge of the anatomy and physiology of the spinal column is necessary. The following chapter is designed to provide a quick review of the working mechanisms of the spine.
CHAPTER II
ANATOMY

There are four basic functions of the vertebral column. The column provides a base of support for the head and internal organs, a base of attachment for ligaments, bones and muscles, links the upper and lower extremities, and allows for trunk mobility. The anatomical structure of the spinal column allows for it to perform all of its functions.\textsuperscript{12}

The spinal column consists of thirty-three vertebrae. There are 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal vertebrae. The upper 24 vertebrae are separated by intervertebral discs, which allow for mobility. The lower nine are fused together as one unit making up the sacrum and coccyx. Spinal nerves pass through the intervertebral foramen formed by adjacent upper and lower vertebrae. There are 31 pair of spinal nerves in all and they are named for the vertebra directly superior to them except in the cervical spine where their name is derived from the vertebra immediately inferior to the nerve. The C\textsubscript{s} spinal nerve is situated between C\textsubscript{7} and T\textsubscript{1}.

The basic structure of each vertebra is essentially the same from levels C\textsubscript{3} to L\textsubscript{5}.\textsuperscript{13} Each vertebra increases in size from the first cervical to the last lumbar because of the increased load each subsequent vertebrae must endure from the
weight of the trunk. Each vertebra is divided into anterior and posterior parts. The anterior portion, the body, is cylindrical and consists of spongy, cancellous bone covered by cortical bone. The cortical bone is thicker around the superior and inferior rims of the vertebra, which is where the epiphyseal plates are located. In the center of each vertebra there is a layer of hyaline cartilage called the cartilaginous end-plate. The cancellous bone mentioned previously is formed into a system of struts and crossbeams known as trabeculae. The flat surface of the vertebral body, combined with its trabeculae system, provide excellent vertical weight-bearing ability.

The posterior portion of the vertebrae is the neural arch, which consists of two pedicles and two laminae from which seven projections arise. The superior and inferior facets project upwards and downwards, respectively, and articulate with the facets of the adjacent vertebra. Connecting the inferior and superior facets of an individual vertebra is the pars interarticularis. The spinous and transverse processes do not articulate with other bony prominences, however, they do provide attachments for ligaments and muscles. The length of these processes provide an increase in torque production for the musculature in the area. The transverse process divides the arch into anterior and posterior sections. The pedicles connect the transverse process to the body while the laminae begin at each transverse process and continue posteriorly until uniting to form the spinous process. The pedicles of adjacent vertebrae form the intervertebral foramen where the spinal roots exit. The vertebrae of the cervical spine also have uncovertebral
joints located just anterior to the nerve roots. These sites are often susceptible to degenerative changes and osteophyte formation, which can lead to compression of the nerve roots.\textsuperscript{9}

**Intervertebral Disc**

The intervertebral disc is located between two adjacent vertebrae. There are 23 discs in the vertebral column and they make up 20-33\% of its height.\textsuperscript{13} Like the vertebral bodies, each disc increases in size as you descend the column. The primary function of the disc is weight-bearing. Mobility is a secondary function\textsuperscript{16} and is greatest in the cervical and lumbar regions where the disc to vertebrae ratio is the highest.\textsuperscript{17} This may account for the higher incidence of spine problems in the lumbar and cervical areas compared to the thoracic spine.\textsuperscript{18}

The disc has two main components --the nucleus pulposus and the annulus fibrosus. These components are primarily composed of water, proteoglycans, proteins and glycoproteins.\textsuperscript{19} The fluid and proteoglycan concentration is higher in the nucleus than the annulus, whereas there is more collagen in the annulus. The proteoglycans contain a substance, chondroitan 4-sulfate, which allows for the absorption of water in the disc.\textsuperscript{12} Fluid content depends on applied pressure and the proteoglycan to collagen ratio. As the disc is compressed fluid leaves the disc until an equilibrium is found.\textsuperscript{19} Once the load is lifted the process reverses and fluid is re-absorbed. The proteoglycan to collagen ratio is highest at birth when fluid makes up 88\% of the weight of the disc. This percentage decreases with age in proportion to the changing proteoglycan to collagen ratio. By fifty years of age
years of age the nucleus hardens and loses its resilience, however, this actually
makes the structure more stable. The disc is most susceptible to soft disc
herniations between the ages of 20 and 50 when the nucleus is in its transition
period.

The nucleus is 70-90% water with 65% of its dry weight being
proteoglycans. It also contains type II collagen, which assists in resisting
compression. Biomechanically, the fluid makeup allows for deformation while
the volume remains the same. The deformation of the nucleus helps to distribute
and transfer weight.

The annulus contains less fluid and consists of fibers that run obliquely
around the nucleus. There are 10-12 layers of these fibers called lamellae and
each layer is oriented 120 degrees from the previous. The collagen makeup
increases as you move from the inner to outer layers and is of the type I variety,
which resists tension. Interestingly, the lamellae are thinner and less in number
posteriorly, which may provide a predisposition for posterior disc protrusions.
The annulus attaches to the inferior and superior cartilaginous end plates of the
vertebral body. The portion of the cartilaginous end plate that is closer to the
body is hyaline cartilage, while the portion closer to the disc is more of a
fibrocartilage.

The disc’s structure provides excellent resistance to axial loading. The
nucleus acts as a ball of fluid that is deformed by compression. Pressure from
above flattens the nucleus. The nucleus in turn distributes this pressure radially
against the annulus fibrosus. The concentric ring formation in conjunction with the end plates of the annulus resist the pressure and keep everything intact. The end plates are the weakest link in this chain and are the most vulnerable during axial loading.

Ligaments

The ligaments are another important structure within the vertebral column and perform several functions. They allow adequate physiologic motion and flexibility while also providing stability. Ligaments protect the spinal cord by restricting movement as well as protecting the cord from trauma. There are seven ligaments of the spine from the axis to the sacrum. They may vary somewhat in size, orientation, and attachments throughout the various regions of the spine, but they are essentially the same.

