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HERNIATED LUMBAR DISC WITH SCIATICA
(INCLUDES OTHER CAUSES OF SCIATICA)

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The WSCC Care Pathways provide a standardized context for clinical decision making as well as a variety of possible interventions. These pathways are not intended to replace the clinical judgment of the individual practitioner. A practitioner may vary from these guidelines, if in his or her judgment, variance is warranted to meet the health care needs of the patient and the variance remains within generally accepted standards of practice.

Limitations

WSCC pathways are intended for use within our clinic system. They may be useful as a seed for regional guidelines or guidelines with wider application, but caution must be exercised. The following limitations would have to be addressed. 1) The literature searches employed would need to be more exhaustive; 2) inclusion criteria for published studies would need to be more stringent; 3) a wider pool of subject-matter experts must be tapped; 4) the participants of the consensus panel would need to be drawn from a broader cross-section of the profession and perhaps other health care providers as well. Although individual procedures and decision-making points within the Care Pathways have established validity or reliability, the pathways as a whole are untested.

ICD-9 Codes:

722.1 Thoracic or lumbar intervertebral disc displacement without myelopathy

722.10 Lumbar intervertebral disc displacement without myelopathy

plus

724.3 Sciatica ("sciatic neuralgia, sciatic neuritis")

724.4 Lumbosacral radiculitis

953.2 Injury, lumbar nerve root

or

724.9 Disorder of back, compression of nerve root

This Care Pathway is designed for patients presenting to the WSCC clinic system with signs and symptoms suggesting a lumbar disc herniation with sciatica. It may also be useful for patients with low back and leg pain, where the nature of the leg pain is unclear.

1999 Search Strategy

Multiple terms were combined and a standardized search strategy was employed in the areas of therapy, diagnosis, etiology and prognosis to ensure that evidence-based, clinically relevant studies would be identified and included. WSCC librarians used published strategies that have been developed by librarians and researchers associated with various evidence-based medicine centers, including the Cochrane Collaboration.[i] The searches used at WSCC are either based on or identical to strategies that have been published by these professionals and in some cases validated by hand searches of the medical literature.[ii,iii]

The following data bases were searched: MEDLINE, CINAHL, MANTIS, and the Index to Chiropractic Literature. ECRI,[iv] the US Agency for Health Care Policy and Research, and appropriate professional organizations were used to search for published guidelines.

Many of the citations were downloaded into reference management software and sorted by probable relevance, divided into groupings of high sensitivity, high specificity, and published guidelines. The primary authors reviewed the citations and abstracts, selected sources that appeared to be useful and relevant, and reviewed the original papers. For the manipulation section, all available pertinent articles were read and presented to the CSPE Committee. More articles were requested and reviewed, as well as focused searches performed on specific issues identified by the CSPE Committee during the review process.

2008 Revision

Multiple terms were combined and a standardized search strategy was employed using the following terms: intervertebral disc displacement/ sciatica/ low back pain /radiculopathy/ lumbar vertebrae/ in [Injuries]/ herniated lumbar disc/ treatment/ therapy/ management/ risk factors/ causation. The following databases were searched spanning from 1999-2006: Ovid MEDLINE, all EBM reviews, Cochrane DSR, ACP Journal club, DARE, CCTR, CINAHL, MANTIS and the Index to Chiropractic Literature. The searches were performed by Janet Tapper, MLS, Director of Learning Resources at WSCC, and one of the authors (SH). Two authors (SH, RL) reviewed the citations and abstracts, selected sources that appeared to be useful and relevant, and reviewed the original papers. In addition, citations from these articles were sometimes followed up and recent textbooks were also consulted.

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[i] Bero L, Rennie D. The Cochrane Collaboration. Preparing, maintaining, and disseminating systematic reviews of the effects of health care. JAMA 1995;274(24):1935-8.

[ii] Greenhalgh T. How to read a paper. The MEDLINE database. [Review] [4 refs] BMJ 1997;315(7101):180-3.

[iii] Haynes RB, Wilczynski N, et al. Developing optimal search strategies for detecting clinically sound studies in MEDLINE. J Am Med Informatics Assoc 1994;1(6):447-58.

[iv] Healthcare Standards: 1999 Official Directory. Plymouth Meeting, PA: ECRI; 1999. Annual.

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BACKGROUND

TERMINOLOGY

Historically, the literature subdivided lumbar herniated intervertebral discs into a variety of categories, with authors often employing different systems and even using conflicting terms to describe the same morphology.

In March 2001, a combined task force of the North American Spine Society (NASS), American Society of Spine Radiology (ASSR), and American Society of Neuroradiology (ASNR) published recommendations to standardize terminology related to lumbar disc pathology. For this care pathway, the following terminology from that document will be used. (Fardon 2001)

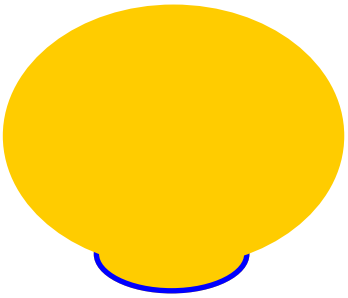
Bulging disc: An apparent *generalized* extension of disc tissues beyond the edges of the apophyses in the horizontal plane, over greater than 50% (180 degrees) of the circumference of the disc. In many cases, it may bulge in every direction (360 degrees). The bulge itself is usually shallow, less than 3mm. Bulging is not considered a form of herniation.

> ➢ **Clinical Tip:** Disc bulges are clinically unimportant unless they contribute to spinal canal stenosis.

Herniated disc: A *localized* displacement of disc material (i.e., nucleus pulposis, cartilage, fragmented annular tissue, fragmented bone) beyond the edges of the apophyses. A *focal herniation* involves less than 25% of the disc circumference. A *broad-based herniation* involves 25 to 50% of the disc circumference.

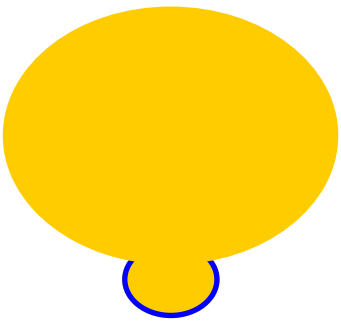
Based on the shape of the disc herniation, the terms *protrusion* or *extrusion* can be used instead of the term herniation. In cases where the distinction cannot be readily made, the term herniation is recommended.

Protrusion: A herniated disc in which the greatest distance in any plane, between the edges of the disc material beyond the disc space, is less than the distance between the edges of the base of that material in the same plane. In other words, the base of the herniation is broader than the distance it protrudes into the spinal canal.



protrusion

Extrusion: A herniated disc, in which at least one plane, the distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base in the same plane. In other words, the discal material balloons into the canal with a comparatively narrow base, as if it is trying to bud off. In fact, the term extrusion can also be used when it does separate itself away, when no continuity exists between the disc material beyond the disc space and that within the disc space (see *Sequestered* on next page).



extrusion

Sequestered (Free Fragment)**:** A herniated disc that detaches and is separate from the disc of origin.

Contained herniation: Disc tissue that is wholly within an outer perimeter of uninterrupted outer annulus or capsule.

Uncontained herniation: A disc in which substance is less than wholly contained by its annulus (i.e., the nucleus is exposed to the spinal canal).

It is important to note that distinguishing a contained from an uncontained herniation may not be possible with currently available imaging modalities and is only verified at surgery.

Additional Terms

The term sciatica refers to leg pain radiating to the foot (or at least past the knee) believed to be due to one of the following: L4, L5 or S1 nerve root injury (e.g., radiculopathy/ radiculitis), disease affecting the sciatic nerve or its nerve roots (e.g., diabetes), or entrapment of the sciatic nerve itself (e.g., piriformis syndrome). Sciatica in this document will not be used to represent *scleratogenous/deep-referred leg pain* (sometimes referred to in the literature as *pseudosciatica*). It should be understood that in any given patient, leg pain may be a combination of "true" sciatica secondary to nerve root irritation as well as somatic referred pain from deranged discs, myofascial and/or facet involvement.

The term symptomatic lumbar disc disease (SLDD) has begun to be seen in the literature to differentiate between incidental disc abnormalities seen on MRI and those that are assumed to be responsible for a patient's pain. (Lisi 2005) In this care pathway, herniated disc will refer to a herniation that is symptomatic and affecting a nerve root.

Not included in this pathway are discal tears (internal derangement) which cause local and/or referred leg pain but do not appreciably enter the spinal canal nor directly damage nerve roots. Symmetrical bulges as a result of degenerative disc disease (DDD) or possibly as a component of spinal stenosis will be dealt with in another care pathway.

MECHANISM

Disc herniations may present with a slow or spontaneous onset, secondary to degeneration, or suddenly as a result of trauma or accumulative microtrauma. There is also mounting evidence of a strong genetic predisposition to disc degeneration. (Battié 2006)

The mechanism of disc injuries is based primarily on compressive forces in *repetitive* flexion (McGill 2007), often with super-imposed torsional forces (Deyo 1990).

The pain associated with lumbar disc herniations is likely a combination of local and deep referred pain from tears in the annular fibers and radicular pain from irritation to the nerve root. The outer third of the annular fibers contains nociceptors and these can proliferate, penetrating even deeper toward the nucleus pulposis as discs degenerate (Coppes 1997).

The accompanying sciatica (e.g., radiculitis and/or radiculopathy) is thought to be caused by mechanical compression, adhesions and/or chemical/immunologic irritation of the nerve or nerve root. The role of each of these factors is the subject of much research. Brisby (2002) has identified the presence of antibodies to glycol-sphingolipid (which is abundant in different cell types in the CNS and PNS) in patients with sciatica and disc herniations, suggesting a local immune response. The amount of pressure on the nerve root has been shown to correlate with the severity of the neurologic deficits and trunk list, but not to the degree of pain (Takahashi 1999). Garfin (1995) cites many studies which suggest that nerve compression without inflammation does not cause pain and that some degree of inflammation must exist to lead to sciatica.

An intraoperative study utilizing the straight leg raise (SLR) test found that tension on the nerve root caused by adhesion to the herniation resulting from the effects of

chemical inflammation may be of more importance than nerve root compression. Since compression of otherwise healthy nerves does not cause pain, it is thought that inflammation and resulting adhesions reduce the intraradicular blood flow. When the SLR caused sciatica in these patients, there was an associated 70% decrease in intraradicular blood flow. (Kobayashi 2003)

EPIDEMIOLOGY

Almost 25% of adults under the age of 60-years old have herniated discs. More than 50% of adults have bulging discs. (Boden 1990, Jensen 1994) The vast majority of these are asymptomatic. *Symptomatic* disc herniations account for less than 5% of LBP, but are thought to be the most common cause of nerve root pain/sciatica. (Gibson 2007) The incidence is usually estimated to be 1% to 2% of patients with low back complaints (Deyo 1987, Rhee 2006) but has been reported to be as high as 5% (Gibson 2007). Perhaps the most commonly quoted number for symptomatic disc herniations is from a large survey taken in the late 1970's in which about 2% of patients reported that they had been told by their doctor that they had a "ruptured disc." (Deyo 1987, 1992)

A retrospective study of 3,553 patients in one chiropractic office revealed a prevalence of about 2%. (Stern 1995) A prospective study of chiropractic patient characteristics found 2.8% of new patients of private practitioners had a lumbar radicular syndrome with neurologic deficits. (Nyiendo 1990)

The presence of leg pain is thought to increase the likelihood to about 14%. (Lurie 1999) On the other hand, in an orthopedic surgeon's patient population, the prevalence is estimated to be about 20%. (Deyo 1996)

The estimates also increase significantly with persistent LBP. In one large study of persistent LBP (intermittent for the previous 10 years, recent episode greater than 3 months), 37% of the patients in that pool were diagnosed with disc herniations. (Long 1996)

The incidence of clinically significant herniated discs is highest in the 30-40 year age group (Deyo 1990).

Herniated discs occur most frequently at L3-L4, L4-L5, and L5-S1 discs. The majority of disc herniations occur at the L4-L5 and L5-S1 levels. L1-L3 nerve root involvement constitutes less than 5% of surgical patients. (Andersson 1996)

Prevalence Table (LBP patients)

Overall estimate	1-2%
PCP (medical)	2%
General chiropractic setting	2-3%
LBP with leg pain	14%
Orthopedic surgeon	20%
Persistent LBP	37%

NATURAL HISTORY

Only about ⅓ of patients report an acute onset. (Kosteljaetz 1984, Vucetic 1997) Most have a gradual onset of LBP *followed* by sciatica and will report having had previous episodes of low back and/or leg pain. (Vucetic 1997) Most of what is known about the natural history is based on comparing nonoperative to operative care. These studies suggest that the pain curve for patients with disc herniations drops gradually, sometimes taking days, weeks or months.

A 2007 Cochrane review suggests that 90% of acute attacks of sciatica resolve with nonsurgical management. (Gibson 2007) The main pain period of radiculopathy appears to be the first 4 to 6 weeks after which there is usually marked reduction of leg and back pain. (Weber 1993)

Rhee (2006) writes that "it is commonly agreed that lumbar disc herniation has a favorable natural history (i.e., the clinical course of the disease without therapeutic intervention)." Functional improvements, however, may not become stationary for as long as one to two years. (Rhee 2006)

Even neurologic motor deficits (except cauda equina syndrome and severe or progressive motor loss) have a favorable natural history. (Saal 1996)

Imaging reveals that most herniations resolve or improve without surgical intervention (78% in one study) (Ellenberg 1993). Saal (1990) suggested that 80% of herniations decrease by > 50%. Even large herniations do not have a negative effect on prognosis. (Ellenberg 1993) In fact, large herniations resorb to a greater degree than smaller ones. Furthermore, the degree of resorption appears to have little correlation with the resolution of signs and symptoms. (Ellenberg 1993, Matsubara 1995) Occasionally, a disc herniation will trigger the formation of an epidural hematoma, which has a high potential for resorption. (Saal 1996)

Tables I and II on Page 10 show three major clinical improvement patterns in a conservative care setting and describe patterns of neurologic loss and recovery.

RISK FACTORS

SUMMARY

- Male
- Genetic
- Circular endplates
- Relative canal stenosis
- Cigarette smoking
- Chronic cough
- Pregnancy
- Obesity
- Jobs involving standing, walking, lifting
- Repetitive lifting and twisting
- Prolonged driving
- Sedentary occupations/lack of sports activities
- Night shift work
- High stress

Biological

Men are more likely to have disc herniations than women. (Heliövaara 1987, Taylor 2005)

Recent research involving twins suggests that genetics may well play the most dominate role. Exposure to physical loads that have generally thought to lead to disc degeneration were significantly less influential than the genetic background of the individual. (Battié 2006)

The shape of the vertebral endplate has been shown to be associated with herniations. More circular endplates have a strong correlation with posterior disc herniations at L4-L5 and L5-S1 in males and females. (Harrington 2001)

Spinal canal stenosis, although it may not instigate a disc herniation, can play a role in symptom development and amplification. Dora (2002) suggests that, in symptomatic patients, spinal canal dimensions are significantly smaller than those in asymptomatic patients.

Cigarette smoking (Kelsey 1984, Lindal 1996, Miranda 2002) has been suggested as a risk, perhaps by affecting the blood vessels that supply the disc. Miranda's random controlled trial (RCT) found that current smokers who had smoked at least 15 years had a three-fold increase risk for experiencing a low back condition that would cause pain radiating beyond the knee.

Other risk factors that have been reported include chronic cough, pregnancy, (Kelsey 1984) and, more controversially, obesity with a reported three-fold increase (Heliövaara$_b$ 1987).

Environmental

A study of 274 patients with pain radiating to the leg showed three patient characteristics: male gender, age group of 51 to 81, and a job that involved standing, walking and lifting. However, these patients were part of a larger group with leg pain in general, not necessarily radicular pain associated with disc herniations. (Vroomen 2002)

Mechanical loading in the form of repetitive flexion predictably will cause a herniation in a laboratory setting. (McGill 2007) Epidemiological studies, too, suggest that repetitive twisting combined with flexion in an occupational setting carries risk (Deyo 1990). Likewise, Miranda (2002) found that workers who did more job-associated twisting were more likely to suffer from sciatica. Not surprisingly, repetitive heavy lifting has also been cited (Rhee 2006).

Prolonged driving of motor vehicles may carry a high risk, perhaps related to vibration and/or the sustained loading in flexion associated with sitting (Kelsey 1980, Kelsey 1984) Long-term occupational exposure to vibration has often been considered a risk factor for disc herniations (Kelsey 1980, Kelsey 1984, Miranda 2002, Younes 2006). However, research comparing matched groups of workers with and without long-term exposure revealed a more complex relationship. While there were higher levels of low back and sciatic pain in the vibration-exposed workers, no differences in disc degeneration or endplate Modic* changes were detected clinically or on MRI. (Kuisma 2007, Kumar 1999) It would appear that vibration may not be a causative factor for disc herniations, but it seems to contribute to increased symptoms.

Sedentary occupations carry risk (Deyo 1990), as well as lack of sports activities. Night shift work has also been implicated. (Elfering 2002)

High Psychological Stress. A large prospective cohort study found that the more stress a worker had, the higher the risk that s/he would suffer from an episode of sciatica (defined as pain radiating beyond the knee). Stress was more strongly associated with the persistence of sciatica as opposed to initiation of a first episode. (Miranda 2002)

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* Modic changes are depicted on MRI and reflect stages of boney degeneration which, in turn, mirror stages of disc degeneration.

Table I: Three improvement patterns with conservative care (Saal 1996)

Pattern 1, type A
- Onset of acute, severe pain: combination of lumbar and leg pain.
- Acute phase lasts 1-2 weeks.
- Severe pain most frequently abates, often before initiation of any treatment other than activity limitation and analgesics.
- Residuals may be relatively painless with mild neurologic deficit.
- Often associated with disc extrusion or sequestration.

Pattern 1, type B
- Onset of acute, severe pain often associated with neurologic deficit that does not abate with time or conservative treatment.
- Often associated with a migrated sequestration and may have underlying spinal stenosis as a complicating factor.

Pattern 2
- Insidious onset of moderate pain that remains relatively constant until treated (this may be several months).
- Often associated with contained herniation or mild extrusion (uncontained).
- Has highest recurrence rate.

Pattern 3
- Insidious onset of mild to moderate pain with a typical duration of 6-12 weeks with spontaneous symptom resolution.
- Often associated with small contained herniations, but may be associated with any type.

Table II: Patterns of neurologic loss and recovery in disc herniation
(Saal 1996)

- Mild loss: Sensory, with or without a loss of one motor grade; typical improvement in 6-12 weeks.
- Moderate loss: DTR absence with more than one grade of motor loss; typically with complete recovery within 3-6 months, with gradual motor recovery over that time. (A grade 0 DTR will rarely return.)
- Severe loss: Motor loss to a grade 3 or below; with full recovery often taking a year, and occasionally with only partial recovery.
- Neurologic loss in patients with extrusions or sequestrations typically occurs within the first two weeks of onset. Progressive motor loss is rare, but will likely occur within the first two weeks of onset of sciatica, rarely after six weeks.
- The chances of resolution of neurologic deficits are about equal when comparing surgical to conservative management. (Postacchini 1996)

EVALUATION: KEYS TO DIAGNOSIS

Key Physical Examination Procedures and Signs

The practitioner should consider the following list of key physical examination procedures and signs in order to properly evaluate a patient with a suspected herniated disc with sciatica.

SUMMARY

- Thoracolumbar AROM
- Mannequin sign
- SLR (seated and lying)
- Maximum SLR (e.g., Slump) or confirmation tension tests (e.g., Bragard, Bowstring)
- Valsalva maneuver or cough test
- Sensory testing (in most cases, L4, L5, S1 dermatomes)
- Achilles and patellar reflexes (consider hamstring reflex)
- Muscle tests (especially ankle eversion, great toe extension and flexion, ankle plantar and dorsiflexion)
- Girth measurement of thigh and calf
- Palpation of lumbar spine and pelvis for painful restrictions, joint challenge, peripheralization or centralization
- Palpation of lumbar and pelvic soft tissue
- Consider McKenzie protocol to identify centralization maneuvers.
- If there are signs of a neurological disease not explained by the low back diagnosis, consider testing cranial nerves, cerebellum and upper extremity sensation, muscle strength, and stretch and pathological reflexes.

NOTE: Other orthopedic maneuvers or biomechanical procedures can be done as needed to explore other diagnoses, but may not be necessary initially when a herniated intervertebral disc diagnosis is made. In female patients, determine whether a pelvic examination is indicated.

Pattern Recognition

A typical patient with a lumbar disc herniation will usually have back pain as the first symptom. The patient often has a history of recurrence, and eventually leg paresthesia (starting distally) and pain develop (starting proximally). The leg pain then predominates (usually by the time the patient presents for care). Symptoms are aggravated by sitting and DeJeurine's triad, with a strong pattern of flexion load sensitivity. Symptoms may be relieved by lying down, and sometimes by walking (Tarulli 2007). Incidental findings can include night pain (sensitivity 65-78%) and pain at rest (sensitivity 84-90%) (Jonsson[b] 1996). There may or may not be an identifiable precipitating event. (See Risk Factors for more detail).

Key Clinical Signs and Symptoms

The key signs and symptoms can be divided into those that suggest nerve root damage and those that suggest that the problem is discogenic.

SUMMARY

Radicular Clues

- Presence of leg pain (especially if dermatomal)
- Presence of dermatomal paresthesia
- Positive SLR and other tension tests
- Neurologic deficits

Discogenic Clues (as cause of radiculopathy)

- Decreased sagittal thoracolumbar range of motion (ROM)
- Mannequin sign
- Pain that centralizes with repetitive or sustained end-range loading
- Positive Valsalva
- Sitting may be poorly tolerated.
- DeJeurine's triad
- Flexion load sensitivity

EVIDENCE SUPPORTING A RADICULAR SYNDROME

The following major indicators, based on McCullough, should be used in assessing patients evaluated for radiculopathy secondary to lumbar disc herniation. Bear in mind that three of these criteria—or two, with a positive imaging test—support a clinical diagnosis of radiculopathy with a good probability of a lumbar disc herniation. (McCullough 1977)

Major Indicators of Radiculopathy

- Presence of leg pain (especially if dermatomal)
- Presence of dermatomal paresthesia
- Positive SLR and other tension tests
- Neurologic deficits
- Positive advanced imaging (e.g., MRI)

Vroomen et al. (2002) identified symptoms and physical exam findings associated with patients having MRI confirmed nerve root compression (usually associated with a disc herniation):

- Symptoms: Dermatomal pain, intermittent pain, predominant leg pain, and increased pain with coughing, sneezing or straining.
- Signs: Paresis, a finger to floor distance > 25cm, absence of knee or ankle reflex, and a positive SLR.

The study also concluded that most of the diagnostic information found during the physical exam had already been revealed by history. (Vroomen 2002)

EVIDENCE SUPPORTING A DISC HERNIATION WITH RADICULAR COMPONENT

Once a radicular syndrome diagnosis is made, the pathoanatomical cause must be identified. Herniated lumbar discs are the leading pathoanatomical diagnosis in most cases in patients < 50- to 60-years old. Other causes include spinal canal stenosis, space occupying lesions (tumor/cyst/hematoma), structural instability including unstable spondylolisthesis, significant spurring around the IVF, nerve root adhesions, fractures and spinal infections.

The following findings are consistent with a discogenic origin:

- Decreased AROM. Decreased sagittal thoracolumbar range of motion (ROM) is an important finding, (Vucetic 1996) which may be reflected as an increase in finger to floor distance. (Vroomen 2002)
- Mannequin sign. The mannequin sign is positive when a patient displays an antalgic posture similar to the classic manner of a mannequin's pose: the symptomatic leg flexed at the hip and knee with the pelvis tilting towards the affected side. It is an observed sign that is recorded as mannequin positive or mannequin negative. In Westbrook's study, the mannequin sign had 100% reproducibility and 80% sensitivity in diagnosing lumbar disc herniations with nerve root impingement. Twenty-four patients had L4-L5 disc herniations and 41 had L5-S1 disc herniations. (Westbrook 2005)
- Pain centralization. Pain that centralizes with repetitive or sustained end-range loading, *most often in extension*. (Berthelot 2007) (See CSPE protocol, Directional Preference Protocol: Centralizing Low Back and Leg Pain.)
- Positive Valsalva maneuver. Valsalva exacerbates leg pain. It has been suggested that this is more likely with sequestered herniations (Jonsson$_b$ 1996) and can also be associated with other space occupying lesions. LBP provoked by a Valsalva maneuver without leg pain is a much less useful finding.
- Sitting intolerance. Sitting may be very difficult. Aggravation may include the leg pain and may occur rapidly, as opposed to the longer periods required to be aggravated by a postural syndrome. Lying often offers relief. (Deyo 1990)
- DeJeurine's triad. Coughing that recreates the sciatica (74% sensitivity for lower lumbar disc herniation) (Kortelainen 1985), sneezing, or straining with a bowel movement may cause low back or leg pain.
- Flexion load sensitivity. A pattern of leg or back aggravation with activities, orthopedic tests or postures that load the spine in flexion.
- Presence of bowel/bladder symptoms or sexual dysfunction (see cauda equina syndrome on Page 19).

LEG PAIN

In patients with a lumbar disc herniation, leg pain is present and often dominates. (Deyo 1990, Vroomen 2002) The pain may have some or all of the following characteristics:

- dermatomal in distribution (Vroomen 2002) especially if it is S1 (Vucetic 1995)
- described as sharp, burning, stabbing, electrical
- superficial in nature
- crosses the knee
- more severe (or persistent) than back pain (Andersson 1996, Vroomen 2002).

The presence of leg pain increases the likelihood of a disc herniation from about 2% (estimated prevalence) to about 14%. (Lurie 1999) *Sciatica is often the first sign of nerve root compression* (sensitivity 98%; specificity 88%) (Deyo 1996). Lurie (1999) reported a +LR of 7.9 for a lumbar disc herniation. In a primary care setting, though, the positive predictive value could be as low as 9% (based on an assumed prevalence of disc herniation of about 1%). (Andersson 1996) However, as more clinical signs of a herniation are present, the positive predictive value is much higher.