The anterior longitudinal ligament runs from the axis to the sacrum. It attaches to both the intervertebral discs and bodies. The ligament provides reinforcement to the disc and also limits extension. The posterior longitudinal ligament limits flexion and runs from axis to sacrum. It is wide in the cervical region and narrows in the lumbar region, which may also predispose the disc to protrusions in the lumbar area. The intertransverse ligaments are present in the thoracic region. They attach to adjacent transverse processes and mainly resist lateral flexion to the contralateral side. The ligamentum flavum connect adjacent vertebrae from lamina to lamina. This ligament is made of a high percentage of elastin making it quite elastic. The ligamentum flavum provides a resting tension
that has been implicated to minimize the chance of spinal cord impingement when moving from flexion to extension. The interspinous ligaments are only well developed in the lumbar region and connect adjacent spinous processes allowing it to assist in limiting flexion. The supraspinous ligament runs from C7 to the sacrum on the tips of the spinous processes and also assists in limiting flexion. Capsular ligaments attach adjacent facets and are perpendicular to the plane of the facet joints.13

Muscles

The spinal muscles are essential in maintaining an erect spine. They stabilize the trunk in any posture, produce movement of the spine, and protect the spine from trauma. According to Panjabi, the spinal muscles can be divided into two major groups called the prevertebral and postvertebral muscles. The prevertebral muscles are the abdominal muscles and include the internal oblique, external oblique, transverse abdominus, and rectus abdominus. These muscles help flex the spine and resist extension. The muscle groups all have varying orientations, which provide the system with strength in all angles of pull.

The postvertebral muscles can be separated again into two groups according to their function. The transversocostal group made up of the sacrospinalis, quadratus lumborum, and splenius capitus and cervicis provide trunk rotation to the same side, lateral flexion, and extension. The transversospinal group consists of the semispinalis, multifidus, rotatores,
interspinales, and intertransversaii muscles. This group performs trunk rotation to the opposite side, lateral flexion, and extension.

**Spinal Cord**

The spinal cord is essential to our survival making protection of this structure vital. It is enclosed in the spinal canal being protected by the vertebrae. In addition to this bony protection there are also several soft-tissue structures designed to preserve the cord. The dura, arachnoid, and pia mater are three membranes that surround the spinal cord. The dura mater is a thick, dense, connective tissue that encloses the cord. The dural sheath also envelops the dorsal and ventral roots as they exit the spinal canal through the intervertebral foramen. In the central portion of the intervertebral foramen along the dorsal root lies the dorsal root ganglion (DRG), which houses the cell bodies of the sensory cells. After the DRG the dorsal root combines with the ventral root just outside of the foramen and becomes the spinal nerve. The spinal nerve gives way to the peripheral nerve and is no longer protected by the dura and arachnoid mater, but rather by epineural and perineural connective tissue. This difference in anatomical makeup may be significant and is discussed in the next chapter.

The whole nervous system is interconnected and quite mobile, which is necessary when considering that every movement we make stresses a portion of the peripheral nervous system. The spinal cord can unfold and untwist as axons straighten. It also has translational motion where it moves in relation to other vertebral segments. Nerve roots are also undulated and can unfold as stretching
becomes necessary. Even the axons within the endoneurium undulate allowing them to unfold as well. There are lamellae on peripheral nerves that can glide over each other during stretch and the collagen and fibril orientation throughout the endoneurium is longitudinal providing protection from tensile stress.\textsuperscript{22}

Nervous tissue can increase its length by 8\% before changes in the intraneural blood flow occur. However, the blood supply is completely cut off when the tension increases the length of the tissue by 15\%.\textsuperscript{23}

The nerve roots, spinal nerves, and peripheral nerves make up the long cellular extensions from the nerve cell bodies called axons. The axons are 100,000 times longer than the cell bodies and their survival is dependent on the protection provided by the nerve roots, spinal nerves, and peripheral nerves. The interconnectedness of these structures is important when considering nerve root injuries, which will be discussed in the next chapter.\textsuperscript{23}
CHAPTER III
PHYSIOLOGY AND DIFFERENTIAL DIAGNOSIS

Because the spinal column consists of many intertwining parts, there are numerous theories regarding the causes of pain in the neck and back. Ideas range from an autoimmune response triggering inflammation to compression of the spinal roots resulting in neural ischemia, edema, and fibrosis. The effectiveness of anti-inflammatory drugs provides evidence that chronic inflammation may also be a primary cause of pain.\textsuperscript{2}

Compression of Nerve Roots

Radicular symptoms can occur with a number of disorders including spinal stenosis, derangements, nerve root entrapment, and nerve root adherence. The complete pathophysiology of the cause of these radicular symptoms is not known, however, compression has been associated with derangement and entrapment disorders.\textsuperscript{24}

The effects of compression on nerves can come from direct mechanical deformation or indirectly through a decreased blood supply. Direct mechanical effects do not occur until pressures of 200 mm Hg have been reached while ischemia can occur at pressures of 30 mm Hg or less.\textsuperscript{25} Ischemia changes the nerve conduction and axonal transport system of the nerve. The axonal transport system is responsible for transporting proteins to the more distal parts of the
neuron and may also be affected by compression. This phenomenon has been associated with the "double crush" syndrome in which damage to the nerve occurs at the original site and more distally because the axonal transport system is unable to move the vital proteins throughout the neuron causing a lack of nutrition.\textsuperscript{22,26}

Early in the development of pathology secondary to compression there is a thickening of the dura mater and arachnoid membrane. This is followed by a breakdown function of the blood-nerve barrier in the endoneurial space, which causes changes in arachnoidal tissue producing edema in the nerve root. The production of edema changes the permeability of the neural tissue, thus, adversely affecting the nerve.\textsuperscript{25} Compression also causes degeneration in individual nerve fibers, which leads to a decrease in the number of large myelinated fibers. The body responds by producing new, smaller fibers.\textsuperscript{27} When there is a decrease in the number of large myelinated fibers the amplitude of the action potential decreases and with it the strength of neural transmission diminishes.\textsuperscript{28}

Spinal roots have been found to be more susceptible to compression syndromes than peripheral nerves.\textsuperscript{25} This is probably because the spinal roots lack perineural and epineural connective tissues, which provide additional protection for the peripheral nerves. Compression of peripheral nerves is associated with paresthesia while the compression of nerve roots results in a state of irritation. This state of irritation is a precursor to the development of pain through mechanical stress. Without an inflammatory process, mechanical stress will not cause pain in the nerve roots except in the dorsal root ganglion (DRG), which
houses the cell bodies of the neurons. The DRG has been shown to be twice as sensitive to pain as the rest of the dorsal root.

Because the aforementioned disorders all present with radicular symptoms, it can be difficult to differentiate among them, but correct differentiation is very important. Proper diagnosis will provide better decision making for treatment procedures and allow therapists to be better prognosticators for these patients. To help differentiate among the disorders a proper understanding of the pathology is advantageous along with knowledge of various approaches for differential diagnosis.

Physical Examination

The physical examination is a vital source for differential diagnosis among the entrapment, derangement, and adherent nerve root disorders. The examination should include inspection of sensory, motor and reflex function. These tests can often assist in identifying the level of the lesion. A table to assist in defining the nerve root level is given in the appendix. The physical exam should also include a visual scan for anatomical deformities such as kyphosis, lordosis, and scoliosis. Range of motion measurements are helpful especially in monitoring the progress of therapeutic intervention. If neurological complaints are present, then neural tension testing is indicated.

Straight Leg Raise

The most common neural test of the lower extremities is the straight leg raise. As the leg is raised tension is placed on the sciatic nerve, which transmits the tension to the nerve roots. A positive SLR is evident when the original
symptoms that the patient complained about are reproduced between 20 and 70 degrees of hip flexion. The lower the angle when exacerbations occur the more severe the disorder.\textsuperscript{31}

According to Gianni,\textsuperscript{32} who performed a study on lumbar herniation in the elderly, the SLR is a reliable test in differentiating bony root entrapment from disc herniations. The test has been found to be positive in 95\% of patients with a herniated disc.\textsuperscript{2} Although the SLR is sensitive in indicating the presence of a herniated disc, it is not entirely specific. This means that the test is known to have a high number of false positives, so the testing may indicate that a herniated disc is present when a herniation really doesn’t exist. A crossed SLR Test is almost 100\% specific for a herniated disc,\textsuperscript{33} but this test is positive in only about 25\% of patients with herniated discs.\textsuperscript{2} The reason the crossed SLR test is positive in merely a quarter of the patients with herniated discs is because it is sensitive to patients with a protrusion medial to the nerve root. When the disc protrusion is lateral to the nerve root, raising the uninvolved extremity pulls the nerve root away from the disc protrusion and can actually relieve pain. However, if the disc protrusion is medial to the nerve root then the nerve root is pulled toward the disc protrusion and radicular symptoms are aggravated.\textsuperscript{34}

In order to assist in discriminating true neural signs from a hamstring strain, a Laseague’s test may be performed. To perform this test the therapist begins with a normal SLR; once symptoms are felt by the patient the therapist slowly lowers the leg about an inch to release tension. After the tension is released and the symptoms disappear the therapist dorsiflexes the foot, which
should only add tension to the nerve, therefore, isolating it from the hamstring. If pain is exacerbated with this maneuver then radiculitis is present. A therapist may also flex the neck, internally rotate the hip, or adduct the hip to solidify a diagnosis of true neural involvement. A sitting root test can also be used to confirm the diagnosis. This test is performed with the patient sitting at the edge of the plinth. From this position the patient extends their knee to see if symptoms are elicited. Neck flexion and ankle dorsiflexion can be used with the knee in extension to assist in the differentiation of neural signs.35

**Prone Knee Bend**

Another tension test in the lower extremity, the prone knee bend, may be used if the patient complains of lumbar pain and decreased sensation in the L1-3 dermatomes. This test is performed with the patient lying in the prone position. The therapist passively flexes the knee while making sure to keep the hip extended. This will stretch the L1-3 nerve roots via the femoral nerve as well as stretch the quadriceps muscle. If there is nerve root involvement the patient may feel symptoms in the lateral hip, lumbar spine, or anterior thigh, while a patient with a strain of their rectus femoris will have their pain isolated to the anterior thigh.31 Furthermore, a manual muscle test of a strained rectus would be painful, but the same test would be non-painful if there was nerve root involvement, since the nerve could only slacken during the contraction.

**Upper Limb Tension Tests**

The upper extremities also have tension tests available that can help decipher the location and severity of the lesion. Different specialized tests were
developed for the median, radial, and ulnar nerves. It is impossible to completely isolate each nerve, but the tests do partially isolate different nerves to aid in diagnosis. Moreover, all of the peripheral nerves stem from different nerve roots, so involved nerve roots can also be discerned using the tests. The median nerve is an extension of the C₆-₈ nerve roots, while the radial nerve is a continuation of C₅-₇ and the ulnar nerve primarily originates from C₈-T₁. For a description of the movements involved in these tests see the appendix.

When performing these tests the examiner can start either distally or proximally. The starting position of choice depends on two factors--the irritability of the current disorder and the location of the primary injury site. A highly inflamed nerve root would require the testing to begin with hand movements and move toward the shoulders, but if the wrist is the primary injury site, testing should begin with the shoulder movement. Patients with a non-irritable nerve root adherence would be better tested starting with the shoulder, likewise, patients with a non-irritable peripheral nerve entrapment at the wrist should be tested starting with the distal movements. In the “double-crush” phenomena mentioned earlier, the testing position would begin at the location of least irritation. The initial testing can be used as a comparable sign to assist in the reassessment for the effectiveness of the treatment.²²

McKenzie Examination

The McKenzie¹⁸,²⁴ system of physical examination uses a system of observation and repeated movements testing to determine the spinal disorder. McKenzie classifies his patients into three categories including the postural,
dysfunction, or derangement syndromes. He primarily uses the repeated motions of flexion and extension in the lumbar spine and flexion and retraction with extension in the cervical spine.

**Postural Syndrome**

Patients suffering from a postural syndrome do not have any radiating symptoms nor do they demonstrate any loss of motion during movement testing, and their movements are pain free. In addition, these patients do not have any deformities but they do often present with poor sitting and standing posture.

**Dysfunction Syndrome**

The dysfunction syndrome is caused by tissue that has adaptively shortened. Like the patients with postural syndrome, these patients often have poor posture, which may actually be the cause for the shortened tissue. However, these patients also exhibit decreased ROM during movement testing and have pain at end range. Patients who have developed the disorder through poor posture find that the loss of range is usually symmetrical. This contrasts from patients who develop a dysfunction secondary to trauma. These patients usually portray an asymmetrical loss in range of motion and often suffer from an adherent nerve root.