> ➢ **Clinical Tip:** Absence of lower extremity pain makes a clinically significant herniation much less likely (sensitivity has been reported as high as 98%) (Deyo 1992). Lurie (1999) reported a negative LR of 0.06. in his analysis.

PARESTHESIA

Paresthesia may be present and is often in an L4, L5 or S1 distribution (Andersson 1996) (sensitivity 74%, specificity 18%). (Kortelainen 1985) Paresthesia is more likely to follow a specific dermatome than the pain distribution (Tarulli 2007), with the possible exception of S1 pain. (Vucetic 1995)

STRAIGHT LEG RAISE (SLR)

Another indicator of possible disc herniation is a positive SLR. The spinal nerve root travels 2-5mm within the neuroforamen with SLR maneuvers (Garfin 1995). A herniation with associated inflammation and adhesions can limit this movement and reduce blood flow to the nerve resulting in sciatica during the SLR (Kobayashi 2003). This concept has also been seen in animal models (Garfin 1995).

One systematic review indicated that a positive SLR was the only examination sign consistently reported to be sensitive for sciatica due to disc herniation ($Vroomen_a$ 1999).

> ➢ **Clinical Tip:** It is recommended to repeat the SLR test, looking for the trend of the response over several visits before making clinical decisions. (Van den Hoogen 1996)

Hard Positive test*

A hard positive SLR creates pain into the foot or at least past the knee. The aggravated leg pain response usually occurs between 35 and 70 degrees hip flexion. (Fahrni 1970) $Vroomen_a$ (1999) reported that requiring a certain angle at which pain is provoked for the SLR to be positive seemed to add little to specificity while diminishing sensitivity. Urban (1981), however, reported that SLR tests that aggravate calf or foot pain below 45 degrees are more specific for disc herniation and often correlate with uncontained discs.

> ➢ **Charting Note:** The distance the pain travels and the hip angle at which this occurs should both be charted.

In patients with foot numbness as the predominant symptom, repetitive SLR ("pumping of the leg") has been reported to increase the symptom. (Macnab 1977)

It is recommended that the positive SLR be confirmed by eliciting radiating pain and/or paresthesia with one or two of the following maneuvers (Xin 1987): Bechterew, seated bowstring test, Bragard's, bowstring, or Bonnet's (adduction with internal rotation).

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* Hard and soft positive SLR are terms used primarily at Western States Chiropractic College.

Soft Positive test
A SLR eliciting pain that crosses the gluteal crease but remains proximal to the knee should be viewed as *equivocal*. A maximum SLR should be performed to see if added tension turns the results into a hard positive.

Negative test
A SLR test that is painless or aggravates back or buttock pain only is construed to be negative for nerve root involvement based on its relatively good sensitivity. The practitioner may wish to perform a maximum SLR to see if added tension changes the result.

Seated SLR (Bechterew's test)
The supine SLR can be cross referenced with the results of the seated test. When both tests are positive, they reinforce each other. In some cases, the SLR may only be positive in the seated position when the disc is loaded. However, since it has poorer sensitivity, this test may often be negative even though the supine SLR is positive.

NOTE: For more on selecting nerve tension tests, see Appendix I: Sciatic Nerve Tests Algorithm.

Test Accuracy
The SLR has its greatest value when it is negative, casting doubt on a lumbar disc herniation diagnosis.

McGee (2001) calculated sensitivity based on several large studies (Kerr 1988, Kosteljanetz 1984, Spangfort 1972), reporting a range from 73-98%. The average calculated negative likelihood ratio was 0.2, making it a very useful test to help rule out radiculopathy associated with a herniated disc. (McGee 2001) Devillé's (2000) larger systematic review reported a pooled sensitivity of 91%, but was critical of the design of most of the studies included, noting that they were on surgical cases, rather than portal of entry care. Rabin's (2007) study reported a 67% sensitivity, speculating that this lower point estimate may have been because they included only hard positives findings (i.e., pain past the knee).

SLR sensitivity may also be associated with age. In Spangfort's landmark study of 2,504 lumbar disc herniation operations, SLR sensitivity was 100% in patients under 30 and lower in older patients. (Spangfort 1972)

There is some evidence to suggest that a medial disc herniation (which is relatively rare) may cause only back pain during the SLR. Therefore, while a negative SLR test casts doubt on the typical posterolateral herniation, the less common medial herniation may remain a diagnostic possibility. (Xin 1987)

As an isolated test, the specificity of the SLR is poor, ranging from 11-61%. This is likely due to it being positive in other conditions that cause radiculopathy (e.g., stenosis), sciatica (e.g., piriformis syndrome, diabetes), or being misinterpreted because of tight painful hamstrings or other causes of referred pain. Nonetheless, in conjunction with other evidence of nerve root damage, it is consistent with and supportive of lumbar disc herniations.

As always, the actual predictive value of the test depends on the pre-test probability that the patient could have a disc herniation in the first place. In a patient with low pre-test probability for disc herniation (e.g., 3%, typical of a patient in a general care setting with no sciatica or neurologic signs/ symptoms), a positive SLR would have a positive predictive value of only 4% and a negative SLR would have a negative predictive value of 99%. (Andersson 1996)

In a patient with high pre-test probability (e.g., estimated at 60%, typical of a patient with sciatica in a referral practice), the positive predictive value would be 67%; the negative predictive value would be 57%. (Andersson 1996)

Accuracy of some of the other tension tests:

Test	Sensitivity
Seated SLR	41% (Rabin 2007)
Bowstring	69% (Supik 1994)
Bragard's	71% (Supik 1994)

WELL-LEG RAISE (XSLR)

The well-leg raise test, *AKA* crossed straight leg raise (XSLR), is most useful when it is positive to rule in a lumbar disc herniation. The specificity has been reported to be between 88-98%. (Devillé 2000, McGee 2001)

The sensitivity, on the other hand, is very poor for this test, ranging from 23-43%. Most lumbar disc herniations will not present with a XSLR and it has no power to rule out the condition. However, a positive crossed straight leg raise (XSLR) is thought to provide a variety of information:

1) It is considered to be one of the three best tests for herniated lumbar disc, a positive finding potentially carrying a high positive predictive value (Vucetic 1996) and one systematic review indicated it to be the only examination sign to be specific for disc herniation (Vroomen$_b$ 1999).

2) A positive XSLR suggests a poorer outcome for conservative intervention (Cox 1990, Saal 1996), but still potentially a good outcome for surgery.

3) Some suggest it is more likely present with an extrusion or sequestration (Vucetic 1996). Although the presence of a sequestration in itself does not necessarily carry a poorer outcome for a functional restoration approach to treatment, a positive XSLR can carry that implication (Saal 1996).

4) Other authors suggest it is indicative of a medial herniation (Scham 1971).

FEMORAL NERVE STRETCH TEST

If L2, L3 or L4 root is suspected, perform the femoral nerve stretch test (aka, reverse SLR) on the affected and well side (Morris 2006, Supik 1994). Pain in the hip and groin that radiates along the medial aspect of the thigh suggests L3; pain radiating into the lower leg suggests L4. (McGee 2001)

- **Clinical Tip:** In some cases of L4 radiculitis, the SLR may be negative while only the femoral nerve stretch test is positive. (Evans 1994)

NEUROLOGIC DEFICITS

Although there is disagreement in the literature with regard to the exact value of decreased muscle strength, sensory loss, and depressed reflexes as signs of nerve root involvement, (Vroomen$_a$ 1999) they are, nonetheless, considered to be important. Neurologic deficits can be present and are relatively root specific. The presence of deficits, however, is probably of more use in differentiating radicular from referred pain than in ascertaining the exact level of the disc herniation. (Vucetic 1996) Deficits tend to be sensory; DTRs are asymmetrical on *repeated testing*. (Andersson 1996) Muscles may test as weak and display atrophy.

Twenty to twenty-five percent of surgical lumbar disc herniations may have no deficits (Kortelainen 1985, Vucetic 1996). However, in one large study, over 80% of surgically proven herniations displayed foot weakness or diminished Achilles reflex. (Spangfort 1972) These deficits may be less common in a chiropractic setting where there would be a larger case mix including less severe presentations. It is probably rare to have all three deficits: reflex, motor and sensory. (Long 1996)

Sensory
Absolute loss of feeling (anesthesia) does not result from the injury to an isolated nerve root. (Andersson 1996)

Stretch Reflexes (DTRs)
The unilateral absence of an Achilles reflex is a more reliable sign of disc herniation than simply a decreased reflex. Its diagnostic value increases if correlated with positive imaging. (Hakelius 1970)

However, a previous herniation can result in a permanent deep tendon reflex loss, making the test less useful in a recurring episode.

Motor
Subtle signs of muscle weakness may be detected with sustained (5 seconds) (Magee 1997) or repetitive (10x) muscle testing.

- **Clinical Tip:** In patients with acute sciatica, often it is best to perform muscle testing at the foot and ankle with at least slight flexion of the knee. This will minimize "false" weakness due to the painful stretch of the nerve. (Macnab 1977)

- **Clinical Tip:** To assess quadricep strength in patients with suspected L3 or L4 radiculopathy, consider asking the patient to rise from a standard-height chair on one leg while holding the patient's hands for balance. This sit-to-stand test may be more reliable and more sensitive than a standard muscle test. (Rainville 2003)

Urinary Signs

Lower urinary tract symptoms appear to be more common in uncomplicated disc herniations than was previously thought (according to one study of pre-surgical patients). (Perner 1997) The prevalence of urinary retention, urgency and incontinence was 51% in the absence of any other major cauda equina syndrome symptoms.

Urinary symptoms were more common in medial disc herniations than lateral.

When treating patients using NSAIDs, practitioners should be aware that use of ibuprofen, naproxen and Celebrex has been associated with doubling the risk of developing acute urinary retention. (Verhamme 2005)

- **Clinical Tip:** The presence of any urinary symptoms should prompt an assessment for the presence of cauda equina syndrome (see Page 19).

Ancillary Studies

In most cases, a working diagnosis of lumbar disc herniation based on clinical grounds alone is sufficient to begin a therapeutic trial of conservative care. (Herzog$_a$ 1996) Radiographic imaging is not necessary (Koes 2007) although it may be useful when there are neurological deficits, when the clinical diagnosis is uncertain or as a preliminary to a surgical consult.

For patients with a first episode of acute LBP of less than 7 weeks, radiographs are not necessary but should be considered in circumstances of an atypical history, an atypical physical finding and special psychological or social situations. These circumstances are listed in detail in Appendix II: Imaging Guidelines and serve as a guideline to which clinical judgment must be applied. (AHCPR 1994, Simmons 2003) Also see CSPE protocol, Red Flags for Serious Disease Causing Low Back Pain.

Plain film radiography should be performed prior to ordering advanced imaging to evaluate for conditions that may mimic a herniated lumbar intervertebral disc. In the evaluation of LBP patients requiring imaging, plain film radiography is commonly the first imaging procedure utilized.

The advantages of using plain film radiography over other imaging include its wide availability, low expense, comfort, convenience for the patient, and low radiation dose. (Taylor 1994) Some conditions that may mimic a herniated disc and that can be diagnosed from plain films are degenerative disease, spondylolisthesis, neoplasms and fractures. In high-risk groups with LBP, plain film radiography has been found to be 90% sensitive overall for detecting degenerative and inflammatory disease, fracture, infection and neoplasm—although the sensitivity will vary depending on which of these particular conditions a patient may have. (Deyo 1986) Plain film radiography also aids in the interpretation of advanced imaging by correlating the findings from both modalities resulting in a more accurate diagnosis.

Plain film findings suggestive of lumbar disc derangement, such as degeneration and herniation, are often nonspecific. However, they can lend some useful information that may suggest a diagnosis of herniated intervertebral disc. Some plain films findings that have been reported as useful in diagnosing a lumbar herniated intervertebral disc are vertebral malalignment (especially retrolisthesis), decreased disc height, scoliosis secondary to muscle spasm, and increased motion visualized on flexion/extension films indicating instability. (Murray 1990)

Plain film radiography does have limitations. Although plain film radiographs demonstrate the size of a disc space, they do not show the shape and quality of the disc. (Simmons 1995) The quality and morphology of an intervertebral disc can be better visualized with magnetic resonance imaging (MRI) or computed tomography (CT).

Advanced Imaging

MRI has become the gold standard in the evaluation of morphological disc abnormalities such as disc bulging, disc protrusion, annular tears, disc extrusion and disc sequestration. (Weishaupt 2003) MRI with gadolinium contrast agent can be especially useful in patients who have had prior disc surgery to differentiate postsurgical changes from new herniation. MRI studies for disc herniation usually consist of T1 and T2 weighted images in the sagittal and axial planes. (Maus 2002) Thornbury et al. (1993) report comparable accuracy in the evaluation of disc herniation between CT, CT with myelography and MRI. CT with myelography can be useful when MRI findings are equivocal or MRI is not an option. (Maus 2002)

Advanced imaging should *not* be ordered routinely. However, the following is a list indicating both relative and absolute indications for an MRI (or a CT if MRI is unavailable).

When to order advanced imaging

- Advanced imaging may be ordered by the portal of entry practitioner or by the referral doctor (e.g., the surgeon), depending on the circumstances.
- There are *signs of cauda equina syndrome*. This demands urgent referral or emergent referral if symptoms have come on rapidly. The patient is an immediate surgical candidate.
- Progressive muscle weakness while undergoing conservative care.
- If there is profound muscle weakness. Saal argues that profound muscle weakness may not be an absolute indication for surgery; these patients may respond to conservative care as well.) (Saal 1996)
- No or poor improvement in outcomes with conservative care in the first 3-6 weeks or if the patient is left with significant disabling pain (AHCPR 1994)
- Suspected upper lumbar disc herniation. Since these are rare, the presence of a space occupying lesion should also be ruled out. (Greenhalgh 2006)
- When the disc diagnosis is in doubt or red flags for serious disease are present (see CSPE protocol, Red Flags for Serious Disease Causing Low Back Pain). In this circumstance, plain film radiography should be ordered prior to advanced imaging.

Test Accuracy

MRI is about 83% sensitive and 73% specific in identifying damage to neural structures. Reliability for diagnosing a disc herniation on advanced imaging is good (kappa value of .74). (Modic 2005)

Any disc herniation found on imaging must be correlated with the clinical presentation to avoid erroneously ascribing the symptoms to an *incidental* finding. A high prevalence of morphological disc abnormalities including disc bulging, disc protrusion, and annular tears was found in asymptomatic volunteers aged 20-50 years suggesting clinical irrelevancy of these lesions. (Weishaupt 2003)

Disc herniations on MRI of asymptomatic patients appear to be common. In 1990, Boden reported that a herniated disc on MRI was present in 20% of subjects under the age of 60 and 36% of those over 60-years old in a pool of subjects with no history of radicular pain. (Rhee 2006) In 1995, Boos reported a 63% incidence of disc protrusion in asymptomatic subjects. (McCall 2000) In contrast, disc extrusion, disc sequestration, and nerve root compression were found to be infrequent in asymptomatic individuals suggesting that these disc lesions are more likely to be clinically relevant. (Weishaupt 2003) However, a discrepancy between MRI findings and clinical symptoms of LBP often exists. The MRI may fail to show compromise of neutral structures even when sciatica is present. In patients with equivocal findings on conventional (recumbent) MRI of the lumbar spine, selected patients may benefit from axially loaded MRI technique in the supine

position, or if available, weight-bearing imaging in upright seated or upright standing positions (usually combined with flexion and extension movements) using vertically open-configuration MRI scanners. (Weishaupt 2003)

NEUROPHYSIOLOGIC TESTING

Neurophysiologic testing usually consists of a combination of an electromyograph (EMG) and a nerve conduction study (NCS).

In most cases, it is not necessary to order neurophysiologic testing to confirm the presence of radiculopathy.

Neurophysiologic testing may be considered if conservative care fails and the clinician needs a precise anatomic diagnosis to guide therapeutic decisions. (Herzog$_b$ 1996) Neurophysiologic testing can be used to

- determine the presence or absence of radiculopathy,
- identify the involved nerve root level,
- determine if axon loss or conduction block is present,
- grade the severity,
- estimate the age of the radiculopathy, and
- exclude other peripheral nerve diseases that mimic radiculopathy.

Electromyograph (EMG)

An EMG should not be performed within the three weeks of symptom onset because of the likelihood of a false negative. It takes several weeks for fibrillation potentials to develop.

EMG is reported to be the single most useful neurophysiologic tool when evaluating a suspected radiculopathy. It offers the practitioner a sensitive technique to detect motor axon loss. The diagnosis of radiculopathy is based on demonstrating abnormalities in two or more muscles that have different peripheral innervation but the same nerve root. (Tsao 2007)

Nerve Conduction Study (NCS)

A basic NCS is usually added to the EMG. The test targets both motor and sensory axons. Additional NCS evaluations for various levels of the suspected radiculopathy can also be added if the basic NCS does not assess the appropriate levels.

In most cases of radiculopathy, only a portion of nerve axons within a nerve root trunk are injured. The motor NCS typically is normal in patients who have radiculopathy, often even when there is weakness detected on manual muscle testing.

Likewise, a sensory NCS is usually normal because in radiculopathy the compression occurs proximal to the sensory dorsal root ganglion (DRG).

On the other hand, when a reduction in sensory action potentials is detected, it suggests that the lesion is distal to the DRG—in the plexus or peripheral nerve. An exception to the rule is in suspected L5 radiculopathy. As much as 40% of the population has the DRG in a location where it would also be compressed along with the nerve root, mimicking the reduced signal found in more peripheral lesions, such as a peroneal nerve entrapment. (Tsao 2007)

DIAGNOSTIC SELECTIVE NERVE ROOT INJECTIONS

When evaluation and imaging do not result in a clear diagnosis in patients presenting with radicular-like symptoms, some clinicians consider nerve root injections to be a pivotal diagnostic test. A study of 101 surgical patients found selective nerve root injections can accurately discern the presence of radiculopathy and prevent surgeons from operating on an initially suspicious but incorrect level. (Sasso 2005, Smeal 2004)

EVALUATION STRATEGY

SUMMARY – Evaluation Steps

1. Rule out causes for emergent or urgent referral.
2. Rule out organic disease or fracture.
3. Rule in the presence of a radicular syndrome.
4. Rule in herniated disc diagnosis. Rule out other potential diagnoses.
5. Determine type of herniation, probability of contained vs. uncontained (on clinical grounds).
6. Determine likely level of herniation and which nerve roots are involved (on clinical grounds).
7. Determine direction of herniation: medial, midline, lateral or far lateral (on clinical grounds).
8. Estimate the severity of the condition.
9. Determine need for imaging.
10. Empirically determine if patient is a candidate for manipulation, flexion-distraction, McKenzie protocol.
11. Set outcome measurements.
12. Determine if there are significant psychosocial factors. This can be done on subsequent visits.
13. Determine if there are other weak links in the kinetic chain (e.g., overpronation). This can be done on subsequent visits.

STEP 1: RULE OUT CAUSES FOR EMERGENT OR URGENT REFERRAL

Determine if this is a case that demands immediate referral: signs and symptoms of cauda equina syndrome (emergency referral) or rapidly progressive motor weakness (urgent referral).

Cauda Equina Syndrome (CES)

The literature suggests that anywhere from 1 to 15% of lumbar disc herniations can lead to cauda equina syndrome (Perner 1997), but 2-3% are most commonly reported. In the rarer midline herniation, the incidence may be as high as 27%. (Ahn 1999, Walker 1993)

Referral should be made immediately. Patients who have decompressive surgery within 48 hours of onset of any urologic symptoms are more likely to have a better outcome. (Ahn 1999) In 90% of cases, symptoms occur less than 24 hours after neurological compromise. Unfortunately, urologic, bowel and sexual function abnormalities may not be recognized in this short time frame. (Morris 2006)

The signs and symptoms of CES relate to loss of S2, S3 or S4 nerve root function. The following are red flags suggesting CES:

Symptom	Sensitivity
Urinary retention	90% (Deyo 1990)
Incontinence	46% (Ng 2004)
Saddle anesthesia/ Paresthesia	80-86% (Deyo 1990)
Sexual dysfunction	unreported
Altered anal sphincter tone	38% (Ng 2004)

Common additional findings include some combination of unilateral/bilateral sciatica, altered SLR, sensory or motor deficits (sensitivity 80%) (Deyo 1990) and the inability to stand. (Postacchini 1999) Bladder abnormalities caused by disc herniations may present several different ways: total urinary retention, chronic long standing retention, irritability and loss of desire to void associated with unawareness of the necessity to void, often associated with difficulty in initiating the stream. (Emmett 1971, Ross 1971)

Some authors suggest that one should strongly suspect a possible CES when both urinary dysfunction and saddle hypesthesia are present (Kennedy 2001).

Isolated urinary symptoms
According to one study (Perner 1997) of presurgical patients, lower urinary tract symptoms appear to be more common in uncomplicated disc herniations than was previously thought. *The prevalence of urinary retention, urgency or incontinence was 51% in the absence of any other major cauda equina syndrome symptoms.* In patients with lumbar spinal stenosis, prevalence of lower urinary tract symptoms has been reported to

range from 50% to 80%. (Deen 1994, Hellstrom 1995, Perner 1997) It is unclear why such a high prevalence of bladder involvement has been overlooked. It was observed in the study that patients often denied urinary symptoms in a direct interview setting, but admitted to them on a questionnaire.

NOTE: The acute CES referral should be urgent, that is, the same day if at all possible. In cases where there is rapid onset of symptoms (especially after trauma), rapidly progressing deficits (over previous several days), or significant urinary retention (e.g., 24 hours of anuria), the referral should be emergent with action taking place as soon as possible, within hours.

For a more thorough discussion, see CSPE protocol, Cauda Equina Syndrome: Recognition and Referral.

Other causes of CES include spinal canal stenosis and space occupying lesions. An unusual condition that can mimic some of the cauda equina presentation is pudendal neuropathy (Alcock's syndrome). This syndrome is characterized by unilateral or bilateral perineal pain (may be burning or a sensation of a foreign body in the rectum or vagina) aggravated by sitting, along with urinary incontinence or sexual dysfunction. It is often related to a fall on the buttocks, traction injuries (e.g., childbirth, repeated straining with defecation) and vigorous bicycling. (Thomas 2002)

STEP 2: RULE OUT SERIOUS ORGANIC DISEASE OR FRACTURE

One of the first steps in triage and differential diagnosis is to rule out the possibility of serious disease.

Most patients with LBP do not suffer from serious pathology. The prevalence of these types of conditions in a chiropractic office is unknown. An estimated 3% of LBP patients that present to a medical ambulatory clinic have a significant disease causing their back pain. Approximately 1% suffer from a tumor (benign or malignant, primary or metastatic) or, much more rarely, a local spinal infection (e.g., disc, meninges or vertebra). (Deyo 2001)

Approximately 2% of LBP is referred from other organ systems, (especially the gastrointestinal, reproductive and urinary) or from an abdominal aortic aneurysm. (Deyo 2001) When leg symptoms are present (with or without accompanying LBP), the index of suspicion for an organic pathology increases, especially in the case of female, pediatric and geriatric patients. Intrapelvic disease should especially be considered with patients presenting with lower extremity neurologic deficits. (Hassan 2001) In one retrospective study of 82 patients with a primary neoplasm, 24% had radicular pain and 55% had objective deficits at the initial visit. Malignant neoplasms were more common in the presence of neurological deficits as well as with older age. (Weinstein 1987)

The history may be the most powerful tool to screen for suspicious cases. Red flags include:

- age (over 50),
- a prior history of cancer,
- unexpected weight loss, and
- pain unaffected or worsened by recumbency.

In cases where the practitioner needs more clinical information, a plain film radiograph of the area of complaint is indicated. In cases of greater concern (e.g., patients with unremitting pain and prior history of cancer), advanced imaging may need to be ordered even if a plain film radiograph appears normal.

An ESR (or CRP) should also be ordered. (See Appendix III: C-Reactive Protein.) ESRs below 20mm/hr are usually considered unremarkable and above 50mm/hr are suggestive of a significant pathological process.

Additional screening tests can include a CBC and a metabolic panel (serum chemistry). (For an in-depth list of red flags and further information, see CSPE protocol, Red Flags for Serious Disease Causing Low Back Pain.)

STEP 3: RULE IN A RADICULAR SYNDROME

This step is actually divided into a sequence of clinical questions as follows:

A) Is there nerve damage vs. a deep referred pain syndrome?
B) If there is suspected nerve damage, is the lesion in the nerve root, plexus or a peripheral entrapment/neuropathy?
C) If a nerve root is involved, which one?
D) What is the nature and degree of the nerve root injury (irritated, soft neurological signs, hard signs)?

A) Is there nerve damage?

✓ *YES*

Consider nerve root, plexus or peripheral nerve damage.

The following findings suggest the possibility of root, plexus or peripheral nerve damage:

- leg pain (especially in a dermatomal or peripheral nerve distribution),
- characteristic quality (e.g., sharp, burning, electrical),
- paresthesia (especially in a root or peripheral distribution),
- positive tension tests,
- neurological deficits, and
- bowel, bladder or sexual dysfunction.

✓ *NO*

Consider deep referred pain (including myofascial pain) or multiple lesions along the kinetic chain.

In the absence of nerve lesion findings, leg pain and subjective paresthesia may be deep referred in nature. Causes of referred pain syndromes that may mimic a radiculopathy include internal disc derangement, facet syndromes, sacroiliac syndromes, joint dysfunction, hip lesions and myofascial trigger points.

Myofascial trigger points (MFTPs) in many different muscles cause leg pain symptoms that can mimic radicular symptoms. See the table in Appendix V: DDX Nerve Root from Peripheral Nerve.

Besides mimicking radiculopathy, it has been suggested that MFTPs can also be caused by radiculopathy. A cross-sectional study of 60 patients with a diagnosis of lumbar disc herniation scheduled for surgery showed MFTPs located in the myotome of the lesion level. (Samuel 2007)

When patients have symptoms extending into the leg, it is a good clinical strategy to evaluate the key joints and muscles that comprise the kinetic chain along that extremity.

In some cases, extremity symptoms may be the result of local lesions in the hip, thigh, knee or lower leg rather than actually originating from the low back. In other circumstances, these lesions may co-exist with actual radicular or somatic referred pain coming from irritated spinal tissue.