An adherent nerve root can produce radicular symptoms and often occurs after an acute episode of the derangement syndrome subsides and scarring has occurred. Laminectomies and discectomies also can lead to adherence. After surgery a scar may form on the dura and nerve roots to the erector spinae muscles and/or the disc and body. This scar restricts mobility of the nerve root and
increases the likelihood for a recurrent disc protrusion. Interestingly, Annertz and Tonneson found that the amount of scar tissue formed after a surgery does not correlate to the symptoms felt by patients. Key and Ford believe that the scar tissue originates from surgically damaged annulus, while Larocca and McNab believe that the surface of the erector spinae muscle complex is the culprit. In a ten-year follow up study of post-laminectomy patients, 1 out of 104 patients had recurrent radicular symptoms caused by nerve root adherence following laminectomy. There is still disagreement as to how the scar causes pain. Some feel that traction on the nerve root may cause nutritional or conduction disturbances, while others believe there is a biochemical factor involved in the production of pain.

**Derangement Syndrome**

The mechanical derangement syndrome occurs when the nucleus pulposus within an intervertebral disc migrates through the annulus fibrosus. McKenzie divided these derangements into seven categories according to the location of the symptoms and presence or absence of deformity. The first six derangements involve a posterior migration of the nucleus and the seventh describes an anterior movement of the nucleus. The anterior derangement is much less prevalent than the posterior derangements. For a more detailed explanation of the symptoms of these derangements see the appendix.

McKenzie believes that every patient goes through the six posterior derangements in succession. The process of a herniated disc begins with a painless fragmenting of nuclear material, which begins to migrate through the
annulus. When the annulus is ruptured, mild to severe pain may result because of the nerve endings surrounding the annulus. This pain from the annulus may be referred to the elbow or the knee depending on whether it occurs in the cervical or lumbar spine. When the fragment penetrates through the annulus, pain may even decrease because there is no longer tension on the annulus. However, the symptoms can become radicular and radiate to the gastrocnemius, foot or hand when it compresses a nerve root. When the symptoms radiate to the end of the extremities they are classified into McKenzie’s 5\textsuperscript{th} and 6\textsuperscript{th} derangements. Sometimes these derangements are treatable and other times the pathology is so extreme that it is irreducible. These irreducible derangements often end up with a nuclear fragment actually dislodging from the disc and getting stuck in the intervertebral foramen causing a nerve root entrapment.

In order to help differentiate among nerve root adherence, nerve root entrapment, reducible derangements and irreducible derangements, Wayne Rath\textsuperscript{41} has come up with a system using McKenzie’s method of repeated movements testing. If the patient has a reducible derangement, their pain will peripheralize with repeated flexion in both standing and sitting, while repeated extension will provide a centralization of pain. If the disc derangement is irreducible, the pain will peripheralize with both repeated flexion and extension tests. When the patient has an adherent nerve root they will experience leg pain at the end range with repeated flexion in standing, but when testing repeated flexion in lying there will not be any symptom reproduction. The repeated extension exercises will not have any effect on the leg symptoms regarding peripheralization or centralization.
The nerve root entrapment provides an interesting scenario for the examiner in that repeated flexion testing produces an increase in leg pain, which improves with repetition, however, the symptoms do not remain better. Furthermore, like the adherent nerve root, the therapist will observe a loss of motion and a deviation toward the involved side during the repeated flexion in standing test. Extension testing may either increase or have no effect on the leg pain. A diagnostic flowchart for differentiating these disorders is given in the appendix.

When assessing the cervical spine for derangements, McKenzie uses the movements of flexion and retraction with extension, which correlate with the flexion and extension motions used to diagnose the lumbar spine. Extrapolating Rath’s diagnostic table from the lumbar to the cervical spine should provide a basis for differentiating among the same disorders in the cervical spine movements.

**Spinal Stenosis**

Spinal stenosis, often referred to as bony entrapment, can also produce radiating symptoms and is caused by degenerative change in the facet joints. It begins with the inflammation of the synovial lining of the facet joints, which causes articular cartilage to thin. As the cartilage thins, the joint capsule stretches and loosens causing instability. Osteophytes on the articular processes develop and protrude into the spinal canal or the intervertebral foramen and encroach upon the nerve roots. Lumbar stenosis is most likely to occur at the L₄-₅ level. In the cervical spine the uncovertebral joints are often the site of osteophyte formation. The spondolitic changes that occur in the cervical spine are the most common
cause of radicular symptoms in the cervical area. This stenosis of the cervical spine is often referred to as a “hard” disc herniation.

People most often develop spinal stenosis when they are in their fifties and sixties. They describe an insidious onset and subsequent gradual increase in symptoms. “Hard” disc lesions of the upper spine lead to loss of stability and localized neck pain. Referred symptoms to the shoulder, arm, interscapular, and suboccipital areas are common. People with lumbar stenosis have symptoms of weakness, tiredness, asthesia, and dysthesia. There is often a progressive difficulty walking and a feeling of “rubbery legs.” Prolonged standing, moving, and walking cause pain and disablement. During the physical examination, ROM of the lumbar spine is usually decreased, but the straight leg raise test is normal. Decreased sensation, as well as muscle weakness may be possible, and patients often complain of pain with walking, which may be quickly resolved with sitting. According to Bassam, patients are asymptomatic when riding a bike in a flexed posture: the flexed posture allows more room through the intervertebral foramen compared to the extended spine. According to Olmarker and Reydevik, a possible cause of pain could be nutrition impairment that occurs when the venules and capillaries in the nerve root area become congested and slow down the transfer of metabolites away from the system. This leads to an increase in the concentration of metabolites, producing noxious stimulus in the nerve root leading to pain. Once the exercise is stopped the metabolites have a chance to leave and the pain is reduced. However, one study showed that riding a bike with a flexed posture was not as reliable for differentiating between vascular
claudication and neurogenic claudication caused by spinal stenosis as was previously thought.\textsuperscript{43} This finding should stimulate the need for further investigation in this area.

**Medical Differential Diagnoses**

The previously mentioned disorders are common for the neck and back, but they are not the only conditions that can cause spinal pain and radicular symptoms. It is important to rule out other possibilities before concentrating solely on mechanical problems. Metastatic disease may cause back and even sciatic symptoms. Signs to look for include pain at night and unexpected weight loss. People with vertebral stress fractures experience constant, localized, severe pain that is exacerbated by small movements.\textsuperscript{33} Cauda equina syndrome is a serious medical emergency and is indicated by bowel and bladder compromise, severe radiating pain in both legs, and saddle anesthesia.\textsuperscript{2} If low back pain is associated with fever, infection such as osteomyelitis may be suspected, especially in the elderly. Lumbar strain or sprain can often occur after heavy lifting and twisting, and can be differentiated by the neural tension tests mentioned earlier.\textsuperscript{3} Spondylolysis is a stress fracture in the pars interarticularis that separates the vertebral body and the neural arch. It can occur on one or both sides of a vertebra and typically appears in adolescent patients with occasional back pain. Hamstring tightness is a common adaptation for the instability. Spondylolisthesis is the forward slippage of the superior vertebra over the inferior vertebra and is often a precursor to stress fractures during sports participation.
Both spondylolysis and spondylolisthesis need radiographic imaging to confirm their diagnosis.²

The cervical spine also has many disorders that can produce radiculopathies. Extramedullary tumors, sarcoiditis, arterites, pachymeningitis, and viral infections all have been implicated.²⁶,⁴⁴ Multiple Sclerosis has also been known to produce radicular symptoms and should be suspected if dysarthria and diplopia are present. The key in these situations is to know when signs and symptoms are not adding up to a musculoskeletal condition and the need for referral to a physician becomes necessary. Upper limb nerve entrapments can cause confusion, but are discernable through the distribution pattern of symptoms. Subacromial bursitis, bicipital tendinitis, rotator cuff tears, and lateral epicondylitis are local disorders that also produce upper arm symptoms but these disorders can be easily ruled out by local testing procedures.⁴⁴ The Spurling Compression test along with the distraction and shoulder abduction tests can all be used to determine if the symptoms are caused by nerve root compression.⁵⁵
CHAPTER IV
TREATMENT

Physical therapy treatment for the spine differs extensively among therapists with a variety of modalities and programs being used. Because of the variability of treatments currently being used to treat the neck and back, many difficulties have arisen in performing proper studies to find the most efficacious method for treating patients. A study performed by Sullivan\textsuperscript{46} was designed to categorize types of treatment into groups in order to simplify analysis for future outcome studies. He managed to make eight categories out of over 25 treatment practices. These categories included Mckenzie, physical agents, exercise with equipment, active exercises, passive exercises, aerobics and walking, ergonomic activities, and manual therapy. Jette et al\textsuperscript{47} found that exercise, modalities and manual therapy were the most common treatments being used. Currently, the attitudes and beliefs of individual therapists seem to be the driving force behind the present treatment procedures.\textsuperscript{48}

Acute Pain

Treatment of cervical and lumbar disorders in the acute phase often involves rest, immobilization, moist heat, and ultrasound to alleviate symptoms.\textsuperscript{7,11,26,44,49,50,51} In a study by Honet\textsuperscript{7} patients with cervical radiculopathy were treated with hot packs, cervical traction, and US as tolerated. They found
that 80% of their patients had good to excellent results with this treatment procedure if it was used during their initial episode of cervical radiculopathy.

**Chronic Low Back Pain**

Studies have shown that people with chronic low back pain have less strength in their lower trunk musculature relative to the rest of the population. A study designed by Takemasa et al\(^52\) compared the effects of trunk strengthening in two groups of chronic low back pain patients. One group had an identifiable lesion causing the pain while the other group did not have a visual lesion. He found that both groups experienced improvement of symptoms, however, the group who did not have a detectable lesion had a much greater improvement of symptoms than the individuals with a lesion. Additionally, the researchers found that increasing the strength of the extensors had a more profound effect than increasing the strength of the flexors in the patients who had a lesion.

**Spinal Stenosis**

Patients who suffer from spinal stenosis are often relieved with Williams Flexion exercises.\(^53\) It is imperative to avoid Mckenzie extension exercises and prone lying. These patients can also improve their symptoms by increasing the strength in their abdominal muscles, especially the obliques. Pelvic traction in the supine 90/90 position can also be helpful.\(^54\) Decreasing the walking distance of patients with spinal stenosis can also assist in symptom relief. The patient should not walk any further once their symptoms begin.
Spondylolisthesis

Spondylolisthesis is also treated by strengthening the abdominals and trunk extensors. Stretching the tight hamstrings that develop as a compensatory mechanism for the instability can be beneficial. Sometimes a corset is worn to assist in limiting the amount of lordosis present. However, care must be taken with this approach because it may perpetuate decreased abdominal strength. 53

Manipulation and Mobilization

Spinal manipulation and mobilization are also commonly used to treat cervical and lumbar symptoms. The rationale behind mobilization is that synovial fluid can be distributed around the articular cartilage and disc through repeated, low stress, small amplitude movements. These movements may also be responsible for providing a partial stretch to the ligaments. Manipulation is designated by a high velocity thrust at the elastic limit. Rationales behind this procedure are that it can release synovial folds, relax tense muscles through a quick stretch, free adhesions, reduce the bulging disc, reposition facet joint cartilage, and reposition subluxed vertebrae. 55

Shakelle 56 investigated the efficacy of spinal manipulation and found that the procedure was effective for patients without radicular symptoms who receive it 2-4 weeks after the initial episode. Patients with chronic neck and back pain showed greater improvement with treatment of physical therapy and manipulation as opposed to physical therapy alone. Di Fabio 57 performed a thorough review on the efficacy of manipulation and mobilization for the treatment of low back pain and found that 11 of 14 studies reported positive effects with manipulation.
treatment. These studies also found that manipulation seemed to be more effective if performed within the first month of the onset of symptoms. On the other hand, only 1 of 4 studies found mobilization to be an effective treatment modality. Mobilization procedures may be more effective during the sub-acute and chronic stages of injury since they mimic movement of the spine and encourage the production of synovial fluid.\textsuperscript{55} Also, mobilization can be used if the patient is experiencing radicular symptoms, whereas, manipulation is contraindicated for people with radiculopathy. It is also important to note that there have been incidents of mortality with the use manipulation in the cervical spine.\textsuperscript{56}