Regardless of the proposed mechanism of involvement, addressing any evident peripheral biomechanical lesions may be very useful in managing the patient's extremity symptoms. The following joints should be evaluated, primarily by motion and static palpation: hip, knee, ankle and foot.

Any dysfunction in the lower chain should be treated according to findings. Restoration of normal tone and function may resolve some or all of the lower extremity symptoms.

When tenderness is found within the territory of the patient's radiating pain or paresthesia, the practitioner must consider still another explanation. As Gifford (2001) explains, "Physically testing or pressing on a particular structure and reproducing the pain that the patient complains of does not therefore mean that the definitive source of the problem has been found." The hyperalgesia may actually be secondary to nerve root irritation or, in the case of somatic referred territories, due to central sensitization at the cord level. This possibility will be strengthened if the practitioner finds no improvement with therapy directed at the tender peripheral joints or muscles. (Gifford 2001)

B) Is the lesion in the nerve root, plexus, or a peripheral entrapment/neuropathy?

Once there is a high index of suspicion that there is nerve damage, the practitioner must try to isolate the location of the lesion. Is it in a discrete nerve root, spread throughout the lumbosacral plexus, or due to a peripheral nerve lesion?

Conjoined lumbosacral nerve roots can cause sciatica even without the presence of additional compression. This anomaly has been reported in 14% of cadaver studies but myelographic and CT studies have shown approximately 4%. (Böttcher 2004)

Differential Diagnosis (DDX)	
Nerve root	**Peripheral nerve/plexopathy**
L1	Ilioinguinal neuropathy genitofemoral neuropathy
L2	lateral femoral cutaneous neuropathy (meralgia paresthetica) femoral neuropathy upper lumbar plexopathy
L3	femoral neuropathy obturator neuropathy diabetic amyotrophy upper lumbar plexopathy
L4	lumbosacral plexopathy saphenous neuropathy
L5	common peroneal neuropathy lumbosacral plexopathy sciatic neuropathy
S1	sciatic neuropathy lower lumbosacral plexopathy

See Appendix V: DDX Nerve Root from Peripheral Nerve for a more in-depth version of this table.

DDX: Plexus and Peripheral Lesions

SUMMARY

- Diabetic amyotrophy/neuropathy
- Herpes zoster
- HIV/AIDS
- Lyme disease
- Entrapment syndromes: Piriformis syndrome and peroneal nerve injury vs. common peroneal nerve injury

Diabetic Amyotrophy/Neuropathy

Diabetic amyotrophy is a syndrome of severe lower extremity pain and weakness. Multiple lumbosacral nerve roots are affected, but sometimes only the femoral nerve appears to be involved. Patients typically have well controlled type 2 diabetes and are middle aged or older. It is important to note that sometimes the extremity symptoms are the first sign of diabetes.

An upper lumbar disc herniation affecting the L2, L3 or L4 nerve roots may need to be differentiated from a femoral nerve involvement.

➢ **Clinical Tip:** Painful femoral nerve involvement should trigger an appropriate diabetes evaluation.

In addition to severe leg pain, significant findings may include some or all of the following characteristics:

- Sudden onset, unilateral lower extremity pain (may involve the groin, anterior thigh and/or lower leg).
- The patient may flex the hip for pain relief.
- Numbness and paresthesia of the anterior or medial thigh may be present.
- Muscle weakness precedes the onset of pain (e.g., the patient reports sudden knee buckling).
- Hip flexors and knee extensors are usually affected first.
- Muscle testing of the hip flexors may produce pain and weakness.
- Quadriceps may demonstrate weakness (e.g., test ability to rise out of a chair on one leg).
- The femoral nerve stretch test may reproduce anterior thigh symptoms.
- The patellar reflex may be decreased or absent.
- Weight loss is a frequent accompanying symptom (Tarulli 2007).
- Advanced imaging (e.g., CT) should be ordered to rule out a mass.

NOTE: The majority of patients with diabetes have lumbosacral plexus involvement rather than isolated femoral nerve involvement and so they develop bilateral and more distal symptoms.

Herpes zoster

Herpes zoster will affect a spinal nerve causing symptoms into the lower extremity about 5% of the time. (Tarulli 2007) The presentation may include some or all of the following characteristics (Tarulli 2007):

- The onset of pain is frequently severe.
- Pain gradually decreases as the vesicles crust over.
- 10% to 15% develop post-herpetic neuralgia.
- Segmental muscle weakness can occur.
- Complete resolution of motor deficits occurs in 50% to 70% of patients.

HIV/AIDS

HIV/AIDS patients may present with signs of polyradiculopathy or cauda equina syndrome. (Crawfurd 1987) These presentations account for only about 2% of HIV-related neurologic consultations. (Tarulli 2007)

Lyme disease

Acute Lyme disease can occasionally mimic the radiculopathy associated with disc herniations. It affects lumbosacral nerve roots in only a minority of patients. When it does, radicular symptoms are most likely to appear within the first two months of infection. Usually cranial neuropathies and lymphocytic meningitis accompany the leg pain. (Tarulli 2007) In such cases, a broader neurologic exam is indicated.

ENTRAPMENT SYNDROMES

Other causes of sciatica include piriformis syndrome and peroneal nerve entrapment.

Piriformis syndrome

Piriformis syndromes can be caused by blunt trauma to the buttock, repetitive microtrauma, bursitis, sciatic irritation by a myofascial band between the biceps femoris and adductor magnus, and nerve compression associated with spasm due to SI or hip pathology/ dysfunction.

The presentation may include some or all of the following characteristics:

- Symptoms are similar to radiculopathy, but with no back pain.
- There is pain and paresthesia along the sciatic nerve (sparing the medial/anterior leg and foot).
- The pain may be aggravated by walking or sitting.
- The SLR may be positive, especially with internal rotation (the hip may be flexed as little as 20 degrees).
- Weakness and DTR changes may occur but are rare.
- Internal rotation of the hip may be restricted and/or painful.
- Commonly, there is sciatic notch tenderness.
- There is usually piriformis tenderness with intrarectal palpation.

Peroneal nerve entrapment

This is one of the most common neuropathies. Most are due to external compression or stretching of the nerve near the fibular head. Specific causes include plaster casts, tight bandages, surgeries, malpositioning during anesthesia, fabella, a fibrous band, trauma to the side of the knee, or a reaction to icing of the lateral knee.

The presentation may include some or all of the following characteristics:

- Pain is not a common symptom (when present, it may be local and actually radiate up the thigh).
- Foot drop may be partial or complete and is often the primary presentation.
- There may be weakness when testing ankle dorsiflexion or eversion.
- Numbness/paresthesia may present over the lateral aspect of lower leg and dorsum of foot.
- Forced ankle inversion may increase pain.
- Eversion, ankle dorsiflexion and great toe extension may all be weak.
- The Achilles reflex is usually normal.

C) If a nerve root is involved, which root?

The L5 and S1 nerve roots are by far the most common roots affected. The distribution of paresthesia and neurological deficits are the key findings used to determine which nerve root is most likely involved. The distribution of pain in the S1 dermatome is helpful, but less trustworthy for other roots. (Vucetic 1995)

The SLR, other orthopedic procedures, and palpation are of little value in trying to identify the nerve root.

D) What is the nature and degree of root injury?

The practitioner should determine whether the nerve root is primarily irritated and inflamed (radiculitis) or whether it is significantly compressed or otherwise damaged (radiculopathy).

The following suggests that the nerve root is inflamed and hypersensitive:

- the presence of leg pain (especially dermatomal),
- positive nerve tension tests,
- spinals loads that reproduce the leg symptoms (e.g., flexion/extension, a true positive Kemp's test with reproduction of leg symptoms), and
- increased response to sensory stimulation (hyperesthesia, hyperalgesia or allodynia).

Paresthesia technically is the result of mild root compression, but for clinical purposes is closer to the "irritation" end of the spectrum than the "significant" compression end.

Neurologic deficits suggest more significant damage, usually associated with compression. Deficits can be categorized as soft neurological signs (sensory loss, depressed or absent reflex, mild loss of muscle strength) or hard signs (e.g., motor loss of 3/5 or worse, significant atrophy). The term *sciatica* is more commonly used than radiculopathy or radiculitis, and does not seek to distinguish irritation from compression. See Appendix VI: Charting Disc Herniation in WSCC Clinics.

STEP 4: RULE IN HERNIATED LUMBAR DISC DIAGNOSIS

Determine whether there is a herniated disc. (Refer to clues on Page 11.) Rule out competing diagnoses. For WSCC charting, the herniated disc diagnosis must follow the designations outlined in Appendix VI: Charting Disc Herniation in WSCC Clinics.

RULE OUT OTHER POTENTIAL DIAGNOSES

SUMMARY

- Stenosis (central and lateral recess)
- Space occupying lesions such as tumors, cysts and hematomas
- Spinal infection
- Spondylolisthesis
- Fracture
- Adhesions
- Instability
- Chemical irritation from disc degeneration, inflamed facet, etc.

Spinal Canal Stenosis

Stenosis can be classified as either being central or lateral recess. Central canal stenosis affects multiple roots and often affects both legs. Lateral recess stenosis more often affects a single nerve root and so may be difficult to distinguish from a disc herniation.

A study comparing 149 patients with either bony entrapment or a herniated disc (that resulted in lateral recess syndrome) demonstrated that disc patients were more likely than patients with bony entrapment to have positive tension signs, a greater decrease in muscle strength and their first symptoms were more frequently lower back pain. (Kanamiya 2002)

Differential Diagnosis (DDX)

	Disc herniation	Stenosis
Age	< 50	> 60
Tension tests	usually +	sometimes +
Flexion	generally aggravates	generally relieves
Sustained/ repetitive extension	may centralize	peripheralize
Sitting	may aggravate	relieves
Valsalva	may be +	negative

Space Occupying Lesions (SOL)

A) Tumors

In general, tumors causing leg symptoms are more common in older patients (> 50-years

old) or very young patients (< 10-years old). Benign tumors can occur at any age. For general indicators, see CSPE protocol, Red Flags for Serious Disease Causing Low Back Pain. Diagnosis is usually by MRI.

> ➢ **Clinical Tip:** Since upper lumbar disc herniations are relatively rare, evidence of L1-L3 radiculopathy should suggest the need for an MRI to rule out an SOL.

Primary tumors

Ependymomas or *neurofibromas* (often associated with neurofibromatosis type 1) are the most frequent primary tumors to produce lumbosacral radiculopathy.

Schwannomas (in neurofibromatosis type 2), *meningiomas*, *dermoids* and *lipomas* can also compress a nerve root, but do so less commonly. (Tarulli 2007)

Metastatic tumors

Approximately 30% of metastases target the lumbar spine, and radicular pain is the initial symptom in approximately 50% of these cases. Breast, lung and prostate cancer are the three most likely cancers to metastasize to the spine and cause LBP. Each of these three cancers accounts for about 10% to 20% of metastatic cases. The rest are caused by a combination of almost any other type of cancer. Spinal cord compression is the initial feature in about 20% of patients with spinal metastasis. Tumors of the pelvic region, including colon and prostate, metastasize most commonly to the lumbosacral region. (Tarulli 2007)

Signs and symptoms associated with metastatic bone cancer are the following (Tarulli 2007):

- Back pain is the most common initial complaint.
- Possible presence of red flags including unexplained weight loss, prior history of cancer, age over 50 years.
- Pain may be unremitting.
- Pain may be worse with recumbency.
- Radicular pain is more variable.
- Exquisite percussion tenderness at the site of the lesion may be present.

Leukemia and lymphomas can also result in back pain and lumbosacral radiculopathy.

B) Cysts

Cystic lesions in the sacral spine are common, with an incidence ranging from 4.6% to 17% on imaging studies. Meningeal sacral cysts can compress nerve roots. There is little in the clinical exam to differentiate them from other causes of lumbosacral radiculopathy. As is also true for tumors, radicular pain often is relieved or disappears when patients are recumbent and may be aggravated by Valsalva's maneuver. Since cysts are common and not necessarily the cause of symptoms, establishing one as the cause of lumbosacral radiculopathy is a diagnosis by elimination. (Tarulli 2007)

C) Hematomas

Epidural and subdural hematomas are rare causes of lumbosacral radiculopathy. Most patients are over 50 and many are taking anticoagulants. Other causes include coagulopathies, recent epidural injections, or instrumentation of the lumbosacral spine. The symptoms present in the legs, but the location of the hematoma and the location of the back pain is usually thoracic, affecting 2-4 segments. (Adam 2007, Tarulli 2007)

Spinal Infection (Infectious spondylitis)

This condition is very rare in an ambulatory setting, especially in a chiropractic practice. Patients are usually over 60 and may have a recent history of recurrent infections. Risk factors include diabetes mellitus, history of intravenous drug abuse, spinal surgery, spinal or paraspinal injection, epidural catheter placement, recent skin lesions, and immuno-compromised status. However, in many cases no predisposing factor is ever identified.

The presentation of a patient with infectious spondylitis may include some or all of the following characteristics (Tarulli 2007):

- Severe back pain, often with a radicular component, is the presenting complaint.
- Fever is somewhat common (61%), but not

highly sensitive.
- Spinal percussion is usually positive (90% in one series) (Kappeller 1997).
- Only 20% of patients have the classic clinical triad of fever, back pain, and neurologic deficits.
- Leukocytosis (61%) and elevation of the erythrocyte sedimentation rate are typical (76-100%). (Kappeller 1997)
- Radiographs may take anywhere from 1 week up to 3 months to become positive.

The diagnostic test of choice is contrast-enhanced MRI. Discitis or spinal infection may be the presenting sign of infective endocarditis and patients should be evaluated accordingly. (Morelli 2001)

Spondylolisthesis

Spondylolisthesis can cause radiculopathy but is not a common cause. However, in one cohort of 111 patients with symptomatic spondylolisthesis severe enough to warrant surgery, 62% had sciatica (Möller 2000). Theoretically, an unstable spondylolisthesis would be more likely to recreate symptoms. The presentation may include some or all of the following characteristics:

- Unlike a lumbar disc herniation, the SLR is rarely positive (sensitivity of 12% compared to 80-100% in disc herniations). (Möller 2000)
- Nerve root deficits are not common (12% in one study). The L5 nerve root is the most commonly involved, followed by the L4 nerve root in more severe cases. (Möller 2000)

Although MRI is not usually necessary when there is strong suspicion of a disc herniation, in these cases an MRI may be useful in trying to determine if the nerve root problem is associated with the spondylolisthesis (by excluding other causes) and whether there is stenosis associated with it.

Other Causes of Radiculopathy

A variety of other spinal conditions can result in leg symptoms and can be considered a part of the overall differential.

Occasionally, a spinal fracture may result in injury to the nerve root. Leg symptoms resulting after trauma to the spine should signal the need for radiographs and advanced imaging.

Adhesions (even in the absence of a disc herniation), either around the nerve root or along the course of the sciatic nerve, may cause irritation and radiculitis/sciatica. Tension tests are expected to be positive; significant deficits are less likely. Adhesions cannot usually be visualized on advanced imaging. The diagnosis is by exclusion.

Instability, even when not associated with a spondylolisthesis on radiograph, may intermittently present with radicular symptoms.

Finally, experiments on an animal model suggest that inflammation of a facet may result in a nerve root becoming chemically irritated, inflamed and symptomatic. (Tachihara 2007) Theoretically, this phenomenon could also occur in a variety of mechanical low back lesions that have not typically been associated with true radiculitis, such as disc derangement. Neurological deficits, however, especially hard neurological signs, would not be expected and would signal the need for further investigation. In summary, radicular syndromes attributed to facet syndrome, disc derangement or joint dysfunction should be a diagnosis by exclusion. Other more classic causes of the radiculopathy should be considered first.

STEP 5: TYPE OF HERNIATION

Having determined a probable diagnosis of a herniated disc, determine the type of herniation. See Background section on Page 5 for recommended terminology to describe.

Uncontained/Sequestered Discs

SUMMARY

- Lumbar flexion-extension excursion < 25 degrees
- Positive XSLR
- A positive SLR below 30 degrees
- Peripheralization with lumbar extension
- Leg pain precedes back pain or without back pain
- Neurological deficits migrate

- Sagittal lumbar range of motion may be the strongest predictor of the grade of the herniation. The more severely limited the sagittal lumbar ROM, the greater the degree of herniation. Vucetic's prospective study of surgical cases found that combined flexion and extension lumbar mobility limited to approximately 25 degrees or less suggested sequestration. (Vucetic 1996)

- Positive XSLR (sensitivity 31%) is considered an important predictor of the type of herniation (Jonsson$_b$ 1996). It is more likely present with a uncontained disc and least likely with a small protrusion (0/20 patients in one study). (Vucetic 1996)

- Patients with symptoms of disc herniation that peripheralize during extension may be suffering from uncontained disc herniation (i.e., extrusion or sequestration). (Donelson 1997)

- Onset of leg pain before back pain suggests a possible disc sequestration. (Rothman 1975) Morris (2006) reports that patients with leg pain only or leg pain greater than LBP usually had an extruded disc fragment at surgery (96% and 85% respectively) and usually experienced resolution or improvement of their LBP as the leg pain developed.

- Leg pain getting progressively worse is more commonly linked with extrusions or sequestrations than with contained protrusions. (Vucetic 1997)

- Neurologic deficits may "migrate" with uncontained discs.

- It is unusual for a small contained herniation to create a profound neurologic deficit, but it frequently can be associated with extreme pain. Large herniations are not necessarily more painful than small ones. They can be either painful or painless. (Saal 1996)

Vucetic (1995) found the two most predictive indicators to be significantly restricted sagittal ROM and a positive XSLR. Jonnson$_b$'s 1996 study of 200 uncontained discs reported that 92% had at least one of the following signs: a positive XSLR, SLR < 30 degrees (sensitivity 60%), or relevant motor loss. Other findings from this study included the following:

- Patients had more severe symptoms than with contained herniations;

- The SLR was generally positive even if not always severely reduced (sensitivity 94%);

- The XSLR was positive more often (sensitivity 31% as compared with 0% for a focal protrusion and 15% with a contained prolapse);

- There was commonly pain with coughing (sensitivity 79%);

- Motor or DTR deficits were more common (82% compared with 40% for a focal protrusion and 62% for a contained prolapse);

- Dermatomal sensory loss was also more common (sensitivity 70% compared to 45% for focal protrusion and 59% for a contained prolapse).

STEP 6: DETERMINE HERNIATION LEVEL AND AFFECTED NERVE ROOTS

Having determined a presumptive diagnosis of disc herniation, the next step is to determine the most likely level of the herniation. This can be a useful step because some manipulation strategies are influenced by the level of herniation (see Management Section, Page 39).

Without the aid of an MRI, the selection of which disc is presumed to be herniated is usually based on determining which nerve root is affected. The affected nerve root, in turn, is identified based on the presence of specific neurologic deficits, the dermatomal distribution of paresthesia, and the dermatomal distribution of pain. Palpatory findings and other orthopedic tests are not helpful in making this determination.

The following assumptions are made:

- An L5-S1 disc herniation usually affects the S1 nerve root before it drops down to the level of its IVF exit.
- An L4-L5 disc usually affects the L5 nerve root (but can affect S1).
- Far lateral herniations, which are much rarer than lateral herniations, affect the nerve root *at the level* of the IVF where it exits. For example, an L4-L5 far lateral herniation will likely affect the L4 nerve root.

The degree of accuracy for determining which disc is involved based solely on clinical findings is controversial. Some studies have reported high specificity and sensitivity values for clinical findings (e.g., pain distribution, neurological deficits) while others have not, creating wide confidence intervals and less certainty in the precision of the estimates. Overall accuracy rates have been reported as high as 91% (Kortelainen 1985). Others report accuracy rates of only 50%, even with the most sensitive techniques (Weise 1985).

Using deficits

Compiling the results of a number of studies, McGee (2001) reports the positive likelihood ratios for a number of exam findings (with very wide ranges).

Finding	Root	Likelihood ratio
Weak plantar flexion	S1	26.6 (1.6-436.4)*
Asymmetric patellar reflex	L3, L4	6.9 (2.4-19.9)
Asymmetric Achilles reflex	S1	5.2 (0.7-36.6)
L5 sensory loss	L5	4.6 (1.3-16)

Sensory loss is thought to correlate more strongly with a specific nerve root when the loss includes a "pure patch." One study in which sensory loss was mapped on 71 patients receiving spinal nerve blocks found the following: the L4 nerve root correlated with the medial side of the lower leg in 88% of individuals, L5 correlated with the dorsum and medial side of the big toe in 82% of individuals, and S1 corresponded with the side of the little toe in 83% of individuals. (Nitta 1993)

Although the distribution of deficits is commonly used, Vucetic (1996) suggested that in his prospective study of 163 consecutive surgical cases, deficit patterns were of only "limited value" in identifying the disc level.

Using pain distribution

Vroomen$_a$ (1999) reported that pain distribution seemed to be the only sensitive history finding and a useful sign of the level of disc herniation in his study. This is very different from cervical radicular pain patterns, which often do not follow predicted dermatomes.

A study involving patient generated pain diagrams found that the posterior foot was marked by L5-S1 disc herniation patients 85% of the time; the anterolateral leg was marked by 68% of patients with L4-L5 lesions and only 23% with L5-S1 disc lesions. Diagnoses were confirmed at surgery and by MR imaging. (Vucetic 1995)

For more information about disc levels see Appendix VII.

STEP 7: DETERMINE DIRECTION OF HERNIATION

SUMMARY

- midline & medial
- lateral
- far lateral

The disc may herniate either midline, medial to the nerve root, lateral to the nerve root or far lateral directly to the IVF. Although an MRI can offer the practitioner this information, it is not usually ordered for this purpose.

The clinical presentation found in this document is based primarily on the posterolateral herniation, which is the most common type. The other variants, however, can cause diagnostic confusion and may be associated with somewhat different prognoses.

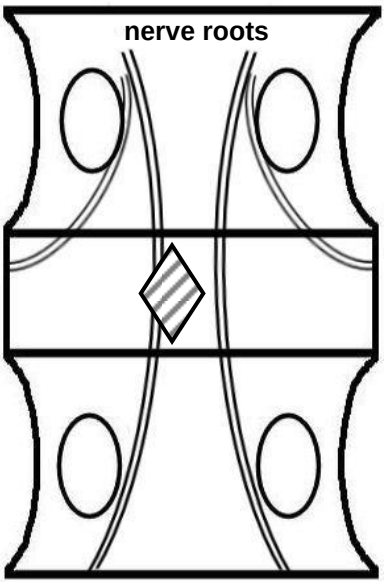
Historically, the antalgic lean was thought to help predict the orientation of the protruding

* Likelihood ratios of 2-5 can produce a small (but sometimes important shift) in post-test probability, 5-10 a moderate shift, > 10 large and often conclusive shift. 26.6 would be considered a very strong finding, but a range that includes a number as low as 1.6 (nearly useless) and as high as 436.4 demonstrates a wide range within which the true value actually lies (both numerically and in terms of clinical value to the clinician).

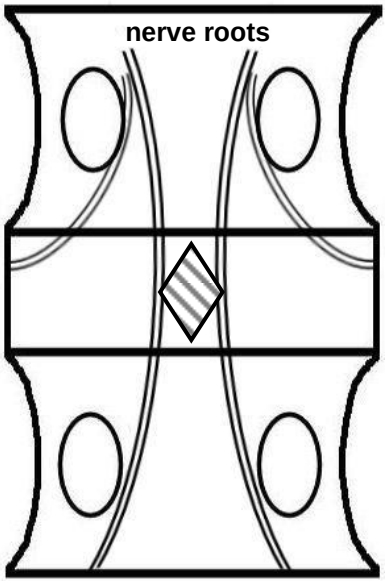
disc. An antalgic lean into the side of leg pain suggested a herniation *medial* to the nerve root (often associated with alternating leg pain, or worse in one and intermittent in the other). (Rothman 1975) An antalgic lean away from side of leg pain suggested herniation *lateral* to the nerve root. No lateral lean suggested a midline or subrhizal herniation (i.e., the herniation is directly under the nerve root). (Rothman 1975) However, these interpretations have been significantly challenged. Porter et al. (1986) could not find a relationship between antalgic lean, side of sciatica, and surgically confirmed medial vs. lateral herniation in their studies. Likewise, Suk (2001) found that the direction of sciatic scoliosis was simply associated with the side to which the disc herniated, not whether the herniation was to the medial or lateral to the nerve root. The patient generally leaned away from the side of herniation. This was thought to reduce the herniation by stretching at the convex side. (Suk 2001)

Midline & Medial Herniations

Midline herniations constitute about 33% of disc herniations or less. Medial herniations, too, are not as common as lateral herniations.



MEDIAL



MIDLINE

Clinical clues

- Patients with midline herniations are more likely to have bilateral sciatica, but they may have only back pain. (Walker 1993)
- Positive tension tests predominate in patients with midline herniations. There are few neurological deficits in the legs. (Walker 1993)
- The site of pain during the SLR (80-88% sensitivity) may indicate the direction: back pain only—medial herniation; both back and leg pain—subrhizal or intermediate position (i.e., directly underlying the nerve root). (Edgar 1974, Xin 1987)
- A positive well-leg raise (XSLR) suggests a medial or midline protrusion. (Scham 1971)

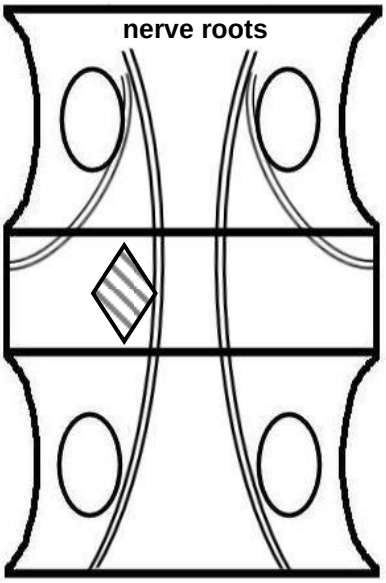
Clinical implications

When compared to more lateral herniations, midline herniations have a higher incidence of cauda equina syndrome (27% in one series of 22 cases) and poorer surgical outcome in general. (Walker 1993)

Some authorities suggest that medial disc herniations do not respond as well to flexion-distraction therapy (Cox 1994) or diversified adjustment (Stonebrink 1996).

Lateral Herniations

The majority of disc herniations are posterolateral. The SLR (80-88% sensitivity) typically aggravates only the leg pain in lateral herniations. (Edgar 1974, Xin 1987)



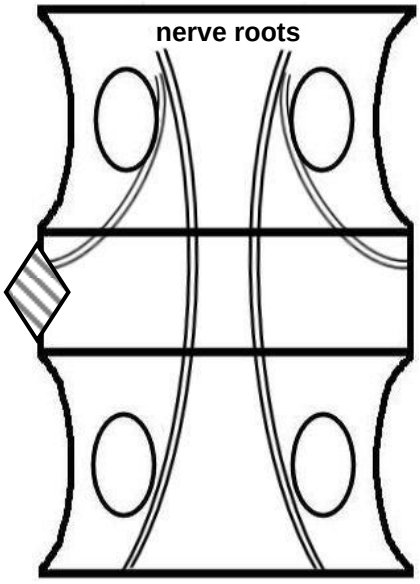
LATERAL

Far Lateral/Foraminal Herniations

These discs herniate either directly along the pedicle into the foramina or further lateral yet, just outside the spinal column. Unlike medial or posterolateral herniations, which typically compress the nerve root below the disc, far lateral herniations compress *the upper root* (e.g., L4-L5 far lateral herniation usually compresses the L4 nerve root).

The incidence is between 6-10% of herniations that require surgery. True far lateral (extraforaminal) disc herniations were found not to be as rare as first thought. However, diagnosis of this entity would be difficult if not impossible without CT or MRI (Faust 1992).

The most common lumbar disc levels to be affected by this type of herniation are L3-L4, L4-L5, and L5-S1. In one study, 75% of the patients had herniations affecting the L4 root or higher, (O'Hara 1997) but in another L5-S1 was more common. (Lejeune 1994)



FAR LATERAL

Clinical clues

Characteristic findings include anterior thigh pain and leg pain, absence of back pain, absent knee jerk, and positive femoral stretch test (AKA, reverse SLR). SLR may be positive but not nearly as common as with usual disc herniations.

Neurological signs are more common in this type of disc herniation and radicular pain often is more severe.

In cases of far lateral disc herniations, patients tend to be older. The mean age was 48.7 years in one series (Lejeune 1994) and 54 in another (Weiner 1997). Usually a single root (65% in one study) is involved. (Lejeune 1994)

Clinical implications

Far lateral herniations have a somewhat poorer surgical prognosis. (O'Hara 1997) Postoperative total relief ranges from 60-82%, which is not quite as good as for the more common posterolateral herniations. (O'Hara 1997)

One case study and a retrospective analysis of 16 cases have shown good outcomes with no surgical treatment. (Erhard 2004) Patients may respond well to steroid injections. (Weiner 1997)

STEP 8: DETERMINE SEVERITY

SUMMARY

Severity can be based on weighing a combination of the degree of neurologic involvement and the impact on ADLs.

- Neurological deficits
- Effect on ADL
- Pain intensity

Severity is clinically determined by the impact on the patient in terms of disability, pain and the degree of nerve impairment. It is not directly correlated to the size of the herniation itself. The practitioner can grade the severity of the neurological involvement separately from the overall impact on the patient. That is, a patient may have a moderately severe lumbar disc herniation (based on effects on ADLs and pain) with only mild nerve involvement (based on the nature and severity of the neurological deficits).

Although the presence of a sequestered disc fragment or the combination of a large disc herniation and spinal canal stenosis can affect the intensity of the patient's symptoms, generally the size and morphology of the herniated disc are not useful factors to consider in determining outcomes for conservative care.

Neurologic Deficits

Cauda equina signs (see Page 19) constitute significant neurological involvement and although these signs may be judged by the practitioner to be mild, moderate or severe, they suggest a severe disc herniation, at least in terms of impact on the patient.

Saal (1996) suggested the following hierarchy of nerve damage as it related to patterns of recovery:

Mild loss	Sensory, with or without a loss of one motor grade; with typical improvement in 6-12 weeks.
Moderate loss	One grade of motor loss along with loss of DTR; typically the patient will experience complete recovery within 3-6 mos, with gradual motor recovery over that time. A grade 0 DTR will rarely return.
Severe loss	Motor loss to a grade 3 or below; with full recovery often taking a year, and occasionally with only partial recovery.

Effect on ADLs

Although there is no commonly agreed upon rating system, the following pain and functional evaluation should be useful. (Saal 1996)

Severity Based on ADLs	
Mild	Patient is working full time, may be using NSAIDs, ADLs are limited.
Moderate	Patient is working part-time/partial capacity, is taking oral medication, but is unable to care for home.
Severe	Unable to work, comfortable in recumbent position only.

➢ **Clinical Tip:** It is important to record not only if patients are missing work, but also whether their ability to perform their duties is comprised or whether tasks are completed but "under duress."

The degree to which work and ADLs are affected can be determined by the routine interview process, by specifically incorporating the Patient Specific Functional Scale (PSFS) into the interview, and/or by utilizing specific disability questionnaires. (See CSPE protocol, Questionnaire: Patient Specific Functional Scale.)

A significant positive relationship has been demonstrated between the severity of disc disease and the Roland-Morris score as well as the score for the items on the SF-36, which measure physical functioning and pain. (Porchet 2002)

An Oswestry score can be correlated with a specific category of severity. (See CSPE protocol, Questionnaire: Oswestry Disability Index.)

The PSFS, although not specifically validated for lumbar radiculopathy (it has been for cervical radiculopathy), can be used to determine the impact on the patient's ability to perform ordinary daily activities.

Pain Intensity

The level of pain that the patient is experiencing should be determined. Both the low back and leg pain should be recorded. The severity of disc disease in general has been correlated with VAS scores for leg pain. (Porchet 2002) At a biological level, pain severity appears to be related to the consistency of the herniated material, with greater pain associated when nucleus pulposis material or endplate cartilage is part of the herniation. (Willburger 2004)

STEP 9: DETERMINE NEED FOR IMAGING

Unless there is evidence of cauda equina syndrome or progressive muscle weakness, neither radiographs nor advanced imaging (CT or MRI) is recommended in the absence of red flags in the acute presentation of a clinically apparent lumbar disc herniation. (See Ancillary Studies on Page 16.)

In typical patients with radiculopathy, MR imaging does not appear to have measurable value in terms of planning conservative care and patient knowledge of image findings did not alter outcome. (Modic 2005)

STEP 10: MANUAL THERAPY

Determine pain-free postures or repetitive motions (especially extension and pelvic shift) that cause pain centralization (based on McKenzie).

Determine patient's tolerance for manipulation and/or decompression-distraction therapy.

(See Management section for further details.)

STEP 11: ESTABLISH INITIAL OUTCOME MEASUREMENTS

It is the policy at WSCC clinics that specific outcome measurements be used to track the progress of all patients with herniated lumbar discs and sciatica. (CSPE Committee 1999) (See Clinical Endpoints and Outcome Measures in Management section.)

STEP 12: IDENTIFY ANY SIGNIFICANT PSYCHOSOCIAL FACTORS (YELLOW FLAGS)

SUMMARY

- Identify risk factors for chronicity
- Consider Waddell's signs
- Screen for depression

The presence of significant psychosocial factors can have a considerable effect on prognosis and case management. Practitioners evaluate patients either formally with questionnaires or informally by interview and observation. (See also Prognosis, Page 36-38.)

Identify Risk Factors for Chronicity

(Waddell 1996, 2000)

An emphasis should be placed on encouraging the patient to take personal responsibility, referring for appropriate counseling, and instituting an aggressive active care program as early as possible, *focusing on return of function rather than pain*.

A number of risk factors have been identified, which may contribute to LBP chronicity or recurrence.

1. Psychological factors

Burton's study (1995) suggests that "psychological status of the patient at the time of presentation has a much stronger influence on outcome than does conventional clinical information." Turk's (1997) review also concluded that "psychological factors are better predictors of chronicity than are clinical or physical factors."

The following are some of the factors that have been shown to have a strong correlation with more difficult and chronic cases.

1.1. Catastrophizing. This is a mental attitude whereby patients think the worst about their situation (e.g., they will never be able to work again), consistently misinterpreting bodily symptoms and perceiving them as negatively as possible. Catastrophizing is strongly related to pain

and disability (level A evidence)* (Linton 2000). In one study, catastrophizing was seven times more useful in predicting outcomes than the most predictive history or physical examination findings. (Burton 1995)

1.2. Fear avoidance behaviors. Some patients believe that their pain is so harmful or damaging that they consequently develop guarding and fear of movement. It can be associated with the belief that all pain must be abolished before attempting to return to work or normal activity. Linton's review (2000) states that "there is strong evidence that attitudes, cognitions, and fear-avoidance beliefs are strongly related to the development of pain and disability (level A evidence)." In one study, fear avoidance behaviors were the best predictors of pain and disability at 12 months (Klenerman 1995). In a population-based study on LBP, the presence of kinesophobia was positively correlated with future pain and disability. (Picavet 2002)

1.3. Depression and anxiety. There is strong evidence that depression, anxiety, distress and related emotions are strongly related to pain and disability (level A evidence). However, there is no support for a "pain prone" personality as such. (Linton 2000)

1.4. Self-perception of poor health. There is evidence that poor self-perceived health is moderately related to chronic pain and disability (level A evidence) (Linton 2000)

1.5. Sexual abuse. "There is limited evidence that sexual and/or physical abuse may be related to chronic pain and disability." (Linton 2000) There is some evidence that sexual or physical abuse is related to the development of more pronounced or chronic problems in women. This has not been clearly demonstrated in men. (Linton 2000)

1.6. Other factors. Other factors that interact and should be considered include complete work loss (because of LBP) in prior 12 months, substance abuse, perceived stress, heavy smoking, poor coping resources, and lack of social support. (Turk 1997)

* Level A evidence was based on support from a meta-analysis or systematic review of good quality of two or more studies.

2. Worker's compensation issues

There are many socioeconomic factors associated with worker's compensation cases: work demands, work environment, availability of modified work, income, job security, advancement and career potential, pension, natural job attrition, job availability, and compensation. To what extent any of these factors affect clinical outcomes or management is debated.

Researchers can arrive at strikingly different conclusions. Some studies and experts contend that there is no clinical difference between those patients who are receiving compensation and those who are not. At the other end of the spectrum, some medical legal experts imply that, in fact, many claimants are malingerers. One problem is that studies examining the influence of compensation on chronic back pain and recovery are generally poorly designed and often compare groups of patients that lack sufficient similarities to be included in the same study. Compensated patients usually have other confounding characteristics such as heavier physical jobs, lower social class and less education. Research bias may account for the tendency of economists to play down the role of psychosocial factors in their studies and of health care providers to overlook economic issues.

According to Waddell's review of the literature (2000), the outcomes for conservative treatment, back surgery and chronic pain rehabilitation programs are consistently poorer in compensated patients. There is, however, conflicting evidence on the magnitude of the effect, with estimates ranging from 0-30%.

Although the specific amount of compensation probably has only a small effect on the time-table in which patients return to work, other related socioeconomic issues may have greater influence. An injured worker may experience a secondary

gain from being off the job. A secondary gain is an economic, physical or emotional "reward" which results from an injury or illness.

However, it is important to remember that secondary gains are often counter-balanced by secondary losses, which include loss of the social benefits of working, financial or social status, and the change from a working role to a sick role. The majority of injured workers receiving compensation (75-95%) do recover and return to work rapidly. True malingering, that is, complete fabrication of symptoms, is thought to be extremely rare.

3. Litigation

It is often assumed that litigation has a negative impact on patient response to care. While a number of studies have attempted to determine the effects of litigation on treatment and/or prognosis, they have not satisfactorily controlled for variables. They have tended to overlook what may be significant differences in the type of accident, claim, insurance, work, severity, disability or patient that result in some cases being litigated and others not. Waddell (2000) performed a literature search and reviewed 14 studies which he judged to be the best designed of the pool. Only four studies dealt with neck pain specifically. The majority of these studies show no impact of litigation on outcomes. Ultimately, however, there is insufficient evidence to assess whether, or to what extent, litigation may be associated with any differences in clinical outcomes, disability or return to work.

4. Job environment

There is a relationship between pain and job demands, job control, monotonous work, perceived workload, and work under time pressure. Lack of social support can also be a factor. (Bonger 1993)

Poor satisfaction with social relationships at work is a risk factor for pain and physical findings (including neck pain). For blue collar workers, additional factors include work content, work control, and "mental overstrain." Physical load was not identified as a risk factor or predictor of chronicity. (Linton 2000)

5. Education

Waddell (2000) reports that most of the evidence on strictly social influences is of low scientific quality, is cross-sectional, and demonstrates only associations rather than necessarily causal relationships. Most of the evidence is for LBP, with much less research on neck pain, although in principle the findings are likely to be similar.

Some studies have found a correlation between lower education attainment (less than 13 years of school) and poorer treatment outcomes. The correlation, however, rarely remains when other factors are controlled for, such as the amount of heavy work, control over the work environment, income, etc.

Although not all studies are in agreement, most do suggest that lower educational attainment is related to poorer outcomes, including increased disability or poorer response to rehabilitation. Possible explanations include occupational factors (e.g., greater likelihood of heavy work, work stress, work injury), psychological factors, or poorer health access. (Waddell 2000)

Waddell's Signs

Use Waddell's nonorganic signs to identify if there appears to be a "functional" component or a component of symptom magnification. Three out of five of the following signs suggest significant illness behavior:

- Widespread (nonanatomic) tenderness to light touch.
- Significant LBP with axial loading (light pressure to skull) or with full trunk rotation in a standing position (rotating hips and shoulders together so that there is no true twisting of the trunk).
- Lack of pain on seated SLR when supine SLR was positive or a difference of 40 or 45 degrees between the two tests.

- Unexplained weakness (e.g., giving way) and/or sensory testing that is not neurologically correlated.
- A pattern of exaggeration (e.g., overreaction, grimacing, bracing, etc.) (Werneke 1993).

These signs may improve during a physical rehabilitation program.

Screen for indicators of depression, especially in patients that already have a history of chronic pain. Patients who are depressed are more likely to have back problems one year later. (Cherkin 1996)

STEP 13: SEARCH FOR WEAK LINKS IN KINETIC CHAIN

As the patient progresses, periodic re-evaluations should be aimed at restoring overall mechanics. The presence of facilitated or inhibited muscles, joint dysfunction throughout the kinetic chain, and problems with balance or pelvic control should be determined and addressed. (For more information, see CSPE protocol, Low Back Rehabilitation Program.)

SPECIAL PATIENT POPULATIONS

Special Considerations: Pediatrics

Lumbar intervertebral disc herniation is considered uncommon in children and adolescents. The true prevalence is uncertain, but studies have shown that among all patients operated on for disc herniation, only 0.4% to 5.9% are adolescents. (Balague 1992) There is no consensus in the literature on etiology, with some finding a traumatic origin, while others suggest a gradual onset. (Balague 1992) This age group can manifest the same signs and symptoms as adults. (King 1996) They may demonstrate physical findings such as marked limitation of range of motion, positive SLR, posture and gait abnormalities. (Balague 1992)

Most investigators found neurologic deficits occur less often in adolescents than in adults with disc herniation. (King 1996)

Other causes of the sciatica should be considered in this age group. One small study suggested that children younger than 11-years old with bilateral sciatica and/or motor weakness were more likely to have spinal neoplasms than herniated lumbar discs. (Martinez-Lage 1997)

Some authors suggest that children may show a “tight hamstring syndrome” with bulging disc on CT and MRI. (Kraemer 1995) In such cases, the SLR may not be able to be completed to more than 60-70 degrees. A bilateral SLR can be performed—the buttocks may come off the table and taut hamstring tendons may be clearly visible. Although linked to disc herniations, hamstring tightness can also be associated with other causes of mechanical back pain without leg pain. If the hamstrings are significantly shortened, performing the SLR as a nerve tension test may be difficult. Pain in the hamstring alone is considered a negative stretch test. (Zhu 2006)

In one series of 16 adolescent lumbar disc herniation patients who had severe hamstring tightness, neurologic deficits improved shortly after surgery, but the hamstring tightness remained even after a year. (Zhu 2006)

Sciatica in Female Patients and during Pregnancy

To accurately diagnose female patients suffering from sciatica, it is necessary to obtain a detailed menstrual/gynecological history to rule out causes other than a herniated disc with radiculopathy. The search for such a cause should be considered even if imagining reveals a disc herniation, as many of these herniations are not clinically relevant. (Al-Khodairy 2007)

A 2006 review of the literature identified 75 articles detailing 127 cases of sciatica caused by gynecological or obstetrical disorders. (Al-Khodairy 2007) The most common causes identified were endometriosis, pregnancy/labor, and uterine fibroids. Other less common causes included sacral osteophytes, endosalpingiosis, vaginal needle intervention, pelvic metastasis and rarely adenomyosis, intrauterine device, hematocolopos, tuboovarian abscess and retroverted uterus.

- Endometriosis can compress the sciatic nerve in the pelvic cavity, in the area of the sciatic notch, in the gluteal region and even within the sheath of the sciatic nerve. The presentation is typically leg, foot and buttock pain that has an onset a few days before menstruation, increasing in intensity until subsiding 2 to 3 days or up to 2 weeks after the end of menstruation. This is termed cyclical or catamenial sciatica. Over time, the symptoms can progress to constant pain with extreme increases during menses.
- Pregnancy-related sciatica can be due to direct pressure on the nerve roots and ischemia of the neural elements due to pressure on the vascular system when lying supine (Al-Khodairy 2007). Severe vomiting can also cause sciatica in pregnant patients. During hospital labor, pressure from stirrups on the peroneal nerve can mimic an L5 lesion (Al-Khodairy 2007). During prolonged labor or in cases of abnormal presentations (e.g., breach birth), the lumbosacral trunk can be compressed at the pelvic brim (Al-Khodairy 2007). These conditions will typically self resolve 3-4 months postpartum. MRIs of pregnant women can be safely done as long as gadolinium chelates are not used.
- Fibroids (leiomyomas, myomas or fibromyomas) can cause nerve compression in a manner similar to pregnancy by causing direct compression of the lumbosacral trunk. These growths are not uncommon in females over 30 years of age (20 to 50%) (Al-Khodairy 2007). Symptoms can include pain with menses, often crampy or labor-like, as well as a feeling of pelvic heaviness. There also may be “pressure symptoms” such as urinary frequency, stress incontinence, retention, constipation and difficult defecation.

PROGNOSIS

The overall prognosis for patients with sciatica is good. Within the first 10 days after onset, about 50% of patients with acute sciatica report improvement and the number goes up to 75% in 4 weeks. Other studies have reported that over half have recovered within 3 months. However, as many as 30% may have pain for a year or longer. (Koes 2007) Studies have also looked more specifically at lumbar disc herniations and sciatica. In one prospective study, the probability of patients reporting recovery after one year was about 95% for both surgical and nonsurgical approaches. (Peul 2007) These findings are consistent with other studies as well. Conservative care emphasizing pain control with epidural steroids (Bush 1992) or aggressive functional restoration rehabilitation programs (Saal 1989) each report about 90% satisfactory outcomes, verified one year after treatment. Earlier studies looking at nonoperative care arrived at similar findings. (Hakelius 1970, Weber 1983)

Saal (1996) has listed prognostic factors suggesting either favorable or unfavorable outcomes for nonoperative care. Not all of these factors have been validated by controlled studies incorporating multifactoral analysis and are not absolutes. However, they may be useful in combination to aid in clinical decision-making.

Favorable, unfavorable, neutral and questionable indicators affecting prognosis follow.

FAVORABLE INDICATORS FOR CONSERVATIVE CARE

Anatomy

- Extrusions or sequestrations had a better prognosis than bulges. (Ahn 2002, Komori 1996, Matsubara 1995, Splendiani 2004)
- The more prominent the herniation, the more likely it will resorb (reflected in MRI changes). (Jensen 2006)
- Absence of spinal stenosis.

Exam findings

- Absence of pain with the crossed SLR (XSLR). (Saal 2001)
- Spinal motion in extension that centralizes pain (Donelson 1990) or at least does not reproduce leg pain. (Kopp 1986)

Psychosocial

- Limited psychosocial issues.
- Self-employed.
- Motivated to exercise, to recover and return to function.
- Educational level > 12 years.
- Good fitness level.

Response to care

- Relief or > 50% reduction in leg pain within first 6 weeks of onset.
- Progressive return of neurologic deficit within the first 12 weeks.
- Positive response to corticosteroid challenge.

UNFAVORABLE INDICATORS FOR CONSERVATIVE CARE

Anatomy

- Subligamentous contained disc herniation.
- Concomitant spinal stenosis (especially lateral recess) (Saal 1996, Saal 2001).
- Far lateral disc herniations. In one study, 3 out of 15 patients responded to conservative therapy. (Faust 1992) Another report suggested a 20% response to a rehabilitation regimen. (Kibler 1998)

Exam findings

- Cauda equina syndrome.
- Positive XSLR. Cox (1994) found this to be a negative predictor for flexion-distraction therapy and Stonebrink (1996) for manipulative therapy as well.
- Leg pain produced in spinal extension. (Donelson 1990)

Psychosocial

- Overbearing psychosocial issues.
- Worker's compensation.
- Unmotivated to return to function.
- Educational level < 12 years and/or illiteracy.
- Unreasonable expectation of recovery time.
- Poorly motivated and passive in recovery process.

Response to care

- Lack of > 50% reduction in leg pain within the first 12 weeks.
- Negative response to corticosteroid challenge.
- Progressive neurologic deficit.

NEUTRAL INDICATORS FOR CONSERVATIVE CARE

Anatomy

- The presence of a large herniation, an extrusion or uncontained fragment does not adversely affect the outcome of nonoperative treatment and should not be used as overwhelming evidence that surgery is necessary. Saal (1989) reported an 87% success rate with extrusions. (Rhee 2006)
- Another study showed treating patients with uncontained disc herniations using conservative care for two months reduced the need for surgery. (Takui 2001)
- At the same time, the higher the grade of herniation, the better the surgical outcome. (Vucetic 1996) Surgical outcome tends to be better with uncontained discs than with a small contained herniation. (Jonsson$_a$ 1996)

Exam findings

- **Imaging.** In general, imaging does not provide strong indication as to whether a patient will respond to conservative care. (Carragee 1997)
- **Degree of SLR limitation.** However, Cox (1990) observed that patients whose whole pelvis came off of the table almost immediately with the initiation of the SLR ("Cox sign"), did not respond well to flexion-distraction therapy and a basic exercise program and were more likely to end in surgery.
- **Degree of neurologic deficit** (except progressive deficit and cauda equina syndrome). Mild to moderate muscle weakness is not necessarily an indication for surgery. (Postacchini 1996) Saal (1989) and Hakelius (1970) suggest that even profound muscle weakness (e.g., foot drop) may be treated successfully without surgery.

Biological

- Gender
- Age

Response to care

- Response to bed rest.
- Response to passive care.

QUESTIONABLE INDICATORS FOR CONSERVATIVE CARE

- **Actual size of herniation.** Some authors believe that small contained herniations may present the greatest challenge to both operative (Jonsson$_a$ 1996) and nonoperative intervention and natural history. (Saal 1996) The larger the herniation, the greater the resorption. (Saal 1996)
- **Canal position of herniation.** Although Cox (1994) found a medial herniation to be a negative predictor for flexion-distraction therapy and Stonebrink (1996) believed it to worsen the prognosis for manipulation, Saal (1996) did not find it to affect prognosis for his functional rehabilitation exercise program. Far lateral and midline herniations tend to have poorer results for surgery. (Walker 1993)
- **Spinal level of herniation.**
- **Multi-level disc abnormalities.**

MANAGEMENT STRATEGY

Treatment for lumbar disc herniation can be divided into two broad categories: surgical or nonsurgical care.

Multiple clinical studies have attempted to determine the optimal treatment approach with mixed results. At least five randomized trials have compared surgical care (discectomy or microdiscectomy) to a variety of conservative approaches. There is broad agreement that in most cases surgery should not be considered for patients with herniated discs and sciatica until after there has been a trial of conservative nonsurgical care anywhere from 3 weeks to 3 months. (Peul 2007, Postacchini 1999, Saal 1990, Weber 1994)

The presence of neurological deficits is not necessarily an indicator for early surgical intervention. Patients with neurological deficits may be good candidates for conservative care. Hakelius (1970), the Maine Lumbar Spine Study (MLSS) (Atlas 2005), Saal (1996), Dubourg (2002) and Peul (2007) have each demonstrated that stable neurological weakness resolves equally well regardless of treatment.

The majority of patients recover with conservative care at least as well as with surgery (Cassidy 1993, Peul 2007). Atlas' large observational study (2001) reported that patients with mild symptoms did well regardless of the type of treatment. Disability outcomes were similar.

Several studies, including the Spine Patient Outcomes Research Trial (SPORT), MLSS and the Weber and Peul trials, have demonstrated that surgery has clear short-term advantages for carefully selected patients. The speedy resolution of severe, disabling sciatica may be of particular value for some sufferers and surgery seems to offer a more rapid recovery and earlier resolution of leg pain. For example, in the SPORT, surgical patients had a decrease of (nearly 40) points on the Oswestry Disability Index from severe disability to nearly normal by six weeks after surgery.

On the other hand, it's equally clear that long-term outcomes (one, two and ten years) do not favor any one type of intervention.

Although the herniated disc may appear to be the cause of the patient's symptoms, this may not always be the case. Many patients recover from disabling back and leg pain without any change in the size and location of their disc herniation. (Bozzao 1992, Cassidy 1993) Even when clinically indicated, surgery may fail. One explanation is that the presence of a disc herniation revealed by MRI and confirmed at surgery turns out not to actually be the cause of the patient's pain. This risk of surgical failure supports the value of a more conservative initial approach, allowing conservative care and natural history to separate out those for whom surgery would be unnecessary.

- **Clinical Note:** The decision for early surgery or a trial period of conservative care will be based on patients' presentation and their personal needs and wishes. For more, see Surgical Referral section, Pp. 65-66.