**Nervous System Mobilization (NSM)**

Another treatment method for both cervical and lumbar spinal nerve root problems is mobilization of the nervous system. This treatment procedure can be applied to both acute and chronic injuries. Acutely, there may be trauma secondary to a compression or tension injury, or post operative damage following a laminectomy. All of these disorders are amenable to NSM. A chronic condition may occur when scarring has developed following surgery, or after conservative treatment of a disc protrusion that did not emphasize stretching the scarring tissue.\textsuperscript{22}

When treating patients who are in the acute stages and have more irritable symptoms there are many factors to keep in mind. The technique that is used should be far away from the location of the trauma. For example, patients with cervical root problems would benefit more from SLR with dorsiflexion
maneuvers than neck flexion movements because small motion of the neck would probably aggravate the patient’s symptoms. The treatment should not reproduce their symptoms and the movement should be through the largest range possible. The therapist should also remember to keep the patient relaxed and comfortable while continually monitoring the treatment through communication. If the disorder is found to be less irritable, movement into the symptom range is allowable. 22

Progression of the patient occurs through patient tolerance. The therapist can increase the number of repetitions and the amplitude of the movements. Also, therapists should keep in mind that there is an unlimited possibility of movements. Although evaluation and treatment may begin in the standard positions provided in the appendix, deviations from these positions are encouraged to provide full mobility. The standard positions are more important for initial evaluation and reassessment of symptoms. Another method for progression is to move more proximal to the site of the lesion if starting with the distal approach. Always reassess and regress if there is too much reproduction of symptoms, which is indicated if the patient feels tingling or pain more than a couple of minutes following the mobilization. 22

Patients with chronic problems benefit from mobilization that is much more aggressive. Adherent nerve roots require large amplitude movements going into the resistance. Patient discomfort is inevitable during these procedures, however, any symptoms encountered should be relieved immediately following the release of tension except minor paresthesias that may be present for a minute
or two. Using a variety of movements is also encouraged for patients with chronic disorders. It is beneficial to start closer to the source of discomfort, so patients with adherent nerve roots in the cervical spine should have their shoulder moved during the mobilization instead of using flexion and extension of the wrist. These patients also receive more benefits when the positions are held at end range, while acute patients are better off with more oscillations.\textsuperscript{22} It is very important to understand the differences in treatment procedures between acute and chronic injuries since the approaches are nearly the exact opposite.

**Exercise Programs**

According to Mooney\textsuperscript{49} the low back has three different exercise programs available for treatment including McKenzie, dynamic stabilization, and guided exercise. The McKenzie exercise program can be used for both the cervical and lumbar spine, while DLS and guided exercises are specific to the lumbar spine. Guided exercises refer to strengthening of the lumbar extensors in the seated position with equipment that can measure the force applied during back extension exercises. The sitting position is mandatory as it isolates the back extensors and doesn't allow substitution of the hip extensors. Guided exercises are not used for patients with radiculopathies in the initial stages, but the DLS and McKenzie programs can be used in all stages.

Saal et al\textsuperscript{58} performed an outcome study on conservative treatment of radiculopathy and found that 90\% of the patients had a good to excellent outcome and 92\% were able to return to work. The treatment started with controlling pain through medications and trials of extension exercises, traction, and basic
stabilization exercises. The exercise training started with stretching the soft tissue: the hamstrings, quadriceps, iliopsoas, gastroc-soleus, and hip internal and external rotators were all stretched. Maintenance of neutral spine was strictly adhered to during the stretches. A neutral spine was defined as the position of lordosis that was most effective in reducing radicular symptoms, not necessarily zero degrees of lordosis. Once flexibility was returned, joint mobility of the lumbar and thoracic segmental units along with hip ROM was addressed. Patients were trained in standing and prone extension exercises and alternating mid-range flexion and extension exercises in quadruped as a part of active joint mobilization.

Dynamic Lumbar Stabilization

The largest part of the Saal program was the stabilization exercises. The treatment started by finding neutral with a co-contraction of the trunk muscles. The idea behind stabilization is that patients can reduce intervertebral disc and facet injury caused by repetitive mechanisms through controlling the forces in the lumbar spine. Technique is the most important factor when performing the exercises. The difficulty increases throughout the program and many repetitions of the proper form are used to ensure proper engram motor programming. The progression of exercises moved to sitting stabilization, prone gluteal squeezes, supine pelvic bracing, and bridging. The bridging progression started at the basic position and moved to single-leg raising, stepping, and balancing with a therapeutic ball. After bridging the patients progressed to quadruped and kneeling positions and finally to continually changing positions while maintaining postural control.
Following the stabilization portion of the program, emphasis was placed on strengthening and aerobic training. These exercises all continued to emphasize the maintenance of the stabilization principles learned earlier.

**McKenzie Treatment Program**

The final treatment program that has been found to be effective in decreasing both lumbar and cervical pain is the McKenzie\textsuperscript{18,24} program. The McKenzie program has been identified as the most useful approach by 48% of physical therapists, and 85% of therapists regard it as moderately to very effective in the treatment of LBP.\textsuperscript{48} A portion of the McKenzie method was used in the DLS program mentioned above regarding the extension exercises to reduce the pain. However, extension exercises are not the only treatment involved in the McKenzie program. McKenzie bases his treatment decisions according to which syndrome-postural, dysfunction, or derangement- is present.

The postural syndrome is not encountered in the clinic often and is relatively simple to treat. Education on proper sitting and standing posture is indicated with the emphasis on the maintenance of lordosis and a slightly retracted neck and head. Patients can also benefit from learning retraction and extension exercises that can be used when discomfort arises following prolonged sitting. Standing tall and walking occasionally during these situations is also recommended for prophylaxis.

The dysfunction syndrome is caused by shortened tissue and may or may not involve the nerve root. The treatment for dysfunction starts with postural education so that gains made during treatment are not lost secondary to poor
posture, which may be the cause of the dysfunction. After postural advice is given the treatment exercises begin with flexion in lying and progress to flexion in standing. Flexion in step-standing with the chair on the contralateral side of the deviation is indicated following the flexion in lying exercise for patients who have a lateral deviation. Exercises should be performed ten times daily with ten repetitions for each set in order to achieve proper remodeling. Patients with an adherent nerve root are progressed much more slowly and are advised not to perform the exercises in the morning because of the imbibation that occurs in the disc at night. It is very important to remember that extension exercises should always be performed following the flexion exercises in order to eliminate the possibility of nuclear migration and subsequent herniation. All patients are also advised to avoid peripheralizing pain and to not over stretch, which is evident when pain from the exercise is felt the next day. Of course, under stretching does not provide any benefit either, so proper education and compliance is vitally important to the outcome of the treatment.