Evidence is currently lacking to identify the most effective form of conservative care. A systematic review of conservative care for sciatica from 2000 found that, although there is some disagreement, in general there is insufficient evidence supporting the effectiveness of one conservative treatment for sciatica (with or without underlying disc herniation) over another. (Vroomen 2000)

THE MANAGEMENT PLAN

Treatment can be loosely organized into three phases of care: the very initial interventions during an *acute phase* which may be very brief or last several weeks, a *subacute* and *reactivation phase* (see P. 43), and a *rehabilitation phase* (see P. 45).

INITIAL ACUTE INTERVENTIONS

This section pertains to treatment delivered soon after initial injury or during acute flare-ups.

Acute Phase Objectives

- Centralize pain and decrease inflammation; prevent further neurologic loss.
- Attempt to reduce herniation.
- Teach the patient how to protect and stabilize the low back.
- Prevent further deconditioning.
- Minimize the potential for illness behavior; address illness behavior already present.

SUMMARY – Initial Treatment Options

Not all of these options need be utilized.

- Palpate the spine with patient seated, supine and prone, assessing centralization, peripheralization and local response.
- Consider HVLA manipulation and/or mobilization.
- Consider flexion-distraction.
- Utilize soft tissue manipulation to treat associated myofascial dysfunctions (MFTP's, spasm, adhesions) and reduce inflammation.
- Consider therapeutic modalities for pain control and reduction of inflammation.
- Consider home exercise for pain control (e.g., directional preference assessment and prescription).
- Teach the patient to protect the spine.

During the initial phase of treatment, the practitioner has several key objectives. The initial step is to try to centralize pain and reduce sciatica as soon as possible. Treatment can also be aimed at attempting to reduce the herniated disc material and possibly decompress the nerve root.

These objectives can be addressed by a combination of manipulation and self-treatment procedures (e.g., directional preference protocols, often in extension). Procedures should also be used that decrease pain, spasm and inflammation in general.

Patient education should focus on preventing exacerbations or further injury *while encouraging patients to maintain some activity*. Patients should be taught how to position their pelvis into a relatively pain-free, functional neutral position so that they can protect themselves during activities of daily living (ADLs) and the exercise program that will be prescribed. As soon as possible, limited aerobic activities should be introduced to prevent any further deconditioning.

Pain Control Strategy

For patients in severe, intractable pain, referral for prescription-strength medication may be indicated to improve their comfort level in the acute phase. In general, the recommended strategy for pain control would be to consider 1) physical medicine (manual therapy, and in some cases, passive physical therapy modalities), 2) then either OTC medications or herbal support for pain (although evidence for their effectiveness for sciatica tends to be weak or negative), and finally 3) prescriptive medication (e.g., antiepileptic drugs or opiates, although the effects are either mild or questionable) or corticosteroid injection.

This first phase of treatment may last anywhere from 1 to 3 weeks and usually employs a treatment frequency of daily or every other day, although this may vary. Optimal frequency for applying manual therapy for LBP or radiculopathy has never been studied in a controlled fashion.

Office Treatment

- ✓ *Determine suitability for high velocity low amplitude (HVLA) manipulation/ mobilization or flexion-distraction* (within first two visits, if tolerated). (See Management: Specific Procedures, P. 47)
  - **The spine should be palpated in multiple positions.** The patient should be seated, supine *and* prone. The practitioner assesses centralization, peripheralization and local response.
  - **Consider HVLA manipulation and/or mobilization.** Whether to manipulate and

the level and direction are based on the following parameters: 1) the foremost consideration is whether palpatory loads centralize or peripheralize the pain; 2) the next consideration, especially if the effects on the leg are neutral, is to monitor which direction the patient can tolerate segmental joint challenges (based on local guarding and pain response); and 3) if multiple spinal levels and directions are well tolerated, identify joint blocks or restriction. In more subacute presentations, joint restrictions may be mobilized or manipulated even if locally painful.

- **Consider flexion-distraction therapy.** Utilize tolerance testing to determine appropriateness and level of securing the patient. This treatment approach may be chosen based on physician preference, patient's ability to tolerate, and when another form of manipulation does not appear to be more successful in centralizing pain. It may be the initial main therapeutic intervention or an adjunct to HVLA manipulation or mobilization. Flexion-distraction can be delivered daily for three weeks or, occasionally, multiple times per day for patients with severe signs or symptoms. (Cox 1996)

- **If none of the above treatments are tolerable,** consider pelvic blocking, muscle energy technique (MET) or a trial of traction therapy.

✓ *Control pain and inflammation (during initial visits if necessary).*

- Electromodalities and/or ice (try to limit to acute phase for during flare-ups).

- Soft tissue therapy for areas of spasm or trigger points (consider erector spinae, gluteus maximus, minimus and medius, piriformis). See also Appendix IV for pain referral chart for MFTPs.

✓ *Determine postures and repetitive motions that centralize leg pain.* Correct antalgic lateral pelvic shift if present. Consider directional preference protocols. Patients who will centralize with repetitive extension will usually do so in the initial visit or within the first three days of care. After that time, assessment for centralization with extension has a poor yield. (Donelson 1990, Kopp 1986)

NOTE: Extension may peripheralize symptoms with far lateral disc herniations. (Kibler 1998)

➢ **Clinical Tip:** If prone extension exercises are prescribed, it is critical that the patient is taught how to transition from standing to lying on the floor and back again *without flexing the lumbar spine* (e.g., use hip hinging and modified kneeling or squat).

✓ *Brace or support (as necessary).* There is no scientific support that bracing alters outcomes. (Spitzer 1987) However, for patients with moderate to severe symptoms, the practitioner may fit a patient in the office with a brace. If it appears to help, the patient can wear it in the short term for pain control, especially if it seems to allow more activity. Less commonly, crutches (Weber 1994) may be used on trial basis for pain control.

Patient Education

✓ *Set expectations*. In terms of patient expectation, give generally positive messages. Reassure the patient that there is no cause for alarm and no signs of organic disease. Conservative treatment is usually successful (reports as high as 90% recovery with conservative care) (Gibson 2007, Saal 1989), but significant improvement may take a month or two. Full recovery is expected, but recurrence is possible. (Waddell 1996) Surgery is not usually necessary, but in cases where indicated, it also can have a very successful outcome. *(Begin at the first visit and repeat periodically throughout care.)*

✓ *Teach neutral pelvis, abdominal bracing and hip hinging.* Instruct patients how create an abdominal brace, hinge from the hip when bending forward, and how to hold their pelvis in a safe, comfortable range. Neutral pelvis and hip hinge with bracing is especially important during various transitional movements such as seated to standing, standing to lying, etc. *This training should be done within the first few visits, preferably within the first*

visit. (See CSPE protocol, Low Back Rehabilitation Program, neutral pelvis track.)

- ✓ *Progress into a lumbar stabilization program.* This is done usually after the extremity symptoms have centralized, although some practitioners may introduce stabilization exercises earlier if the patient can tolerate specific tracks.

- ✓ *Address any significant current or potential psychosocial components*. (See Pp. 32-35.) (Variable, often within first week of treatment.)

- ✓ *Give emergency instructions*. Patients should go to an emergency room if they experience anuria for more than 12 hours or sudden urinary or bowel incontinence. Patients should contact the clinic as soon as possible if milder urinary retention or any other symptoms of a cauda equina syndrome develop (incontinence, saddle paresthesia, etc).

Home Care

- ✓ *Give specific exercises.* These may be McKenzie home activities and/or lumbar stabilization exercises. (See CSPE protocols, Directional Preference Protocol: Centralizing Low Back and Leg Pain, as well as Low Back Rehabilitation Program.)

- ✓ *Avoid aggravating loads*. Educate patient to avoid aggravating postures, especially those that increase disc pressure. (*This is usually done at the first visit*.) Identify these postures based primarily on patient history and response during the physical assessment. Additional advice can be given based on knowledge of the physical loads on the disc, but the practitioner should be aware that injured discs often respond to loads very differently from healthy discs. Research on lumbar intradiscal pressure has demonstrated *in vivo* that intradiscal pressures are higher in the sitting than the standing posture, (Nachemson 1960, 1964) higher in the straight or kyphotic posture than in the physiologic lordotic posture, (Andersson 1974) and are further increased during active trunk flexion exercises (Nachemson 1970). However, Merriam et al. (1984) showed that pressure changes in degenerated discs are not as predictable as in normal discs.

- ✓ *Encourage mild activity*. Patients may remain cautiously active using leg symptoms as their guide, especially if they can control these symptoms with a neutral pelvis strategy. Bed rest may used for relief of sciatic pain, but should be limited to only a few days. Even then, it need not be strict and may be punctuated with walking. (Gibson 2007, Vroomen$_b$ 1999). For example, within the first week a goal would be to work up to a 20-minute walk for every 3 hours spent supine. (Deyo 1990) Using a recumbent bicycle is another option.

- ✓ *Address home and work ergonomics.* Considerations include quality/age of bed, use of pillow between the legs, and chair/car seat comfort.

- ✓ *Increase water and fiber intake to soften stool and reduce the chance for constipation*. Beware of overuse of codeine or other narcotics since constipation is a common side effect. Over-the-counter stool softeners can also be used.

Additional Home Care Options (as needed)

- ✓ *Use pain relief postures* (e.g., 90/90) as necessary. Lying with the hips and knees bent to 90 degrees affords relief for some patients.

- ✓ *Use other pain relief aids as necessary.* If patients cannot adequately control pain by posture or rest, recommend ice, heat wrap, bromelain, acetaminophen or NSAIDs. Doses of medications should be continuous for several days as opposed to taking them as needed. Analgesics like acetaminophen are often cited as the first choice over NSAIDs because of fewer side effects. NSAIDs have been

associated with urinary retention (perhaps mimicking a cauda equina syndrome) (Verhamme 2005), significant gastrointestinal bleeding, heart disease, and even death.

NOTE: Consult the CSPE protocol on NSAIDs for dosage, side effects and screening risk patients. It is WSCC Clinic policy to screen all patients taking OTC NSAIDs and to provide them with an educational sheet on side effects.

Acetaminophen also can have serious side effects and contraindications must be carefully checked. If necessary, patients can be referred for pharmaceutical strength medications.

- ✓ *Home traction*. For patients not responding to extension therapy or manipulation, consider home traction.
- ✓ *Sleep aids.* For patients getting very little sleep due to pain, recommend sleep aides. Several natural options are available:
  - Valerian, either 1.5-2 grams of powdered root or 300-500 mg of a concentrated extract (labeled for either 0.5% essential oil or 0.8% valerenic acid content), taken 30-60 minutes before bedtime. Products that include either hops or lemon balm extracts are also effective. (Balderer 1985, Cerny 1999, Gerhard 1996, Leatherwood 1982)
  - Tryptophan (available again, 1-2.5 grams) or 5-hydroxytryptophan (100-200 mg) taken 30-60 minutes before bedtime. (Lindsley 1983, Schneider-Helmert 1986, Soulairac 1998, Wyatt 1971)
  - Melatonin (500 mcg-3 mg) taken 30-60 minutes before bedtime (Garfinkel 1995, Zhdanova 1995, Zhdanova 2001)

NOTE: In cases that present with severe motor loss at the initial visit, the practitioner may immediately seek medical or surgical consult or may treat for 3-6 weeks while carefully monitoring motor status. If there is still no improvement at that time, a surgical consult should be considered. (Saal 1996)

SUBACUTE AND REACTIVATION INTERVENTIONS

Progression to the subacute phase is not strictly based on length of time from the initial onset or initial treatment, but reflects improvement in the operational end points listed above.

CLINICAL WARNING! Progressive motor loss at any time during the treatment program should trigger a neurological/surgical consult.

Subacute Phase Objectives

- Continue to control pain.
- Return to work with modified duties.
- Restore biomechanical function as it applies to joint function, flexibility, endurance, proprioceptive integrity, and aerobic conditioning.

As the patient reaches the endpoints signaling completion of the acute intervention phase, the "reactivation" phase of management becomes more prominent. The objective now is to continue to sufficiently control the pain so that the patient can be fully engaged in the active care program (elements of which have been introduced during the early acute intervention phase).

If it has not occurred already, the goal is to return the patient to carefully regulated work activities. Physiologic therapeutics are used sparingly, if at all, usually to manage flare-ups.
Joint manipulation is aimed at pain control as needed, and as a tool to restore good joint mechanics throughout the spine and pelvis to aid the exercise and stabilization program.

The key objective of this phase of treatment is to train the patient to stabilize and protect the lumbopelvic region. To achieve this, the patient is trained first for good motor control, then endurance.

Finally, the goal of the treatment plan should focus on improving overall conditioning. Duration for this phase is a general approximation, depending on severity of the

signs/symptoms and the number of complicating factors (all of which should be clearly charted). *In some programs this phase is based on an 8-12 week core,* (Saal 1992) *after the pain has begun to centralize.* To decide when a patient has moved out of the subacute phase, the practitioner can use the endpoints of care for this phase, the patient's ability to tolerate the treatments and exercises of this phase of treatment, and the specific indicators for progression through the steps of appropriate stabilization tracks. It is important to note that some components listed in this phase may be introduced earlier, in the acute phase intervention, based on the practitioner's discretion and patient tolerance.

Office Treatment

- ✓ *Wean the patient from passive modes of therapy as appropriate.* Reserve electrotherapy and massage techniques to manage occasional flare-ups. Use manipulation to control pain during flare-ups and to aid in restoration of joint movement as the patient proceeds through the stabilization and reactivation program.
- ✓ *Soft tissue therapy* (e.g., pin and stretch, instrument assisted myofascial technique) may progress from passive to a more active application. In such cases, treatment is administered while the patient performs functional movements that are problematic.
- ✓ *Continue taking the patient through lumbar stabilization protocols and progress into proprioceptive training*. (See CSPE protocol, Low Back Rehabilitation Program, seated and standing tracks.)
- ✓ *Restore good biomechanics.* Evaluate muscle imbalances using posture, movement patterns, length testing, and patient's performance of the lumbar stabilization activities. Based on the results, balance pelvic and abdominal muscles, stretching short tight muscles and facilitating weak or inhibited muscles. The object is to create optimum biomechanical components so that the patient can learn to stabilize the low back. (See introduction to Low Back Rehabilitation Program protocol for a more detailed discussion of the key stabilizing muscles.)

Patient Education

- ✓ *Teach the patient how to protect the low back.* Patients should avoid bending and lifting for six weeks after the leg pain has centralized. (White 1996) Then advise patients on proper lifting techniques (see P. 63). Other "back school" strategies can also be taught at this time.

Home Care

- ✓ *Emphasize progression through the stabilization program.*
- ✓ *Continue aerobic activities.* These can include swimming or brisk walking. When the patient can sit comfortably, stationary bicycling may be introduced. (Deyo 1990)
- ✓ *If doing directional preference protocol, continue as needed.*

Additional Home Care Options (as needed)

To control delayed muscle soreness associated with exercise program, instruct the patient to remain well hydrated. The practitioner may also consider Vitamin C loading. The amount used in one small study was 3 one-gram doses per day starting three days prior to the exercise and continued for one week. (Kaminski 1992)

If a patient is having trouble with pain during the exercise program, consider using TENS during the activity.

Operational End-Point/Outcome Measures

The patient has returned to work with either restricted activities or full duty. S/he has progressed into the higher, more demanding steps of the stabilization program. Leg pain is gone or is absent most of the time.

NOTE: If patients improve early in the course of treatment but then plateau, up to 2-3 months of additional conservative care is indicated. If at that time, patients have not improved to an acceptable functional level, consider a surgical consult. However, at least one researcher suggested that waiting up to 6 months may be a reasonable option (Peul 2007). (See Surgical Referral section, Pp. 65-66.)

REHABILITATION PHASE

The overall goal of this phase of treatment is to return the patient to full work capacity and ADLs with minimal residuals. Another important goal of this phase of treatment is to try to reduce the likelihood of recurrence, even in patients who have returned to full duties and who are essentially pain-free.

Rehabilitation Objectives

- Address any flare-ups of back pain.
- Improve low back and pelvic stabilizer strength to normative values.
- Continue to improve proprioceptive integrity and aerobic conditioning.
- Return to full work duties and ADLs with minimal residuals.

Not all herniated disc patients will remain in treatment for this final phase. However, this phase of the program is reasonable for the following patient populations: patients who initially had moderate to severe signs and symptoms; patients who still have appreciable LBP; patients with a previous history of chronic or recurrent LBP; and patients who, at one extreme, are returning to very physical work or lifestyle demands, or, at the other extreme, returning to very sedentary lifestyles.

The key objectives are attaining good endurance of the low back muscles (especially the lumbar extensors, multifidi and abdominal obliques), good coordinated control of the pelvis, adequate lower extremity strength and endurance (especially the quadriceps and gluteus maximus), and overall good aerobic conditioning.
As in the subacute phase, passive care (e.g., manipulation, soft tissue therapy and physiologic therapeutics) is utilized sparingly to either control pain or to address joint dysfunctions that may be specifically preventing further progress.

Office visit frequency is significantly reduced, but the duration of the phase may last 24-32 weeks (from first visit) or longer (see Oregon Guidelines, cited on the next page). The emphasis is on patient self-care, guiding the patient toward achieving the objectives listed above, and managing flare-ups.

NOTE: Components of subacute/reactivation and rehabilitation interventions may overlap considerably. Many of the following components cited can be introduced during mid- to late-subacute phase, based on the patient's tolerance and response.

Office Treatment

- ✓ *Treat acute flare-ups as necessary (see acute intervention).*
- ✓ *Evaluate muscle endurance.* Abdominal strength, lumbar extensor endurance, and leg strength should be tested using standardized procedures. (See CSPE protocol, Low Back and Leg Endurance Tests.) Assign exercise activities accordingly.
- ✓ *Take patients through advanced steps of appropriate stabilization tracks.* More difficult steps should be assigned that challenge patients' ability to maintain good pelvic control. Ideally, patients should feel a "muscle burn."

Patient Education

- ✓ *Periodically check in on the quality of home exercise programs.*
- ✓ *Continue to give postural and ergonomic advice as needed.*

Home Care

- ✓ *Continue directional preference protocols as needed to manage flare-ups.*
- ✓ *Continue lumbar stabilization and proprioceptive activities.*
- ✓ *Do muscle endurance exercises.*
- ✓ *Follow prescribed aerobic conditioning program.*

Operational End-Point/Outcome Measures

- ✓ Patient returns to full work responsibilities and ADLs with minimal residuals.
- ✓ Patient demonstrates good motor control in lumbar stabilization and proprioceptive activities.
- ✓ Patient attains normative values or significantly improves in abdominal, extensor and quadriceps endurance tests.
- ✓ Patient achieves a maximal functional improvement that could not be advanced by further exercise training or pain control. (Saal 1989)

TREATMENT PLAN: FREQUENCY AND DURATION

Three to six treatment sessions per week are recommended initially, gradually reducing as the patient responds to care.

Treatment parameters from the Oregon Chiropractic Practices and Utilization Guidelines (1990) are as follows:

- Mild intervertebral disc syndrome without myelopathy: 2-12 weeks of treatment.
- Moderate intervertebral disc syndrome without myelopathy: 1-6 months of treatment.
- Marked intervertebral disc syndrome without myelopathy, with or without radiculopathy: 2-12 months of treatment.

MANAGEMENT TIMELINE AND MILESTONES

First three days: Centralization of leg pain (Werneke 1999)

End of first week: In the rare cases that patients are under bed rest, they are beginning to ambulate. (Deyo 1990)

First 3 weeks: 50% improvement based on flexion-distraction treatment (but usually extrapolated to various forms of manual therapy). (Cox 1994)

First 6 weeks: 50% improvement based on functional rehabilitation. (Saal 1992)

At week 6: Refer for surgical consult if treating a profound muscle weakness that has not responded. (Saal 1992)

At 8-12 weeks: Refer for surgical consult patients that have had poor response to care and who have relative indication for surgery. (See PP. 65-66.)

NOTE: Opinions of how long surgery can be delayed range from 6-8 weeks (Koes 2007) to 3-6 months (BackLetter 2007).

MANAGEMENT: SPECIFIC PROCEDURES

High Velocity Low Amplitude (HVLA) Manipulation and Mobilization

The practitioner selects which patients are suitable for HVLA manipulation or mobilization and carefully chooses patient positioning and treatment vectors. The history and physical examination may offer clues to aid in this analysis.

Identify Antalgic Behavior

Observe the patient's antalgic posture and limited ROM, if present. Note which movements the patient avoids. Segmental treatment that *mimics* the direction of global antalgia may be effective.

Explore Various Patient Positions

The patient should be motion palpated while seated, side-lying and prone. Patient response may be more prominent or less prominent depending on which position s/he is in, for example, seated (weight bearing) versus lying. The general strategy is to find a position that yields the most information and one in which the patient can be manipulated *without aggravating* back or leg symptoms.

> ➢ **Clinical Tip:** The patient's tolerance to palpation/treatment in side posture may also be influenced by whether the affected leg is side up or side down. Both positions may need to be explored in difficult cases.

Inquire about the most comfortable position, best sleeping position, etc. for clues to aid in the manual evaluation.

In some cases, a lateral pelvic shift may need to be corrected before other therapeutic postures can be identified and adjustments administered.

Explore Spinal Levels and Vectors that Centralize Pain

The first level of interest is to find segmental levels and directional loads that may centralize the patient's symptoms (for the purpose of manipulation) as well as directions that peripheralize the symptoms (so that these can be avoided). It is important to note that sometimes vectors that centralize the pain out of the leg actually increase low back discomfort while they are being applied. *Response of the leg pain is the main indicator* providing that any increase in LBP is temporary and tolerable to palpation or mobilization. Symptom relief may or may not be in the direction of a true restriction.

Patients with severe, acute pain are manipulated in the direction that reduces or centralizes their radicular pain. Lisi (2001), in a series of 3 cases, reported the utility of this centralization phenomenon in locating vectors and positions which led directly to manual intervention strategies.

Individual joints are challenged with overpressure in all ranges of motion.

- side-posture rotation
- side-posture lateral bending
- side posture extension
- seated rotation
- seated lateral bending
- seated extension
- explore combination vectors seated and side-lying (e.g., extension plus lateral bending and slight rotation)
- prone distraction

In some cases, therapeutic positions or challenges will neither centralize nor peripheralize the leg pain. In these cases the clinician may choose to determine the vector of manipulation/mobilization either based on local response to joint challenge (e.g., decrease in back pain or segmental tenderness) or on adjusting to release a palpable restriction.

As the leg pain centralizes over time, the strategy can change to manipulation in the direction that reduces motion restriction. (Hubka 1991)

CHOOSE MODE OF MANUAL THERAPY

- Mobilization & HVLA
- Flexion-Distraction
- Other Treatment

MOBILIZATION & HVLA

Mobilization may be utilized as a substitute for or precursor to HVLA adjustments when patients are acute. Segmental joint mobilization has not been specifically studied as a treatment for lumbar disc herniations, but is commonly applied throughout the spine for a variety of mechanical back pain conditions. In one study it compared favorably with HVLA for mechanical neck pain. (Hurwitz 2002)

- **Clinical Tip:** It is important to note that in some cases, testing loads may need to be sustained anywhere from 30 seconds up to several minutes.

A pumping mobilization may be all that is possible in some acute cases. On the other hand, if well tolerated, mobilization may progress to a fast, very shallow thrust adjustment or a standard high velocity low amplitude manipulation. Treatment choice will be based on patient response and tolerance as well as the practitioner's discretion.

Seated extension or side-lying mobilization with sustained segmental pressure over the spinous process may also be particularly useful and tends to be very well tolerated. As the patient is passively extended over the doctor's hand, a normal lordosis is encouraged with reduced loading of the disc. Segmental restoration of extension should facilitate global extension techniques, such as directional preference exercises. For more details, see Appendix VIII.

Approximate Level of Herniation

Knowing the level of the herniation is not usually necessary when employing mobilization and HVLA techniques since treatment is based on patient response. In some cases, the manual therapy may be at the level of the herniation and in other cases may not. Knowing the segmental level of the herniation is more important when applying flexion-distraction methods (see P. 51). The practitioner can use the pattern of neurologic deficits as well as the pain and paresthesia distribution to predict the level of herniation, although the accuracy of these methods is limited.

Summary of Rationale/Theoretical Mechanism for Manipulation

Manipulation has several purported effects. Evidence suggests that there are both analgesic and anti-spasm effects (Herzog$_b$ 1996, Sterling 2001). The strategy would be to allow time for the herniated disc inflammation to resolve and the disc material to resorb according to natural history.

In addition, there is some evidence suggesting that manipulation may have an effect on inflamed nerve roots. Song et al. (2006) created nerve root inflammation in rats and showed significant histological and behavioral improvement following segmental manipulative treatment. The spinal manipulation appeared to significantly reduce severity and shorten duration of pain caused by lumbar IVF inflammation. Treatment of adjacent levels did not produce the same effect, suggesting the importance of segmental specificity. (Song 2006)

Finally, repetitive end-range loading is proposed to re-position herniated material back into the disc and away from nerve roots and other pain-sensitive structures.

Efficacy of Manipulation

A 2007 review by the American College of Physicians (ACP) and the Pain Society reported that spinal manipulation had consistent evidence of fair quality imparting

moderate benefits for patients with radiculopathy or sciatica. (Chou 2007)

An RCT of 64 patients with acute LBP and sciatica with disc protrusion demonstrated that patients receiving real spinal manipulation (compared to sham manipulation) had significantly greater relief of local and radiating acute LBP, spent fewer days with moderate to severe pain, and consumed fewer drugs for pain control. Treatment frequency was based on a pre-planned protocol of 5-minute treatments five days per week, terminating with either symptom resolution or a maximum of 20 treatments. (Santilli 2006)

A randomized trial compared manipulation to chemonucleolysis (a treatment with proven efficacy compared to placebo) (Gibson 2007) in a group of 40 patients with lumbar disc herniations. The patients were from an orthopedic clinic and had back pain and sciatica with CT- or MRI-confirmed disc herniation. At two and six weeks, patients who were manipulated showed a decrease in severity of back and leg pain and disability. The chemonucleolysis patients improved only in leg pain. (Burton 1998) After twelve months, there was no significant difference in overall outcome between the treatments (Burton 1998, Burton 2000).

In a prospective clinical case series of 16 MRI-confirmed lumbar disc herniations with neurological and root tension signs, BenEliyahu (1996) reported clinical improvement, which correlated with MRI improvement. Lumbar and cervical cases were combined in this study with 22 of 27 reporting good outcomes and resolution of leg (or arm) pain. Lumbar disc herniations were treated with flexion-distraction and physiotherapy in the acute phase, and "judicious rotational manipulation" in the subacute phase. (BenEliyahu 1996) No cases of aggravation of leg or arm pain were seen.

In a retrospective case series of 59 patients treated for lumbar disc herniation with "side-posture" manipulation and physiotherapy, Stern et al. (1995) reported 90% of the patients improved and none worsened. Of the improved group, 75% had improvement in straight-leg raising and lumbar range of motion. This study concluded that a "nonoperative approach, including spinal manipulation may be an effective and safe treatment for LBP and radiating leg pain." (Stern 1995)

In an uncontrolled descriptive study of 14 CT-documented lumbar disc herniations, Cassidy et al. (1993) used daily side posture rotary manipulation to treat patients with radiculopathy. Thirteen of the fourteen cases had a successful clinical outcome, and six had a measurable reduction in herniation on CT scan, with one of those showing a greater than 50% reduction. (Cassidy 1993) These authors concluded that side posture rotary manipulation is safe and effective. However, they caution that patients should first carefully be tested to determine if they can tolerate mobilization of the motion segment in question and that leg pain is not aggravated. If leg pain is produced during a given session, manipulations should not be performed. Cassidy et al. also suggest that in severe cases, the first few treatments involve mobilization rather than manipulation

In a single case study, Bergmann (1998) reports on the treatment of a 48-year-old woman with MRI-confirmed disc herniation, sciatica, mild extensor hallucis longus weakness and decreased sensation. Treatment included both flexion-distraction therapy and high velocity, low amplitude adjustments. Pain resolved and there was significant improvement on an Oswestry questionnaire. Treatment dose was 9 treatments over 2½ months. There was no recurrence at two years out. (Bergmann 1998)

Safety of HVLA Manipulation

Published medical experts in manipulation such as Cyriax in England (1980), Bourdillon and Day in Canada (Bourdillon 1987), Lewit in the Czech Republic (1985), and Maigne in France (1978) agree with the chiropractic and osteopathic professions that skilled manipulation is safe and appropriate for the

great majority of patients with disc herniation and should be considered as a first option for conservative care.

The authors of many standard textbooks describing manipulative procedures for the treatment of lumbar disc herniations do not consider the presence of disc herniation to be a contraindication for spinal manipulation. (Bergmann 1993, Cox 1990, Cyriax 1980, Gatterman 1990)

A literature review from 2004 using data from the previous 40 years estimates the greatest risk of developing a clinically worsened herniation or cauda equina syndrome attributable to spinal manipulation to be one in 3.72 million manipulations. If complications following manipulation under anesthesia (MUA) are included, the risk doubles. Even in patients presenting with lumbar disc herniations, the risk of manipulation appears minimal, especially compared with other common treatments, such as NSAIDs and surgery. Spinal manipulation may be no more dangerous to an injured disc than a cough or a stumble. (Oliphant 2004)

A 2005 systematic review of HVLA manipulation for symptomatic lumbar disc disease found that, while the evidence is limited and not yet conclusive, it does not suggest that HVLA manipulation is unsafe for this patient population. (Lisi 2005)

Cauda equina syndrome as a complication of spinal manipulative has been cited in the literature. A review of the literature from 1911 to 1989 by Haldeman and Rubinstein found ten reported cases. They presented three more cases, only one of which showed a temporal cause-effect relationship with manipulation. (Haldeman 1992) In addition to these cases, these authors found sixteen cases in the world literature of cauda equina syndrome following more vigorous MUA.

In view of the low incidence of this complication, Haldeman and Rubinstein conclude that “manipulation does not appear to be contraindicated in the patients with bulging or herniation. It does not appear that the rare occurrence of cauda equina syndrome would be reason to avoid such treatment.” (Haldeman 1992) Evidence of cauda equina syndrome should be considered a surgical emergency, with prompt referral to minimize the risk of permanent neurological complications.

Some of the objections to manipulation have been based on faulty biomechanical assumptions. Some researchers, such as Farfan (1970), have suggested that rotational stress (torsion) during manipulation might cause disc failure. However, Cassidy et al. (1993) have analyzed their work and subsequent evidence, and disagree for several reasons.

First, Farfan’s work shows that normal discs withstand an average of 23° of rotation before failure, degenerated discs 14°. However, the posterior facet joints in the lumbar spine only allow about 2-3° of rotation. Failure of the disc from rotational force (torsion) could only arise following fracture of the facets.

Second, when researchers experimentally load the disc in torsion, failure occurs in the form of peripheral tears in the annulus rather than prolapse or herniation.

Third, the structure of the lumbar disc is in fact very well-suited to resist rotational forces. Cassidy et al. (1993) reported that they are arranged so that “during the coupled motions of lateral bending and rotation, half of the annular fibers are placed under a tensile stress” while the others are not. The disc provides “more resistance to torsion than to other directions of force.” (Flexion actually results in more displacement and higher internal pressures in the disc than torsion.)

Cassidy et al. (1993) concluded that in general “it is hard to comprehend how the small amount of rotation introduced during side-posture manipulation could damage or irritate a healthy or herniated disc.”

Side Effects of HVLA Manipulation

The most common side effect of spinal manipulative therapy is local discomfort. Of those reporting reactions to manipulative

therapy, local discomfort appeared in 53%, fatigue in 11%, and radiating discomfort in 10%. At least one reaction was noted by 55% of 1085 patients over 4712 treatments. (Senstad 1997) These were noted as general effects of manipulative therapy, not necessarily relating specifically to manipulation for disc herniation.

As previously mentioned, careful monitoring of the patient's response to pre-manipulative positioning, manipulation, etc., should minimize the risk of complications or side effects.

FLEXION-DISTRACTION

Flexion-distraction does not fit neatly into technical definitions of manipulation or mobilization, but represents a hybrid of both. There are numerous reports of benefit for a variety of lumbar and pelvic conditions. Proponents have primarily cited mechanical theories of effect but the exact mechanisms are unknown. (Gay 2005)

For treatment parameters, see Appendix IX.

A 2005 systemic review indicated that flexion-distraction can increase intervertebral disc height, decrease disc protrusion, and reduce intradiscal pressure (Gay 2005). It is also thought that improving mobility of the motion segment may enhance imbibition of fluid and nutrients into the disc to assist healing.

A 2006 RCT (n=235) comparing flexion-distraction to an active physical therapy program (modalities, McKenzie and active exercises) for chronic LBP found improvement in both groups, but the flexion-distraction group had significantly greater relief from pain (p=0.01). Subgroup analysis of 38 patients with sciatica showed that these patients did better with flexion-distraction. Patients with chronic or moderate to severe symptoms also fared better. (Gudavalli 2006) A one year follow-up study found improvement in both groups; however, patients who received flexion-distraction had significantly lower pain scales than those who received a physical therapy exercise program (p=0.02). (Cambron 2006)

A single cadaver study demonstrated that flexion-distraction led to a 39 to 192 mmHg decrease in intradiscal pressure and 117 to 720 decrease when the disc was pre-pressured with water. (Gudavalli 1998)

In another study that included 30 chiropractic clinics, each reported on outcomes of 20 consecutive cases of LBP or sciatic pain treated with flexion-distraction. Results showed average number of days to maximum improvement as 29 and number of treatments as 12. Sixty-one percent returned to work with no further treatment needed, an additional 10% returned to work but required supportive care, and 3.5% required surgery. The study suffered from lack of detail, descriptive results and control groups. (Cox 1994)

BenEliyahu (1996), in a prospective case series (cited earlier in the manipulation section) of 16 MRI-confirmed lumbar disc herniations with neurological and root tension signs, reported clinical improvement in leg symptoms when initially treated with flexion-distraction and physiotherapy in the acute phase, and "judicious rotational manipulation" in the subacute phase.

Risk Management Issues

Data from chiropractic malpractice insurance records (2006) suggest that allegations of disc injuries are the most common cause of claims (personal communication with NCMIC). In the opinion of one author reviewing this data, these injuries appear to be related to over-aggressive or inappropriate rotational manipulation in many cases (although the terms "over aggressive" and "inappropriate" were not defined). (Jagbandhansingh 1997)

- **Clinical Tip:** In view of the relatively serious nature of disc herniations, the treating chiropractor should take special care in discussing and documenting procedures, alternatives and risks with the patient (PARQ conference).

Informing patients fully of their condition increases their active involvement in care,

and has been noted as an important step in avoiding malpractice claims.

Although cauda equina syndrome is extremely rare, the patient should be instructed to notify the clinic immediately if there is any sudden change in bladder/bowel habits or sexual function. If the symptoms are severe or rapidly progressive, they should report directly to an emergency room.

Other Treatment

- Muscle Energy Technique (MET)
- Blocking
- Long-Axis Traction
- Manual Therapy: Soft Tissue
- Neuromobilization of the Sciatic Nerve ("Flossing")

MUSCLE ENERGY TECHNIQUE (MET)

For acute patients who cannot tolerate HVLA thrust adjustments or mobilization, MET can be considered. This low force technique addresses the spine and its muscles by applying hold relax techniques. Positive responses may include temporarily decreased pain levels and increased range of motion. Like mobilization, it has never been studied as an approach to lumbar disc herniations, but the CSPE Committee agreed that it may be a reasonable alternative to manipulation or mobilization on empirical grounds. The few studies performed to date have been small, poorer quality, and focused on changes in pain and disability in acute and chronic LBP. (Lenehan 2003, Schenk 1997, Wilson 2003)

BLOCKING

As previously noted, ascertaining the position(s) that most effectively reduce the patient's leg and/or back pain is an important part of treatment. In the acute patient, or where subtle modification of manual treatment vector(s) is contemplated, the use of Sacral-Occipital Technique (SOT) blocks may be helpful.

With the patient in a prone position, blocks can be placed under the ASIS's (posterior pelvic tilt) or under the hips at the level of the greater trochanters (anterior pelvic tilt). One block at the ASIS and contralateral hip provides a small torque to the pelvis and lumbosacral area which may reduce pain. Mobilization, manual stretching, physiotherapy, and possibly flexion-distraction can be applied with the patient positioned appropriately on the blocks.

LONG-AXIS TRACTION

In most cases, long-axis traction is not recommended as a "frontline" or stand alone treatment. If used at all, it should be limited to the following situations: 1) when other conservative treatments cannot be applied, 2) as an adjunct to manipulation, flexion-distraction therapy or directional preference procedures, 3) as a final resort when other treatments have failed, or 4) perhaps for patients with who peripheralize with extension or positive XSLR.

Traction (if done alone) may have only temporary results but may be used to provide enough pain relief so that a lumbar stabilization program can progress. (Saal 1996)

Other potential indications include a history of prior benefit from traction or reduction of leg pain during a trial application.

Traction can be applied continuously or intermittently up to one-half body weight on a table with a moveable section, which slides to reduce friction. (Saunders 1983) Traction units are also available for home use and may be more practical and cost effective than daily in-office treatments.

Effectiveness

A systematic review (2007) of 24 RCT's dated through 2004 found that because of the lack of quality research to date, the reviewers could not recommend traction as a single therapy for patients with sciatica. However, it did not rule out the possibility that

traction actually may be an effective treatment. The reviewers qualified their conclusion with the caveat that: “because high-quality studies within the field are scarce, because many are underpowered, and because traction often is supplied in combination with other treatment modalities, the literature allows no firm negative conclusion that traction, in a generalized sense, is not an effective treatment for patients with LBP.” (Clarke 2007)

A Cochrane Review in 2005 also concluded that “traction is probably not effective” as a stand alone treatment on the basis of the finding that neither continuous nor intermittent traction was more effective for decreasing pain, disability, or work absence when compared to placebo, sham, or other treatments for patients with LBP with or without sciatica (Clarke 2005)

An earlier meta-analysis of pooled data from four randomized controlled trials showed some benefit of traction therapy compared with a placebo (odds ratio = 1.2) (Vroomen 2000). In one controlled trial, traction with physical therapy resulted in a greater reduction in the sizes of disc herniations than did physical therapy alone (Ozturk 2006).

More recently, Fritz (2007) conducted a small single blinded RCT comparing extension exercises and mobilization for patients with low back and leg pain with the same regimen plus traction for the first two weeks of care. Traction was on a table that could accommodate various directions (e.g., extension, flexion or lateral bending) depending on patient’s tolerance. Patients in the traction cohort reported having improved more rapidly on Oswestry questionnaires after the first two weeks. The benefit was lost at 6 weeks.

Subgroup analysis revealed that those in the traction group who responded the best were those who peripheralized with extension at the first visit or had a positive XSLR.

Vertebral axial decompression therapy (VAX-D) is an expensive, aggressively marketed form of spinal traction that is popular among some practitioners. Claims regarding efficacy of VAX-D rely on a single randomized clinical trial. This study demonstrated >50% relief of chronic low-back and leg pain in 68.4% of patients treated with VAX-D therapy compared with 0% of patients treated with transcutaneous electrical stimulation (Sherry 2001).

This study, in which one of the authors was the medical director for a VAX-D manufacturer, has been criticized for potential conflict of interest (Clarke 2007), small sample size (44 subjects), ineffective randomization and lack of blinding (Daniel 2007). A 2007 critique of the literature and claims about spinal decompression therapy found: "Only limited evidence is available to warrant the routine use of nonsurgical spinal decompression, particularly when many other well investigated, less expensive alternatives are available." (Daniel 2007)

Individual studies have on occasion supported the use of traction, but have been criticized for design flaws. One study of 143 patients with radicular symptoms receiving 45 kg of continuous traction for 30 minutes daily for up to 6 weeks, found that improvement in pain relief compared to controls reached borderline statistical significance. (Mathews 1988)

Another study used CT to investigate the effect of 45 kg of continuous traction on 30 patients with lumbar disc herniation. In 21 patients, the herniated nuclear material had retracted during traction. Global clinical assessment showed improvement in 28 patients; however, there were no comparison or control groups. It was also noted that traction was more effective on median and posterolateral herniations and not very effective on lateral herniations. (Onel 1989)

A study that included ten subjects showed that traction using 30% and 60% of body weight was effective for increasing SLR motion. (Meszaros 2000)

Some investigators have suggested that traction may be more effective when combined with manipulation. (Blomberg 1994, Lesiak 1992)

MANUAL THERAPY: SOFT TISSUE

Muscle spasm, trigger points, and change in muscle tone may all accompany a lumbar disc herniation. Therapy directed at the soft tissue may be useful in controlling symptoms and critical in restoring adequate mechanics. To reduce pain and spasm, paralumbar and gluteus maximus digital compression or other trigger point therapy may be used.

As the acute phase resolves, the practitioner may progress, as tolerated, to deeper and more vigorous techniques.

Hamstrings, piriformis, low back extensors and TFL may at some point require either muscle relaxation techniques such as post-isometric relaxation or more vigorous stretching techniques.

NEUROMOBILIZATION OF THE SCIATIC NERVE ("FLOSSING")

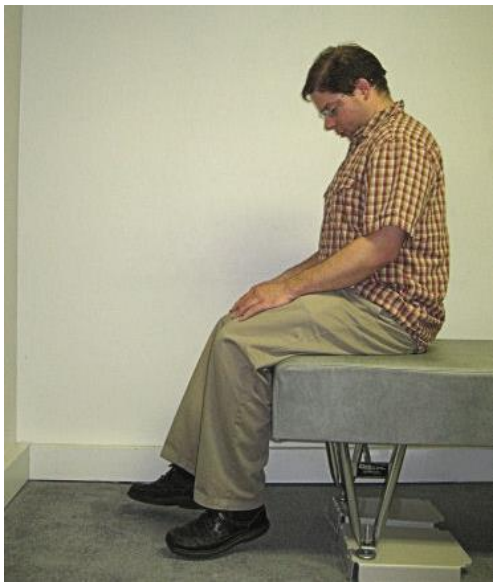
Patients with chronic sciatica may benefit from a procedure that creates an alternating tensile load at each end of the nerve-cord complex. This "flossing" technique may not be appropriate for patients with acute sciatica.

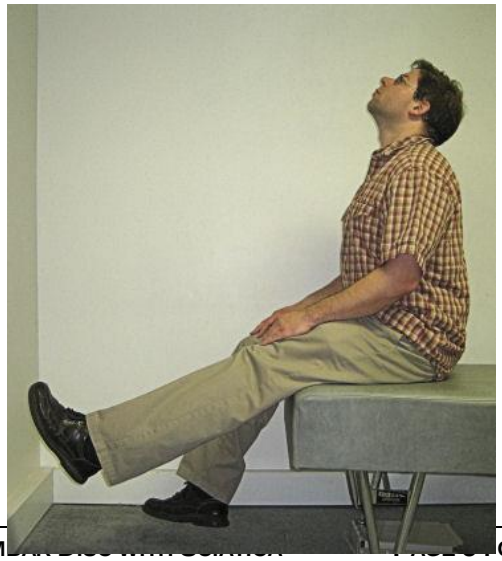
The patient sits at end of a chair or bench and flexes his/her neck forward with the legs relaxed (creating a cephalad load on the nervous system). The symptomatic leg is then extended straight out as the neck is extended backwards (creating a caudad load). This motion is repeated 10 times in a smooth coordinated fashion. (See photos to right.)

If the sciatica is mildly aggravated by the neck flexion or leg extension, the motion should be limited to just within a pain-free range.

McGill (2007) has the following recommendations:

- If any exercise has already been identified that centralizes the symptoms, it should be performed first.
- During the nerve mobilization, there are two options regarding how the patient's thoracolumbar spine is pre-positioned. The patient can hold the spine in a "safe" neutral pelvis pose or can adopt a position that has been previously found to be beneficial. For example, the patient's patellar reflex can be tested with the patient sitting in extension, then in forward flexion. If one position improves the stretch reflex, the thoracolumbar spine can be held in that position during the neuromobilization exercise.
- The motion should be performed at a slow, coordinated pace (about 5 seconds for one cycle).
- The practitioner should first carefully monitor





the patient in the office. The patient should monitor his/her response to the treatment throughout the following day. If there is no adverse reaction, the patient can perform 10 repetitions 3-4 times a day. If symptoms are exacerbated between sets, the exercise should be discontinued.

- Some patients may be made worse by this exercise so patient response needs to be cautiously monitored.

Those who respond with symptom improvement are reported to do so within a few days to 2 weeks.

Rationale

Theoretically, this procedure produces a "gliding" motion or load on the nerve helping to release any impingements and reduce possible adhesions at the nerve root or along its course. This theory has never been validated. The rationale for applying this procedure is based on biomechanical plausibility, expert opinion (Butler 1999, McGill 2007, Murphy 2006) and inclusion as part of a management plan in a small pragmatic trial (Murphy 2006).

(Consult the CSPE care pathway: Shoulder Impingement Syndrome, Pp. 41-44, for a more complete discussion of all of these soft tissue techniques.)

Physical Therapy Modalities*

NOTE: In this section, physical therapy modalities refer to the application of hot and cold, various electrical modalities (e.g., TENs, interferential, ultrasound) and low level laser therapy.

For specific parameters of the various modalities, see CSPE protocol, Physical Therapy Modalities.

Since 1994, several guidelines for the treatment of LBP have been published. These have included extensive literature reviews and evaluations of clinical evidence.

* Many of the basic principles outlined this section were drawn from Gersh 1992, Hooper 1996, Jaskoviak 1993, Michlovitz 1990.

Typical examples include the *AHCPR Guidelines, New Zealand Acute Low Back Pain Guideline* and Danish *Low Back Pain Guidelines.* (For several references see Koes 2001). An extensive literature review can be found in the 2007 Guideline from the American College of Physicians (ACP) and the American Pain Society (Chou 2007). Practice guidelines have been consistent in finding little or no evidence for the efficacy of passive therapy modalities for LBP or sciatica. The 1994 AHCPR guidelines, for example, conclude that "No well designed controlled trials support the use of physical agents and modalities as treatments for acute low back problems. However, some patients with acute low back problems appear to have temporary relief with physical agents and modalities." In contrast, recommendations for other therapies, such as manipulation and exercise, can be made with a greater level of certainty.

Health care practitioners, including chiropractors, commonly use physical therapy modalities in patient care despite an insubstantial evidence base. According to the Job Analysis of Chiropractic (Christensen 2005), 66% of chiropractors use ultrasound, 77% use electrical stimulation and 80% use traction. These figures illustrate the large gap between evidence and practice. This gap results from the high costs and substantial challenges inherent in conducting high quality clinical trials on the one hand and the pragmatic realities of daily patient care on the other.

In considering the application of modalities in patients specifically with sciatica, the CSPE Committee has considered available evidence and integrated it, where possible, with generally accepted practices.

Hundreds of clinical trials have evaluated conservative care for patients with back pain but only a small number have been focused on patients with sciatica. Some conclusions in clinical guidelines and systematic reviews are based on trials of patients with a combination of back pain and sciatica, but in many cases patients with sciatica were specifically excluded. In many cases, it is

unclear if treatments for LBP can be expected to have similar effects in patients with sciatica (manipulation and exercise therapies seem to have similar efficacy in the presence or absence of leg pain) (Assendelft 2003). The following considerations of physical therapy modalities take the position that treatments for LBP patients can usually be generalized to sciatica patients.
The application of physiotherapeutic modalities for treatment of lumbar herniated intervertebral disc syndrome follows the same general principles for soft tissue trauma. In the acute phase, therapy is directed to reducing pain and muscle spasm. (Kibler 1998) This should allow an early return to limited activity.

NOTE: In the subacute phase, the patient should be weaned from any of these passive physical therapy modalities if they have been used at all.

For patients who are in the subacute or chronic pain phase, active exercises are more appropriate than passive modalities (Rhee 2006). These modalities are then primarily used to control symptoms during flare-ups with the purpose of having the patient more fully engage in the active care program and overall increased activity. In the rehabilitation phase, the goals and use of physiotherapy are the same as in the subacute phase—to minimize symptoms in order for the patient to continue with active care.

CRYOTHERAPY

Cold packs are used to reduce pain, inflammation and edema in the acute and subacute phases, as well as for pain reduction in the chronic phase and with flare-ups.

Cryokinetics combines the use of cryotherapy and exercise to provide analgesia while performing range of motion or other exercises in order to promote early return to activity.

Effectiveness

A 2006 Cochrane review (last updated in October 2005) could not find sufficient evidence to make any definitive statement regarding cryotherapy relative to LBP or sciatica. There were no studies that compared cold to placebo. Only two non-randomized studies were reported comparing cryotherapy to hot packs. One study found no difference. The other found ice massage superior in chronic LBP. (French 2006)

SUPERFICIAL HEAT

Heat wraps and hot moist packs can help reduce pain and muscle spasm and are best utilized during the subacute and rehabilitation phases.

Heat wraps can be worn for up to eight hours and may be used prior to and during therapeutic exercise. Heat wraps should not be used with pain rubs, medicated lotions, creams or ointments; on unhealthy, damaged or broken skin; on areas of bruising or swelling that have occurred within 48 hours; or with other forms of heat. Caution should be exercised with patients who have diabetes, heart disease, rheumatoid arthritis and/or are pregnant.

Effectiveness

In a 2007 evidence review for the ACP and the Pain Society, Chou reported that the Cochrane review found consistent evidence from five higher-quality trials that heat wrap was moderately superior to placebo, a nonheated blanket, oral acetaminophen or ibuprofen, or an educational booklet for LBP. Benefits were short term (3-7 days). Superficial heat has more supportive evidence than most of the other passive modalities in this section of the care pathway.

SHORT-WAVE DIATHERMY

Diathermy may also be used for pain control, but the evidence is not strong. Some practitioners use diathermy during the rehabilitation phase to soften scar tissue and

adhesions and promote tissue healing by direct heating effects.

Effectiveness

In a 2007 evidence review for the ACP and the Pain Society, Chou et al. found no systematic reviews. Three small, lower-quality trials met inclusion criteria. These studies had mixed results, showing diathermy to be inferior to manipulation in acute patients with LBP while, paradoxically, having an effect equal to sham treatment, manipulation and extension exercises in chronic patients.

CONTRAST THERAPY

Contrast therapy may be used in the subacute phase to aid in flushing inflammatory exudates. Optimal circulatory effects are achieved if gentle active range of motion is performed while receiving the therapy.

- **Clinical Tip:** Recent evidence shows that the traditional way of doing contrast therapy (called "passive" contrast therapy) provides the vascular pumping only in the superficial tissues. Instead, it is recommended that while patients are receiving the hot and cold, they actively contract their muscles. This muscle pumping has a greater (deeper) effect on edema, venous return and lymphatic fluid. This is referred to as "active" contrast therapy.

HIGH VOLT THERAPY (HIGH VOLTAGE PULSED DIRECT CURRENT)

Treatment indications include reducing pain, muscle spasm and edema. For radicular pain, the active electrodes can be placed both centrally over the nerve root or sciatic notch and peripherally along the distribution of the affected nerve.

LOW VOLT THERAPY: DIRECT CURRENT (LOW VOLT GALVANISM)

Iontophoresis of certain substances may be useful, particularly during the acute and subacute phases. It is uncertain as to whether these substances will effectively penetrate to the depth of target tissues such as the nerve root or disc to provide anti-inflammatory or edema-reducing effects. Hydrocortisone 0.5% cream has anti-inflammatory effects; magnesium sulfate 2% solution reduces pain and muscle spasm; sodium salicylate 2% solution reduces pain and edema; Xylocaine 5% ointment reduces pain. To find details of application, see CSPE protocol, Physical Therapy Modalities.

SINE WAVE STIMULATOR (ELECTRICAL MUSCLE STIMULATION: LOW FREQUENCY ALTERNATING CURRENT)

Sine wave application may reduce pain and muscle spasm.

LOW LEVEL LASER THERAPY (LLLT, COLD LASER)

LLLT may be used to reduce pain, inflammation, edema and contribute to tissue healing. Laser application can be over the level of the involved segment or peripherally along the distribution of the affected nerve. There is some thought that steroid injections within the prior 72 hours or use of oral anti-inflammatory medication may potentially decrease the effectiveness of LLLT. Consider reducing or discontinuing anti-inflammatory medications when utilizing LLLT.