Treatment for the derangement syndrome is designed to centralize the pain and reduce any deformity that may be present. There are four stages involved in this process: reducing the derangement, maintaining the reduction, recovering function, and preventing the recurrence of the derangement.

Like the first two syndromes, treating a derangement begins with postural instruction. For the posterior derangements, instruction emphasizes maintaining a lordotic posture, while patients with an anterior derangement benefit from a kyphotic posture. The proper posture is mandatory in order to maintain the gains
made during exercise. If the proper posture is not maintained, healing of the tissues will not occur. Next, the therapist uses the movements during repeated movements testing that were found to reduce the symptoms as their guide for treatment. The lumbar spine exercises for the posterior derangement start with prone lying for five minutes with progression to extension in lying and then the modified push-ups, while the cervical spine uses retraction, retraction with overpressure, and retraction with extension exercises. Patients with an anterior derangement of the lumbar or cervical spine are given flexion exercises to the back or neck, respectively. When these movements provide improvement of symptoms the exercises are prescribed to the patient in a home program, and should be performed every waking hour until treatment the next day.

One of McKenzie's primary goals is to allow patients to care for themselves as much as possible, which reduces the amount of dependence that a patient has on their therapist. Therefore, as long as patients experience a centralization and reduction of symptoms, the exercise prescription remains the same. However, if no more centralization occurs and/or a deformity is present, then more progressive treatments need to be performed. In the lumbar spine the therapist may perform and teach a lateral shift to the patient. If this does not centralize the symptoms properly, other procedures may be used including rotation, rotation with manipulation in extension, and rotation with manipulation in flexion. Advanced procedures used for the cervical spine include lateral flexion and mobilization. If these maneuvers are unsuccessful, McKenzie recommends traction as an alternative. Only one different procedure should be
performed during a treatment session, otherwise, it is difficult to determine if the technique was effective. Once a therapist is able to centralize the patient’s pain through advanced techniques, the responsibility is placed back onto the patient to continue with their exercises independently. The original exercises should be performed and the patient should experience a continual reduction in symptoms. As the symptoms improve the extension exercises can be reduced to 2-3 times per day.

After the symptoms subside it is recommended to perform exercises to decrease the chance for nerve root adherence by remodeling the scar tissue from the derangement. These exercises are performed in the afternoon and evening after the disc has had a chance to lose some of its water that was absorbed over night. Flexion in lying is the first exercise performed to provide remodeling in the lumbar spine. The exercise is performed ten times with close attention being paid to the onset of symptoms. The patient should feel some tension but the ROM should improve while the symptoms either remain the same or decrease. However, if peripheralization occurs the exercises have been added too soon and should be stopped immediately. Once the patient has full ROM with flexion in lying then they should be progressed to flexion in sitting followed by flexion in standing. Cervical patients simply use passive neck flexion to remodel the scar tissue. As a reminder, patients should always follow flexion exercises with extension exercises to avoid the chance of a recurrent derangement. Following reduction of the derangement the patient should continue to perform extension exercises twice a day and flexion exercises once a day for six weeks.
Nerve Root Entrapment

Patients who are suffering from a nerve root entrapment are poor candidates for mechanical treatment. Fortunately, the problem may resolve itself as the surrounding structures find a way to accommodate the intrusion. However, it is important for the physical therapist to supervise the patient during this period, which often requires 3-6 months. The therapist's duty is to reduce the patient’s fear of flexion movements and activity, as well as encourage proper remodeling of the scar tissue. Treatment sessions can be infrequent once a proper diagnosis is made and the patient is independent in an extension based treatment program.\textsuperscript{42}
CHAPTER 5
CONCLUSION

The spine is a common site for musculoskeletal injury. Pain may be localized to the neck or back, or it may radiate to the extremities. It is important to understand the biomechanics of the vertebral column and the structures within the spine, so patients with mechanical disorders can be properly diagnosed. Various procedures for physical examination of the spine have been presented to properly differentiate among the disorders that produce radicular symptoms. Proper administration and interpretation of these tests is mandatory in order to choose the best treatment options for the patient. Unfortunately, outcome studies regarding treatment of the spine are limited.

Although many treatment approaches for patients with radicular symptoms have produced satisfactory results, there is still not total agreement among therapists regarding the best treatment approach to use. Since therapists tend to use a vast array of both passive and active modalities during their treatment, it is difficult to ascertain which modality provides the most benefit for patients. Conversely, having a variety of treatments in the therapist’s arsenal is advantageous, since patients do not all respond the same to treatment. However, I feel more research in the area of treatment outcomes for patients that are experiencing low back and neck pain with radicular symptoms would enrich the physical therapy profession and provide a stronger basis for our decision-making in this area.
### Table of Cervical Nerve Roots

<table>
<thead>
<tr>
<th>Nerve Root</th>
<th>Reflex</th>
<th>Dermotome</th>
<th>Myotome</th>
<th>Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4</td>
<td>None</td>
<td>Top of shoulder</td>
<td>Shoulder elevation</td>
<td>Interscapular, Neck, Shoulder</td>
</tr>
<tr>
<td>C5</td>
<td>Biceps</td>
<td>Lateral deltoid</td>
<td>Shoulder abduction</td>
<td>Neck, shoulder interscapular</td>
</tr>
<tr>
<td>C6</td>
<td>Brachioradialis</td>
<td>Lateral thumb</td>
<td>Elbow flexion</td>
<td>Shoulder, radial forearm, interscapular</td>
</tr>
<tr>
<td>C7</td>
<td>Triceps</td>
<td>Dorsum of middle finger</td>
<td>Elbow extension</td>
<td>Interscapular, forearm, chest, ulnar hand</td>
</tr>
<tr>
<td>C8</td>
<td>None</td>
<td>Ulnar aspect of little finger</td>
<td>Thumb extension</td>
<td>Medial forearm</td>
</tr>
</tbody>
</table>