Effectiveness

The ACP and Pain Society 2007 evidence review found no systematic reviews on the effectiveness of LLLT. Individual trials that met the inclusion criteria were small (20 to 120 patients with LBP), used different types of lasers, different dosages, and monitored different outcome measures. No studies specifically assessed treating patients with sciatica.

For chronic LBP or back pain of unspecified duration, 3 higher-quality trials and one lower-quality trial demonstrated that laser therapy was superior to sham for pain improvement or functional status up to one year follow-up. Another lower-quality trial

reported similar outcomes in pain control or in back-specific functional status for patients treated with laser compared to exercise or both treatments in combination.

INTERFERENTIAL CURRENT THERAPY

Interferential current therapy is used primarily to control pain and muscle spasm.

Quadripolar technique is useful for reducing pain and edema due to deeper penetration of the medium frequency currents. Electrodes are crisscrossed above and below the affected spinal level(s) or the electrodes can be placed more centrally over the nerve root or sciatic notch and peripherally along the distribution of the affected nerve.

Bipolar technique can be applied unilaterally or bilaterally (one or two channels) for reducing paraspinal muscle spasm or edema. It can also be used for nerve conduction block (4000 Hz) with central and peripheral electrode placement.

Effectiveness

In a 2007 evidence review for the ACP and the Pain Society, Chou et al. found no systematic reviews. Three RCTs (Hurley 2001, Hurley 2004, Werners 1999) met the inclusion criteria evaluating the effects of interferential therapy compared to manipulation, traction or a self-care booklet for LBP.

In these trials, all of the treatment groups showed improvement and there were no clear differences between interferential therapy and either spinal manipulation or traction for subacute or chronic back pain. A lower-quality trial (Hurley 2001) (with two apparently dissimilar treatment wings) found interferential therapy to be initially superior to a self-care booklet in terms of improvement measured by a Roland Morris questionnaire. There were, however, large baseline differences between the groups. At three months, outcomes were similar.

In another of these trials (Hurley 2004), 240 acute LBP patients with and without leg pain were randomized to one of three treatment arms: combined manipulative therapy and interferential therapy, manipulative therapy alone, or interferential therapy alone.

All three groups had significantly reduced functional disability levels and the effects persisted at 6 and 12 months.

TENS

TENS units are used to reduce pain. Many clinicians find anecdotally that some patients find short-term pain relief and this modality is still often used based on individual patient response.

High Rate (Conventional) and Low Rate (Acupuncture-like) modes can be tried first. Burst and modulated modes may help minimize the tendency for accommodation to the electrical stimulation with consequent reduction of analgesia, particularly with longer application times. Four electrodes can be crisscrossed above and below the affected spinal level(s), placed centrally and peripherally along the distribution of the affected nerve or over acupuncture, trigger or motor points. TENS can be used several times a day for 20 minutes to several hours per use. TENS may also be used to provide short-term pain relief during extended exercise, perhaps improving the patient's ability to perform the activity. (JointLetter 1997)

Effectiveness

AHCPR guidelines (1994) state that "TENS is not recommended in the treatment of patients with acute low back pain problems."

A study of 350 chronic low back patients reported in 1997 also failed to find outcomes differing among four TENS treatment groups, including a sham. The author, however, did indicate that he had observed some benefit in terms of decreased pain and improved activity when used *during* a one-hour exercise regimen. (Jarzem 1997)

More recently, a 2007 evidence review by the ACP and the Pain Society published the

following analysis. For subacute LBP, one higher-quality trial found TENS moderately inferior to spinal manipulation. For chronic LBP, the Cochrane review included one lower-quality trial that found TENS superior to placebo, but a larger, higher-quality trial found no differences between TENS and sham TENS for any measured outcome. One higher-quality trial found TENS superior to superficial massage. Evidence from single, lower-quality trials is insufficient to accurately judge efficacy of TENS versus other interventions for chronic or acute LBP.

MICROCURRENT

Application of microcurrent may reduce pain. Tissue healing and edema-reducing effects are probably too attenuated to affect the deeper target tissues. Application via electrodes rather than with probes may be more effective. Portable microcurrent units can be worn for several hours (4-6) repeated several times a day.

ULTRASOUND (US)

In general low back conditions, ultrasound has been used to reduce inflammation, edema and pain. It is purported to aid in tissue repair by increasing circulation, dispersing inflammatory exudates, and providing deep heating effects.

Pulsed mode is best used during acute and early subacute phases to minimize heating effects. Continuous mode is best during the late subacute and rehabilitative phases to enhance deep heating, which helps reduce and soften scar tissue and adhesions.

Phonophoresis can be used to drive in one of the following medicinal substances: Hydrocortisone 1% ointment has anti-inflammatory effects; lidocaine 5% ointment has analgesic effects; salicylate 10% ointment (Myoflex) has both anti-inflammatory and analgesic effects.

NOTE: Ultrasound may be used in combination with EMS therapy. The dispersive pad is placed adjacent and, where appropriate, proximal to the treatment area. See parameters for US and EMS therapy in the CSPE protocol, Physical Therapy Modalities.

Effectiveness

The ACP and the American Pain Society Guideline (2007) reported methodological flaws and inconsistent results in the literature for ultrasound in the treatment of back pain and sciatica.

For acute sciatica, one nonrandomized trial (73 patients) found therapeutic ultrasound superior to sham ultrasonography or analgesics for pain relief.

No systematic reviews of therapeutic ultrasound were found for LBP. From 265 potentially relevant citations, three lower-quality trials met inclusion criteria. For chronic LBP or LBP of unspecified duration, two small (10 and 36 patients, respectively) trials reported inconsistent results for therapeutic versus sham ultrasound, with the larger trial reporting no differences.

Although at least one study found benefit, ultrasound, if used, should be applied with caution as it has also been reported that it can aggravate a radiculopathy. A 1989 case report documents in which two patients with lumbar disc herniation were given ultrasound over the lumbar paraspinal region, and this led to a transient increase in pain in a radicular pattern. (Gnatz 1989)

Rehabilitation Procedures

Practitioners may use a combination of lumbar stabilization exercises, directional preference protocols, and sensory motor (balance) training.

In general, active exercises are more appropriate than passive physical therapy modalities, particularly for patients with subacute or chronic LBP (Chou 2007, Saal 1996). Stabilization exercise programs

specifically for sciatica have not been evaluated by RCTs.

WSCC Rehabilitation "Menu"

- Neutral pelvis, hip hinge, abdominal bracing
- Directional preference exercises
- Posture and breath training
- Return to activity
- Floor exercises to re-program stability (quadruped, dead bug, side-bridge)
- Weight-bearing exercises (lunge, squat)
- Muscle balance exercises (stretches, activation)
- Proprioceptive training

See CSPE protocol, Low Back Rehabilitation Program, for specific details.

A formal rehabilitation program can take as long as 8-12 weeks (Saal 1992). The complete program should be employed as much as possible, starting with an emphasis on motor control and building toward assertive endurance and balance training. This is particularly true for patients with more severe symptoms, chronic or recurrent presentations, or who return to significant work demands.

This program should be instituted on the first day by helping the patient find a pain free, neutral pelvis. The patient should then be shown abdominal bracing and hip hinging, especially during transition movements (e.g., transition from standing to lying).

When the symptoms begin to centralize, the rest of the stabilization tracks may be employed.

- **Clinical Tip:** If curl-ups are introduced at some point, the patient should not hold a posterior pelvic tilt because of the possible injurious load it could place on the disc fibers. (McGill 1998)

As patients recover, it may be useful to monitor lingering proximal muscle dysfunction (e.g., gluteal muscles) by assessing their ability to perform the single- leg stand and single-leg bridge, noting fatigue and/or poor motor control. (Millisdotter 2003)

POST-SURGICAL REHABILITATION

A 2006 Cochrane systematic review stated that there is no evidence that patients need to have their activities restricted after their first lumbar disc surgery. There was strong evidence that intensive exercise programs started 4-6 weeks after surgery were more effective on functional status and there was a faster return to work with no increased rate of re-operation when compared to mild exercise. (Ostelo 2002)

DIRECTIONAL PREFERENCE PROTOCOLS

The most common directional preference is repetitive or sustained extension. However, patients' symptoms may also centralize with rotation or flexion. To perform an adequate assessment and for specific details, see CSPE protocol, Directional Preference Protocol for Centralizing Low Back and Leg Pain.

Patients whose pain centralizes with repetitive extension will usually do so in the initial visits or within the first three days of presenting to the practitioner. (Donelson 1990, Kopp 1986)

Dietary Considerations, Botanical and Nutritional Supplements

In the acute phase, consider advising use of non-constipating/non-gaseous foods and stool softener.

During the acute phase, pain and inflammation may be treated with proteolytic enzymes. In several small, older studies, treatment of lumbar disc prolapse patients with trypsin-chymotrypsin resulted in greater symptom reduction, improved straight-leg raising and decreased intake of analgesics compared to placebo (Gaspardi 1971, Gibson 1975).

A 2007 Cochrane review identified a number of botanical agents that have been studied as palliative treatments for LBP. Devil's claw (*Harpagophytum procumbens*) extracts

standardized to 50-100 mg/day of harpagosides reduce pain and dependence on pharmaceutical analgesics. Similar evidence has been reported for willow bark (*Salix alba*) extracts standardized to 120-240 mg salicin. Topical plasters containing oleoresin extracts of cayenne (*Capsicum sp.*), applied for 4-12 hours per day, have also reduced pain as well as disability measures. (Gagnier 2007) In each of these cases, patients with sciatica were not specifically studied.

During the rehabilitation phase, nutritional supplementation may also be of use. (See CSPE protocol, Trauma: Diet, Nutritional Supplements and Botanical Considerations.)

OTC Medications

The evidence regarding pain relief medications for lumbar radiculopathy/sciatica is either sparse or generally negative, especially for medications available over the counter. One meta-analysis of the literature (Vroomen 2000) demonstrated that NSAIDs had no benefit in the treatment of radiculopathy compared with controls (odds ratio = 0.99). A 2007 systematic review of systematic reviews for the American College of Physicians and the Pain Society resulted in no recommendations relative to NSAIDs or acetaminophen in the treatment of LBP with sciatica because of what was judged to be insufficient data.

The same 2007 review *did* find consistent, fair to good quality evidence supporting the use of NSAIDs or acetaminophen for acute and chronic LBP. Acetaminophen appears as though it may not be quite as effective as NSAIDs for pain control (based on studying patients with osteoarthritis), but has a generally more favorable safety profile. Chronically high doses of acetaminophen may cause hepatic toxicity. Chronic heavy alcohol abusers in particular may be at increased risk of liver toxicity from excessive acetaminophen use. Less is known about short-term effects. When used in chronic LBP patients for 4 weeks, the only side effects reported were increased asymptomatic liver function tests. (Chou 2007)

- **Clinical Tip:** If the practitioner decides to attempt a therapeutic trial with an OTC, acetaminophen is a reasonable first choice. (Chou 2007) Analgesics should be prescribed at regular intervals, not on an "as needed" basis.

CLINICAL WARNING! Because acetaminophen is also an ingredient in many other OTC medications, it is important to survey the patient's total intake so as not to exceed recommended doses.

Acetaminophen doses

Ages 0-12 yrs: 15 mg/kg every 4 hours (not to exceed adult dose) with a maximum of 5 doses.

Ages 12 yrs and older: 325-650 mg every 4 hours with a maximum dose of 4000mg.

If pain is more severe or the analgesic fails, an NSAID may be the next choice, weighing the potential gastrointestinal, renal and cardiac risks to a particular patient.

Ibuprofen (Motrin, Advil) doses

Ages 6 mos-12 yrs: 10 mg/kg every 6 hours (not to exceed adult dose) with a maximum of 4 doses.

Ages 12 yrs and older: 200-400 mg every 6 hours with a maximum dose of 1200mg.

For more information, see CSPE protocol, NSAIDs—Use of Over-the-Counter Nonsteroidal Anti-Inflammatory Drugs and Analgesics. In addition, note that patients using ibuprofen or naproxen have been associated with double the risk of developing acute urinary retention, potentially mimicking the evolution of a cauda equine syndrome (Verhamme 2005).

In the event of continued poor pain control, referral for prescription medications or corticosteroid injection is an option, although many of these options are either of questionable effectiveness or have limited evidence supporting their use. (See Prescription Medications, Pp. 70-74.)

Self-Care Advice

ACUTE PHASE

SUMMARY

- Limit bed rest
- Short-term use of back belt (optional)
- Modify activities (sitting, side lying, aggravating loads)
- Crutches (optional)

Bed rest

There is no evidence that bed rest alters the natural history of lumbar disc herniations or improves outcomes.

> ➢ **Clinical Tip:** Due to its potentially harmful effects, bed rest should be short term only. Active rest is preferable (i.e., bouts of activity which still manage to protect the back and may be punctuated with periods of rest). Normal activities should resume as soon as possible. (Hagen 2000)

One study has shown that bed rest is no more effective than watchful waiting for patients with lumbosacral radicular syndromes. (Vroomen$_b$ 1999) Likewise, a Cochrane review indicated that it is reasonable to advise patients with sciatica to stay active because there is not a significant difference in outcomes between staying active and bed rest and because there are potential harmful effects of prolonged bed rest. (Hagen 2002) In a 1999 study, patients with disc herniations and sciatica who remained cautiously active had the same outcomes as those who spent two weeks in bed (Vroomen$_b$ 1999). Another study found that bed rest for 2-7 days was actually worse than placebo or ordinary activity and is not as effective as alternative treatments for relief of pain, rate of recovery, and return to daily activities and work (Waddell 1996).

If a patient has severe pain that improves with bed rest, a few days of bed rest may be palliative (Weber 1994). In patients with sciatica, but no neurologic deficits, bed rest should not exceed two days. Bed rest should be considered the consequence of pain, not a treatment. By the third day of symptoms, most patients even with severe sciatica are able to stand and walk for short periods. Within the first week, a goal would be work up to a 20-minute walk for every 3 hours spent supine. (Deyo 1990)

Back belts

Some practitioners find that a short-term application of a back support may help select patients through the acute phase. The Cochrane review found "limited" evidence favoring lumbar supports compared with no treatment (van Tulder 2001, 2003). However, these devices have been shown not to be effective for primary prevention of low back injuries. Whether they play a role in secondary prevention of LBP is still controversial. (BackLetter 2007)

Modify activities

Sitting. Avoid sitting in the initial acute phase. This recommendation includes avoiding sitting in bed to watch television (Deyo 1990). Sitting can then be gradually re-introduced (e.g., no more than 20 minutes at first), then no more than an hour without getting up. Chairs with arm supports are preferred. (Kibler 1998) A lumbar roll or back support can also be placed in the chair.

In addition, it may be useful in the acute or subacute phase to instruct patients how to maintain a pain-free position when they are sitting. Strategies include sitting on the ischial tuberosities, maintaining neutral pelvis and supporting the lumbar spine. As always, the patient should be monitored to be sure that none of these recommendations result in peripheralization of symptoms.

Side-lying. In the acute phase, avoid side-lying since this elevates disc pressure, (White 1996) unless the patient gets obvious symptomatic relief from this position.

> ➢ **Clinical Tip:** A common recommendation is to lie with knees bent and a pillow between the legs.

Other strategies

A variety of other interventions can be employed during the acute phase. These include helping the patient learn how to avoid positions that peripheralize their symptoms (e.g., these are often flexion positions) and the temporary use of crutches if pain is severe.

SUBACUTE PHASE

Teach proper lifting

Teach the patient biomechanically sound methods to lift objects.

- Do not lift immediately after prolonged flexion, sitting or stooping, or rising from bed (because of hysteresis* or high discal pressure).
- Lightly co-contract abdominal and back muscles before and during lifting.
- Maintain proper lordosis, hip hinge.
- Keep the load as close to the body as possible (maintaining spinal lordosis).
- Avoid twisting in a flexed position.
- Keep the weight as centered as possible.

If possible, patients should avoid frequent lifting (25 times/day) or heavy lifting (approximately 25 lbs/11.3 kg or more) (White 1996). McGill (1993) recommends that patients with disc injuries should avoid heavy lifting for the first 6 weeks.

Encourage life-style modification

The patient should be advised on the importance of smoking cessation and physical fitness. There is little research in the realm of weight loss as a treatment for LBP (with or without sciatica), and the role it should play is controversial. However, the practitioner may in some cases wish to advise or assist the patient with weight loss program (White 1996). (See CSPE care pathway, Overweight and Obesity in Adults.)

* Hysteresis is temporary tissue deformation and loss of energy due to sustained or repetitive end-range loading.

OTHER ASPECTS OF MANAGEMENT

Clinical Endpoints and Outcome Measures

It is the policy of WSCC clinics that, whenever possible, *each* of the following outcome measurements be used to track the progress of all patients with herniated lumbar discs or sciatica of other origin. (CSPE Committee 1999)

Baselines will be established during the initial visits and will be periodically repeated at the clinical supervisor's discretion. In addition, all pertinent outcome measurements will again be charted at the time of re-exams and progress reports.

SUMMARY

When possible, all of the following are recommended:

- Neurological deficits
- Centralization/peripheralization
- Oswestry, Roland Morris or SF-36
- PSFS or any specific activity (e.g., sitting time)
- m-VAS or VAS
- Analgesic use
- SLR
- Thoracolumbar AROM
- Work status or Functional Capacity Exam (FCE)

Change in neurologic deficits, especially motor loss or atrophy

Progressive worsening of sensory, DTR and especially motor deficits can indicate poor treatment response. *Improvement* of neurological deficits, on the other hand, may lag behind pain reduction and return of functional capacity.

- **Clinical Tip:** Motor deficits should be checked every visit especially during the acute phase.

Distribution of back and leg pain (centralization vs. peripheralization)

Change in pain distribution can be monitored informally by having the patient simply point to the area of pain or can be captured by a *pain drawing* at intake and monitored by serial drawings.

Questionnaires

The use of functional status questionnaires is a reliable, valid and relevant method of assessing patient outcomes (Deyo 1988), and is appropriate and feasible in a clinical setting (Haas 1995). The Oswestry, the revised Oswestry (Hudson-Cook 1989), and the Roland Morris (Roland 1983) have been the most widely studied and used.

Lauridsen (2006) reported that both the Oswestry Disability Questionnaire (ODQ) and the Roland Morris Disability Questionnaire (RMDQ) are suitable for patients who present with leg pain in primary care and specialty settings.

These questionnaires have the most evidence for being responsive to change in the patient's status (Beurskens 1995). The RMDQ tends to be more sensitive than the ODQ in detecting change when patients have a lesser degree of disability, but seems less sensitive when there is more severe disability. (Baker 1989)

A shortened version of the RMDQ (12 items versus 23 items) has been shown to perform extremely well in comparison to the original. (Atlas 2003)

NOTE: The minimally clinically important difference (MCID) for Oswestry is 4-6 points and for Roland Morris is 3-5 points. (Liebenson 2007)

Analysis of longitudinal data from 970 patients found that the SF-36 was more responsive than the Oswestry for reporting improvement or worsening of pain, for patients with co-morbidities, and for patients with low baseline function. The SF-36 scales that assess pain were statistically superior to the SF-36 scales measuring function. (Walsh 2003)

PSFS

Although the Patient Specific Functional Scale has not been validated specifically for patients with sciatica, the committee recommends that it be used. It has been validated for neck pain, cervical radiculopathy, LBP and knee pain. For references and more information, see CSPE protocol, Patient Specific Functional Scale.

m-VAS or VAS for pain

Visual analog scales (VAS) are widely used and accepted in the measurement of pain. (McDowell 1987) The VAS or mVAS can be included as part of the functional status questionnaire.

Change in quantity/dose of analgesics

Decreasing dependence on pain medications is both a goal and a useful method for monitoring improvement. The type of medication, dose and frequency should be established at baseline.

Straight-leg raise (SLR)

It is important to record both the distance that the pain/paresthesia radiates during the test and the angle the hip is at when the symptoms are reproduced. Other parameters that may be recorded are the quality and severity of the pain (using a verbal pain scale).

- **Clinical Note:** For Worker's Compensation cases, an inclinometer should be used.

Thoracolumbar AROM

Although studies have not specifically addressed how responsive this measurement is in reflecting improvement, reduced sagittal range of motion has been cited as one of the more consistent findings in lumbar disc herniations (Vroomen 2002). A variety of methods can be used to measure active range of motion. Measuring the distance of the fingertips to the floor (FFD) with the patient in full flexion has been recommended as an acceptable method. (Vroomen 2002)

- **Clinical Note:** For Oregon Worker's Compensation cases, on the other hand, an inclinometer must be used to measure ranges of motion of the spine for workers who are medically stationary. (Bulletin 239 (rev). Worker's Compensation Division. Oregon Department of Consumer and Business Services 1998)

Work status or Functional Capacity Exam (FCE)

As a patient moves into the subacute and rehabilitative phases, a series of functional baselines can be established by performing a FCE (i.e., establishing a flexion-extension endurance ratio, side-lying endurance, ability to perform a single-leg stand and single-leg bridge, etc). See Appendix X for a sample of the exam form used at WSCC for assessing functional capacity.

Other findings

A variety of other exam findings may also be monitored to guide treatment such as tissue tenderness (using the clinic's tenderness grading system or an algometer), number and degree of joint restrictions, ability to perform certain exercises, single-leg stand, single-leg bridge, etc. These can be chosen on a patient-to-patient basis at the discretion of the intern and the clinical supervisor and may change throughout the phases of care.

Indications for work release

Limited duty: restrict from lifting, climbing, squatting and strenuous physical activity during the initial acute phase. (White 1996) Keeping patients out of work longer than three months rarely improves recovery.

Indications for Surgical Referral or Consultation

The decision to refer for surgical consult can occur at several different critical junctures in the course of management: at the end of the initial work up, during the first few weeks based on the patient's initial response, and then again after 2-3 months of care based on whether the patient appears to be returning to pre-injury status. It should also be considered at *any* time there are progressive neurological deficits, especially motor. Referral is dependent on whether there are relative or absolute/strong indications for a surgical consult and, of course, on the patient's wishes and needs.

It is estimated that only 5-10% of patients with persistent sciatica will require surgery (Frymoyer 1988). Actual practice profiles, unfortunately, do not reflect a set of commonly agreed upon criteria as to who should be a surgical case. Rhee (2006) reports 5 to 15 fold variations in the rates of lumbar surgery in geographically adjacent areas, reflecting "radical heterogeneity in the application of surgical criteria to this diagnosis." The literature, on the other hand, does provide some reasonable guidance.

The 2007 Cochrane review of surgical interventions for disc herniation concluded that the main indication for surgery is to provide more rapid relief of pain and disability in the minority of patients whose recovery from natural history or under conservative care is judged to be too slow. (Gibson 2007) It is also indicated in those more rare cases where *immediate* nerve root decompression is necessary.

Except for a few urgent situations (e.g., cauda equina syndrome), there is insufficient evidence to indicate the optimal timing of surgery. Evidence does suggest that delaying surgery for a trial of conservative care does not create any long-term harm. (Gibson 1999, 2007) Peul, a lead researcher in a

2007 RCT comparing surgical to nonsurgical care, suggested that surgery might even be delayed 3-6 months. (BackLetter 2007)

Absolute/Strong Indicators

- Cauda equina syndrome
- Progressive deficits (especially motor)
- Myelopathy

The incidence of cauda equina syndrome in a chiropractic setting is unknown, but is likely rare (e.g., perhaps a typical chiropractor in a typical practice setting might see 0-2 in a career based on estimates of the CSPE committee). However, it is considered an absolute indication for an urgent surgical consult. If the symptoms have come on rapidly, an emergent referral should be made.

NOTE: The best prognosis is thought to be for surgical intervention within 48 hours of the onset of the urinary symptom component of the syndrome.

Progressive muscle weakness while under care during any phase of treatment (acute, subacute or rehabilitation) always demands a consultation. (AHCPR 1994)

Evidence of spinal cord compression (e.g., signs of an UMNL) associated with upper lumbar disc herniations should also trigger prompt referral for a surgical consult. The degree of cord compromise and disability may be a factor in whether conservative care could be continued in lieu of surgery.

Relative Indicators

- Severe radicular pain
- Underlying stenosis
- Acute onset of severe muscle weakness/atrophy

In many cases, even for patients with a relative indication for surgery, conservative care should first be attempted for approximately 2-3 months. (Postacchini 1996) In the absence of cauda equina syndrome or progressive weakness, the best indication for surgical management is severe refractory radicular pain. A 2007 RCT comparing surgical to nonsurgical treatment found that for patients with severe sciatica of 6-12 weeks duration, surgery produced more rapid patient perception of recovery and relief of sciatica. (Peul 2007) In such cases, a decision for referral may be based on the patient's unwillingness to cope with the leg pain or his/her desire to potentially accelerate recovery. However, in the aforementioned study, withholding surgery until a course of conservative care failed did not reduce the chances for complete recovery at 12 months. (Peul 2007)

Another relative indication for surgery is a disc herniation complicated by underlying spinal canal stenosis. Again, a trial period of conservative care is usually reasonable (Postacchini 1996). Because an MRI is usually not indicated in the initial work up of a suspected lumbar disc herniation, the presence of stenosis may not be known initially.

Some practitioners may also choose to get a surgical consult for patients with acute onset of grade 3 (or worse) muscle weakness.

Disputed Indicators

- Uncontained disc (extrusion or sequestration)

There is some controversy whether an uncontained disc herniation is, in itself, an indication for surgery. Takui (2001) reported that treating patients who had uncontained disc herniations for two months using conservative care reduced the need for surgery. Postacchini (1996) cites an extrusion as a relative indicator, but also recommends a therapeutic trial of conservative care first. Peul (2007), on the other hand, reported no difference between surgical and nonsurgical outcomes for patients with sequestered discs, making surgery an option as opposed to a necessity.