### Table of Lumbar Nerve Roots

<table>
<thead>
<tr>
<th>Nerve Root</th>
<th>Reflex</th>
<th>Dermotome</th>
<th>Myotome</th>
<th>Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2</td>
<td>None</td>
<td>Anteromedial mid thigh</td>
<td>Hip flexion</td>
<td>NA</td>
</tr>
<tr>
<td>L3</td>
<td>Patellar</td>
<td>VMO</td>
<td>Knee extension</td>
<td>NA</td>
</tr>
<tr>
<td>L4</td>
<td>Patellar</td>
<td>Medial ankle</td>
<td>Ankle dorsiflexion</td>
<td>Lower back, hip, postero-lateral thigh, anterior leg</td>
</tr>
<tr>
<td>L5</td>
<td>Medial hamstrings</td>
<td>Dorsum of foot</td>
<td>Great toe extension</td>
<td>Above SI joint, hip, lateral thigh and leg</td>
</tr>
<tr>
<td>S1</td>
<td>Achilles</td>
<td>Lateral border of foot</td>
<td>Ankle planterflexion</td>
<td>Above SI, hip, posterlateral</td>
</tr>
</tbody>
</table>
**TABLE OF LUMBAR DERANGEMENTS**

**Derangement One:**
- Central or symmetrical pain across L4-5
- Rarely buttocks or thigh pain
- No deformity

**Derangement Two:**
- Central or symmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Deformity of flat or kyphotic spine

**Derangement Three:**
- Unilateral or asymmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Deformity of lumbar scoliosis
- No deformity

**Derangement Four:**
- Unilateral or asymmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Deformity of lumbar scoliosis

**Derangement Five:**
- Unilateral or asymmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Pain extending below the knee
- No deformity

**Derangement Six:**
- Unilateral or asymmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Pain extending below the knee
- Deformity of sciatic scoliosis

**Derangement Seven:**
- Symmetrical or asymmetrical pain across L4-5
- With or without buttock and/or thigh pain
- Deformity or accentuated lumbar lordosis

---

TABLE OF CERVICAL DERANGEMENTS

Derangement One:

Central or symmetrical pain across C₆-₇  
Rarely scapular or shoulder pain  
Extension obstructed  
No deformity  
Rapidly reversible  
Comprises approximately 35% of cervical spectrum  
Able to curve reverse

Derangement Two:

Central or symmetrical pain across C₆-₇  
With or without scapular and/or shoulder pain  
Deformity of kyphosis  
Extension obstructed  
Rarely rapidly reversible  
With deformity of flattened or fixed cervical spine  
Comprises approximately 3% of cervical spectrum

Derangement Three:

Unilateral or asymmetrical pain across C₆-₇  
With or without scapular and/or shoulder pain  
No deformity  
Extension, rotation, and lateral flexion may be individually or collectively obstructed  
Rapidly reversible  
Comprises approximately 39% or cervical spectrum  
Able to curve reverse
Derangement Four:

Unilateral or asymmetrical pain across C6-7
With or without scapular and/or upper arm pain
With deformity of acute wry neck or torticollis
With obstruction of lateral flexion, rotation, and extension
Rapidly reversible
Comprises approximately 2% of cervical spectrum

Derangement Five:

Unilateral or asymmetrical pain across C6-7
With or without scapular and/or upper arm pain
With pain extending below the elbow
No deformity
Extension and lateral flexion towards the side of pain obstructed
Often rapidly reversible
A small percentage fail to respond to mechanical therapy
Comprises approximately 15% of cervical spectrum
Able to curve reverse

Derangement Six:

Unilateral or asymmetrical pain about C5-6-7
With arm symptoms distal to the elbow
With deformity of cervical kyphosis, acute wry neck, or torticollis
Extension and lateral flexion towards the side of pain obstructed
Neurological motor deficit is common
Not rapidly reversible
A significant number or patients fail to respond to mechanical therapy
Comprises approximately 6% of cervical spectrum

Derangement Seven:

Unilateral or asymmetrical pain across C6-7
With pain occasionally referred to antero-lateral neck and throat*
Table of Upper Limb Tension Test Movements$^{22,31}$

<table>
<thead>
<tr>
<th>Median Nerve Bias (C$_{6,7,8}$)</th>
<th>Radial Nerve Bias (C$_{5,6,7}$)</th>
<th>Ulnar Nerve Bias (C$_{8T_1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder abd and ER to 90</td>
<td>Shoulder abd and IR</td>
<td>Shoulder abd ER</td>
</tr>
<tr>
<td>Elbow extension</td>
<td>Elbow extension</td>
<td>Elbow flexion</td>
</tr>
<tr>
<td>Wrist/finger flexion</td>
<td>Wrist/finger flexion</td>
<td>Wrist/finger extension</td>
</tr>
<tr>
<td>Shoulder girdle depression</td>
<td>Shoulder girdle depression</td>
<td>Shoulder girdle depression</td>
</tr>
<tr>
<td>Cervical spine ipsilateral</td>
<td>Cervical spine ipsilateral</td>
<td>Cervical spine ipsilateral</td>
</tr>
<tr>
<td>moving to contralateral</td>
<td>moving to contralateral</td>
<td>moving to contralateral</td>
</tr>
<tr>
<td>lateral flexion</td>
<td>lateral flexion</td>
<td>lateral flexion</td>
</tr>
</tbody>
</table>
Diagnostic Flowchart for Radicular Symptoms

Radicular Symptoms

Spinal Stenosis
- Insidious onset
- Pain with standing and walking
- Pain decreased with flexed posture

Perform SLR
- Negative
- Positive

Perform Repeated FIS
- Centralization

Anterior Derangement
- Repeated EIS
- Increases symptoms

Peripheralization

Reducible Derangement 5 or 6
- Peripheralization

Irreducible Derangement 5 or 6
- ANR
- Repeated FIL Has no effect

Nerve Root Entrapment
- Movement increased with reps but does not remain better

Decreased with flexed posture

 Increases symptoms
REFERENCES


41. Rath WW. Nerve Root Entrapment Syndrome in the Lumbar Spine. Presented at the McKenzie International Institute; September, 1993; Syracuse, NY.