Non Indicators

- Size of herniation
- Stable neurological deficits

Contrary to popular opinion, the absolute size of a disc herniation does not appear to

correlate with the need for eventual surgical intervention. Large extruded herniations tend to resolve more predictably than smaller herniations (Rhee 2006). *However, the ratio of herniation size to the spinal canal size may be a relative indicator (see relative risks above).*

Neurological deficits presenting at the first visit, if stable, do not necessitate a surgical intervention. A possible exception would be grade 3 motor weakness of rapid onset. The ultimate resolution of motor and sensory deficits is similar following either conservative or surgical management, although there is some evidence that they resolve faster with surgery (Rhee 2006). Hakelius (1970) did not find a significant advantage to surgical treatment of patients with stable motor deficits (excluding those with cauda equina syndrome). Forty-five percent of such patients improved with nonoperative treatment and 53% after surgery. (Rhee 2006)

Effectiveness

"There is a dearth of level-1 evidence comparing surgical with nonsurgical management of lumbar disc herniations." (Rhee 2006).*

Overall, discectomy appears to be a safe and well-tolerated surgical procedure. Current surgical techniques for HLD are much less invasive than in the past, and have significantly fewer complications than other spinal surgeries such as instrumented and non-instrumented fusion procedures.

Open discectomy and microdiscectomy are the most studied and most practiced surgical techniques for HLD. In many cases, a discectomy is an outpatient surgery that takes about one hour and recovery after an uncomplicated discectomy may only take two weeks (Carragee$_a$ 2006).

The comparative effectiveness of various surgical techniques to each other was reported in a Cochrane systematic review (2007) which concluded that microdiscectomy offered generally similar results compared to traditional open discectomy. Studies of automated percutaneous discectomy and laser discectomy have to date been inferior to microdiscectomy. The review found insufficient evidence to assess the effectiveness of intradiscal electrotherapy, coblation or arthroscopic discectomy.

Short-Term Results (less that one year)

Overall, the current evidence suggests that surgery may be faster than a variety of nonsurgical interventions in resolving leg pain. There does not seem to be any added advantage when comparing longer term outcomes relative to pain, neurological status or function.

The 2007 Cochrane review of surgical treatments for lumbar disc herniations suggested that carefully selected patients appear to experience faster relief from the acute attack with surgical care than with nonsurgical care. However, any positive or negative effects on the lifetime natural history of the underlying disc disease are unclear. Many of the trials had major design weaknesses which introduced considerable potential for bias. Therefore, the authors of this review suggest that conclusions should be read with caution. (Gibson 2007)

Not included in the Cochrane review was a 2007 RCT of patients with severe sciatica associated with lumbar disc herniations. This study demonstrated more rapid pain relief for patients who had early surgical intervention rather than prolonged conservative care. However, the probability of patients reporting recovery after one year was about 95% for

* The nonsurgical interventions referred to in most research studies on lumbar disc surgery range from standard medical care (e.g., rest, NSAIDs, analgesics, injection therapy) to aggressive rehabilitation programs to comparatively minimal interventions. Details of the nature and frequency of the conservative care regimens are often poorly reported. Whereas some conclusions can be drawn comparing surgery to a nonsurgical approach, the effectiveness of medical conservative management versus a chiropractic mix of treatments versus a physical therapy approach cannot be inferred.

both approaches. (Peul 2007) In this study 283 patients with severe sciatica for 6-12 weeks were randomized into early micro-discectomy or conservative care. Of 142 patients selected as an early surgery group, 125 were successfully fast tracked into early surgery (mean 2.2 weeks). Of 142 designated for conservative care, 55 ended up in surgery anyway (mean 18.7 weeks). The nature of the prolonged conservative care ranged from simple patient education about the natural course of disc herniations to more aggressive pain control medications. Patients identified with fear avoidance behavior were referred for physical therapy (not described). After surgery, leg pain and LBP diminished quickly compared to conservative care. The median time for recovery was 4 weeks (95% CI 3.7 to 4.4) for early surgery and 12.1 weeks (95% CI 9.5 to 14.9) for conservative care. The superior outcomes were based on reduced reported intensity of the leg pain and self perception of global improvement, but there were no additional benefits in function. Roland Morris scores did not achieve the necessary minimally clinically important difference (MCID) of 4 points.

The randomized Spine Patient Outcomes Research Trial (SPORT), designed to shed light on the role of surgical versus nonsurgical interventions, followed a cohort of 501 image-confirmed disc herniation patients and reported that both surgical and nonsurgical treatment groups improved substantially over a two-year period. However, because there were large numbers of patients who crossed over in both directions in this study, the authors could not draw firm conclusions related to treatment comparisons. They stated, “What it comes down to are patients’ values, preferences and what works for them in their life situation—an informed choice.” (Weinstein 2006)

Results from the Maine Lumbar Spine Study (n=507) indicated that surgically treated patients had more complete relief of leg pain and return of function, but improvement in the patients’ predominant symptom and work/ disability outcomes were similar regardless of treatment received. This was a large observational (non-randomized) study comparing outcomes of operative and non-operative outcomes over a ten-year period. The results showed that the proportion of patients who reported that their LBP and leg pain were greatly decreased or completely gone was larger in the surgically treated group than in the nonsurgical group (56% compared with 40%, p=0.006). More patients who received surgery were satisfied with their current status (71% compared with 56%, p=0.002). (Atlas 2005) It was also reported that optimal outcomes from surgery can take 3-12 months to achieve. Work and disability outcomes are similar to those treated nonsurgically. (Atlas 2001)

Long-Term Results (1 year or longer)

While short-term success rates are often reported to be between 80-90%, long-term success is reported to be between 65-90%, depending in part on what outcomes measures were used. (Davis 1994, Gibson 2007, Findlay 1998, Goupille 2007, Koures 1992, Loupasis 1999, Spangfort 1972, Yorimitsu 2001) Another long-term post-discectomy follow-up study indicated that the sustained response may not be as good. Den Boer et al. (2006) reported that more than one third of patients had unsatisfactory results and more than one quarter had significant residual pain. Residual effects include back or leg pain, restricted ADLs, and the inability to work. (den Boer 2006)

Other Outcomes

While leg pain tends to respond immediately, most neurological recovery occurs within four months of surgery. Some patients may take a year or longer. (Jonsson$_a$ 1996) In most cases, motor impairment is expected to recover (with or without surgery), but sensory deficits may remain in many patients (Weber 1983).

Complications of Surgery

In Peul’s 2007 RCT, the complication rate for surgery was 1.6% and consisted of two dural tears and one wound hematoma. All complications resolved spontaneously. None

had neurologic signs after surgery. In the SPORT less than 5% of 528 surgical patients had any complication, and most adverse events appear to have been minor. Dural tearing was the most common surgical complication (2%). Other sources have shown complication rates ranging from < 1% (Newman 1995, Papadopoulos 2006) to 8.6-9.6% although one of those studies included recurrent herniation as a complication (Best 2006, Hernandez-Perez 2005).

There is a relatively wide range of reported outcomes regarding further herniation and re-operation. Rhee's review suggests that lumbar disc herniations recur at about equal rates (approximately 5%) whether surgically or medically managed. (Rhee 2006) In the SPORT, re-operation occurred in 9% of cases at the two year follow-up (over half were for recurrent herniations). However, a large Finnish study showed a re-operation rate for disc patients of 12.3% (Keskimäki 2000). Elsewhere, reported re-intervention rates range between 5-25%. (Atlas 2001, Davis 1994, Goupille 2007, Malter 1998, Vik 2001) In Peul's 2007 RCT, 3.2% of patients with severe leg pain who underwent early surgery had recurrent sciatica leading in another surgery compared to 1.8% of conservative care patients who ended up being operated on later.

Possible Factors Affecting Surgical (Discectomy) Outcomes

Factors predictive of positive clinical outcomes after lumbar discectomy have been shown to include a large herniation seen on MRI, a shorter duration of disability and extruded disc herniation at surgery. (Carragee 2001) Rhee's systematic review suggested that patients who had extruded disc fragments with intact annular fibers had the better postoperative outcome scores than those with massive annular defects (Rhee 2006). Den Boer's systematic review (2006) reported that age, smoking and the degree of SLR restriction do not appear to be negative predictors. While den Boer's systematic review identified the degree of pre-operative pain as a possible negative predictor, Peul's 2007 RCT found that the severity of the leg pain did not seem to affect the prognosis for a good surgical outcome.

Negative Predictors

- Midline disc herniations
- Radiculopathy > 1 year
- Far lateral disc herniations
- No pain with sitting
- Bulging or protruding disc
- Ongoing litigation
- Low education level
- Heavy manual labor
- Low work satisfaction
- Longer duration of sick leave
- Anxiety, somatisation and passive avoidance coping
- Depression (Arpino 2004)

A number of possible negative factors have been identified affecting surgical prognosis. Patients with midline herniations appear to have poorer surgical outcomes (only 41% had a good outcome in one series of 22 midline herniation patients). (Walker 1993) Patients with radicular pain lasting more than a year tend to have less favorable results and longer time off work than those with a shorter duration of symptoms (Postacchini 1996). In Peul's 2007 study, surgery was beneficial for most patients with severe leg pain secondary to a lumbar disc herniation, with the possible exception of a poorer trend for those patients whose pain was not aggravated by sitting. Predicting who would respond to early surgery was *not* related to the SLR, relative pain intensity (all of the patients in this study had severe pain), sequestration (based on MRI), or patient preference. Far lateral herniations also can present more of a problem. Postoperative total relief ranges from 60-82%, which is not quite as good as for the more common posterolateral herniations. (O'Hara 1997)

Patients with ongoing litigation have decreased success for low back surgery in general, regardless of diagnosis. In one study, the surgical success rate dropped from 81% to 50% in worker's comp cases, to 23%

in combination worker's compensation and litigation, and down to 0% in litigation alone. (Klecamp 1997) However, when combined with an aggressive rehabilitation program, the success rate in another study was 87% in a worker's compensation environment. (Mayer 1997) Finally, low education and heavy manual work have also been suggested as negative predictors of a good outcome. (Loupasis 1999)

Patients undergoing microdiscectomy who scored higher on a depression questionnaire (the SDS) ended up with higher levels of post-surgical pain (measured with the VAS) than patients who did not show signs of depression when measured at 3 and 12 months after the procedure. (Arpino 2004)

Prescription Medications and Other Pharmaceutical Therapeutics

Patients whose pain cannot be managed conservatively may need to be referred for pharmaceutical treatment or co-treatment.

Relatively few drug studies have looked specifically at the treatment of radiculopathy/sciatica. The trend in systematic reviews for various medications ranges from weak evidence of mild benefits to evidence of no positive effects beyond placebo. There is, however, better evidence supporting short-term use for acute and chronic LBP without sciatica. (Chou 2007, van Tulder 2000, Vroomen 2000)

The following summary table is based on findings from a 2007 systematic review of systematic reviews by the American College of Physicians and the Pain Society. Medications with mild to moderate* benefit are printed in bold. (Chou 2007)

* Moderate benefit is defined as 10-20 points on a 100 VAS pain scale, 2-5 points on Roland Morris, 10-20 points on the Oswestry, or a standard mean difference of 0.5-0.8.

Evidence of Effectiveness of Common Medications

TABLE: The fractions listed in this table represent the number of studies cited over the number that were judged to be of higher quality by at least one systematic review (e.g., 3/2). Drugs with evidence of positive benefits are in bold.

	SCIATICA	ACUTE LBP	CHRONIC LBP
Anti-epileptics	**Small benefit, consistent evidence of fair quality (3/2)**	Unknown	**Small to moderate benefit, poor quality evidence (1/1)**
NSAIDs (e.g., Motrin)	No benefit, consistent evidence of fair quality **(4/2)**	**Moderate benefit, consistent evidence of good quality (31/10)**	**Moderate benefit, consistent evidence of good quality (6/3)**
Acetaminophen (e.g., Tylenol)	Unknown	**Moderate benefit, fair quality, some inconsistency when compared to NSAIDs (3/0)**	**Moderate benefit, consistent evidence of good quality (2/1)**
Skeletal muscle relaxants	No benefit based on one higher quality study (1/1)	**Moderate benefit, consistent evidence of good quality (31/21)**	Benefit unclear, poor quality **(6/2)**
systemic cortico-steroid (oral, IM)	No benefit, consistent evidence good quality **(3/3)**	No benefit, fair quality evidence **(1/1)**	Unknown
Opioids (e.g., Tylenol 3, Vicodin)	Unknown	**Moderate benefit, fair quality (1/1)**	**Moderate benefit, evidence of fair quality (7/1)**
tricyclic anti-depressants (e.g., amitriptyline)	Unknown	Unknown	**Small to moderate effects, good quality (10/5)**

ANTI-EPILEPTIC DRUGS

Three small studies (41-89 subjects) found small but consistent clinical benefits for antiepileptic drugs (gabapentin and topiramate). Side effects include drowsiness (6%), loss of energy (6%), and dizziness (6%). (Chou 2007) Numbers and variety of side effects, however, may actually be higher than those cited. For example, one of these double blind RCTs which assessed the efficacy of topiramate (brand name Topamax) for chronic lumbar radiculopathy reported a 26% dropout rate due to changes in sensorium, fatigue, paresthesias and gastrointestinal disturbances (Khoromi 2005). This is comparable with trials of topiramate in painful diabetic neuropathy in which the average dropout rate was 24%. The authors of this particular study concluded that "topiramate is at best marginally effective in the treatment of chronic lumbar radiculopathy in patients who can tolerate its prominent side effects."

NSAIDS & ACETAMINOPHEN

NSAIDs in this category may be administered orally or via suppository. There is fair evidence that they are not effective for sciatica.

There is good quality evidence that non-specific NSAIDs are moderately effective for patients with acute and chronic LBP.

Acetaminophen has not been studied for sciatica. It has been judged to be moderately effective for acute and chronic LBP based on fair quality evidence. Based on studies of patients with osteoarthritis (OA), it appears to decrease pain less effectively than NSAIDs, but it also appears to have fewer side effects when recommended doses are not exceeded. Chronic or high dose ingestion can result in renal failure.

Side effects for either medication are poorly reported in LBP studies, which are usually limited to only 4 weeks follow up. (Chou 2007)

In addition, note that patients using ibuprofen or naproxen have been associated with double the risk of developing acute urinary retention, potentially mimicking the evolution of cauda equine syndrome (Verhamme 2005)

CLINICAL WARNING! Since acetaminophen is also an ingredient in many other OTC medications, it is important to survey the patient's total intake so as not to exceed recommended doses.

MUSCLE RELAXANTS

There is little data from well-controlled studies on the use of muscle relaxants for sciatic pain with or without lumbar disc herniations. One higher quality study found no difference between tizanidine and placebo for sciatica. There is consistent, good quality evidence that they are effective in the short term (studies lasted no more than 2-3 weeks) for acute LBP. (Chou 2007, Rhee 2006) Studies of patients with chronic LBP are either of poor quality or have tested drugs not available in the United States and so no conclusions can be drawn. Side effects appear to be mild and self-limiting. (Chou 2007)

Trials of benzodiazepines, a class of tranquilizers, suggest moderate benefits for acute and chronic LBP, based on evidence of fair quality with some inconsistencies between studies. Side effects include somnolence, fatigue and light headedness. (Chou 2007)

Muscle relaxants may be appropriate for some patients, but selection criteria are unclear. There is potential for habituation with use of muscle relaxants. Accordingly, these drugs should be prescribed for a fixed period of time.

NARCOTIC ANALGESIC MEDICATIONS

No randomized clinical trials have tested the effectiveness of opioid analgesics for patients with lumbar disc herniations, although such analgesics are commonly used in clinical practice for the treatment of acute and chronic radiculopathy despite the lack of research. (Chou 2007, Rhee 2006) There is fair evidence that they are moderately

effective for decreasing pain in acute and chronic LBP. (Chou 2007)

Narcotic analgesics may be appropriate for patients with severe pain who do not respond to more conservative medications. Selection criteria are unclear, however. Constipation and sedation are the most common side effects of narcotic analgesic use. Although less common, addiction is a more serious concern.

ANTIDEPRESSANT DRUGS

The rationale for use of antidepressant medications implies a primary analgesic effect of the drugs. Additionally, the effect of antidepressant medications for chronic pain simply may be for management of depression and/or the sedative effect, resulting in improved sleep.

There are no good data for the effects of anti-depressants for the treatment of sciatica or acute LBP. There is consistent, good quality evidence that tricyclics specifically are mildly to moderately effective in treating chronic LBP. Side effects include dry mouth (9%), drowsiness (7%), dizziness (7%), constipation (4%) and loss of energy. LBP studies were not designed to assess for more serious adverse effects such as arrhythmias, overdose, or an increase in suicidal behavior. (Chou 2007)

CORTICOSTEROIDS

Systemic corticosteroids can be administered orally or by intramuscular injection. While *oral* steroids are commonly prescribed in clinical practice, as of 2006 only one study on their use for the treatment of lumbosacral radicular pain had been done (Haimovic 1986). In that study, dexamethasone was not superior to a placebo for either early or long-term relief of lumbosacral radicular pain, but it helped patients who had presented with a positive result on the SLR test.

The use of *intramuscular* corticosteroid injections for acute sciatica was examined in two RCTs. One trial showed no benefit (odds ratio = 0.8) (Porsman 1979), and the other trial showed a modest benefit (odds ratio = 2.0) (Hoffenberth 1982). However, Chou's 2007 review of prior systematic reviews concluded that there is inadequate evidence showing benefit for treating sciatica. He also concluded that there is consistent, good-quality studies that systemic corticosteroids are <u>not</u> effective for LBP.

"Steroid psychosis" is a side effect of high-dose, short-term systemic corticosteroid administration. Many patients experience a disconcerting euphoria and unusual behavior.

CLINICAL WARNING! The practitioner should be alert to patients who have been on systemic corticosteroids for weeks, months or years. Side effects with musculoskeletal implications include osteoporosis, attenuation of the transverse ligament of Atlas, and increased risk for spinal/ peripheral joint infections, avascular necrosis and infections in general.

EPIDURAL STEROID INJECTIONS

Epidural steroids, although safe, are controversial in the treatment of herniated lumbar discs, with contradictory results in the published literature (Karppinen 2001, Riew 2000, 2006, Schmid 1999, Stanley 1993, Stitz 1999).

Current thinking is that many of the symptoms of disc herniations are associated with local inflammation around the nerve root. Theoretically, therefore, epidural steroid injections may help reduce inflammation and pain. They do not appear to change the rate at which lumbar disc herniations regress (Butterman 2002). What benefits there are appear in the realm of short-term pain relief. Even at that, their value remains debatable.

- **Clinical Note:** The practitioner will need to decide whether short-term relief for any given patient in severe pain warrants a referral for corticosteroid injection. In certain select cases, it may provide enough temporary relief to allow a patient to remain more active and more fully participate in a physical rehabilitation program.

Effectiveness

Two reviews of epidural steroid injections for the treatment of sciatica found only equivocal evidence for effectiveness.

A systematic review by the American Academy of Neurology (Armon 2007) found that although epidural steroid injections provide some short-term pain relief, they do not improve function, reduce surgeries, nor do they provide long-term pain relief. According to this review, "the extent of leg and back pain relief from epidural steroid injections, on the average, fell short of the values typically viewed as clinically meaningful." (Armon 2007)

Another 2007 systematic review (Luijsterburg 2007) found no conclusive evidence for long-term effectiveness of steroid injections for sciatica and did not recommend them as a treatment.

A 2005 double-blind, randomized, placebo-controlled trial with 12-month follow-up with 228 sciatica patients investigated the cost effectiveness of epidural steroid injections (Arden 2005, Price 2005). Outcomes included the Oswestry Disability Questionnaire (ODQ) and measures of pain relief as well as psychological and physical function. The injections led to a transient benefit in ODQ scores and pain relief, compared with placebo at three weeks. There was no benefit over placebo between weeks 6 and 52.

The investigators concluded that epidural steroid injections "confer only transient benefit in symptoms and self-reported function in a small group of patients with sciatica at substantial costs. Epidural steroid injections do not provide good value for [the] money…." (Price 2005)

Where and how the injection is administered may have some impact on its effectiveness. One study showed transforaminal injections to be superior to trigger-point injections, with "successful" outcomes following 84% of the former procedures and 48% of the latter (Vad 2002). There is also some evidence that transforaminal injections appear to be superior to interlaminar injections (Schaufele 2002).

The evidence regarding corticosteroid injections into the spine is complicated by the fact that currently there is no consensus regarding the most effective route of administration, type of steroid, volume, concentration, number of injections or use of fluoroscopic guidance. (Weinstein 2003)

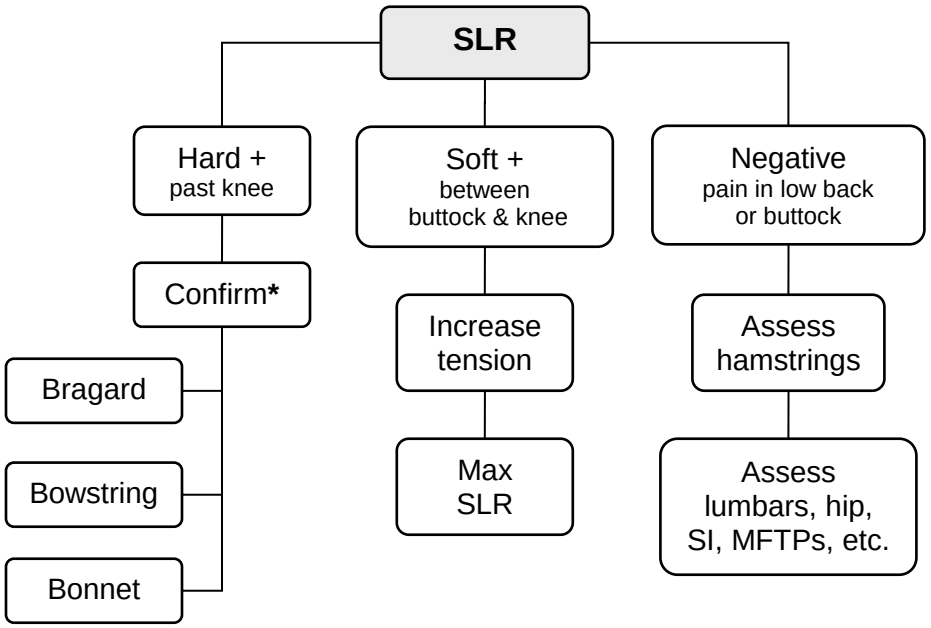
NOTES

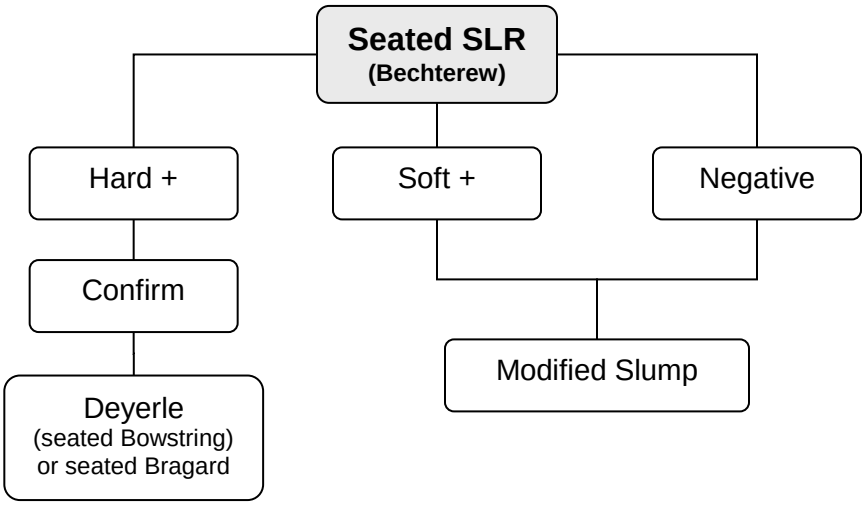
Appendix I: Sciatic Nerve Tension Test Algorithm

Ronald LeFebvre, DC (2007)

This algorithm is to help examiners make decisions about which nerve tension tests to perform on a patient with possible sciatica depending on the initial response of the SLR test. Also correlate the response of the supine SLR with the seated SLR testing and the well-leg raise test (XSLR).

Note: For suspected femoral nerve or L2, L3 or L4 nerve root lesions, perform the femoral nerve tension test. In the case of possible L4 root lesions, do both the sciatic nerve sequence and the femoral nerve tension test (AKA, the reverse SLR).





***** Not all confirmation tests need to be done. Continue until one yields a confirmation. In cases of suspected piriformis syndrome, Bonnet's test may be useful.

Appendix II: Imaging Guidelines for First Episode of Low Back Pain (present for less than 7 weeks)

Beverly Harger, DC, DACBR (2007)

This appendix contains recommendations regarding plain film radiographs for patients with LBP and is not limited to those with sciatica. Advanced imaging may also be necessary in some cases.

Imaging is generally not indicated the patient with a first episode of low back pain of less than 7 weeks who has not been treated or who is improving with treatment. If one or more of the following circumstances are present, radiography may be indicated.* For additional red flags suggesting the need for imaging see also the CSPE protocol, Red Flags for Serious Disease Causing Low Back Pain for other possible indicators.

HISTORY
- Injury of sufficient force to cause fracture
- Potential stress fracture
- Reported radiographic abnormality but with no films or reliable report reasonably available
- Findings from other study requiring follow-up radiographs
- Patient unable to give a reliable history
- Previous lumbar surgery or fracture
- Recurrent back pain with no radiographs taken in the past 2 years
- High risk for osteoporosis

SYMPTOMS
- Urinary tract dysfunction
- Persisting sensory deficit
- Worsening pain in spite of adequate treatment
- Intense pain at rest
- Pain worse at night*
- Fever, chills

EXAM FINDINGS
- Unexplained weight loss
- Significant motor deficit
- Unexplained deformity
- Radicular sensory deficit
- Reflex deficit

SPECIAL CIRCUMSTANCES
- Age over 65†
- Child‡ or student athlete
- Need for immediate decision about career or athletic future
- History of cancer or crippling cancer phobia focused on back pain
- Follow-up evaluation not possible if pain doesn't resolve
- Anticipation for another study or treatment that would be facilitated by preliminary radiography (e.g., epidural injection)
- Need for legal evaluation
- High risk for violent injury

This list is based on Simmons 2003.

* Night pain used to be listed in guidelines as a red flag for cancer. A 2004 study of 482 patients with LBP found that 42% reported some night pain and 20% presented with pain "every night." There was no correlation with serious disease. (Harding 2004) A number of guidelines no longer include night pain, although there may still be concern when the pain is severe, progressive, or unabated by position.

† Some sources use a cut off of 50-years old rather than 65 (Deyo 1992, Fernbach 1976, Mazanec 1993).

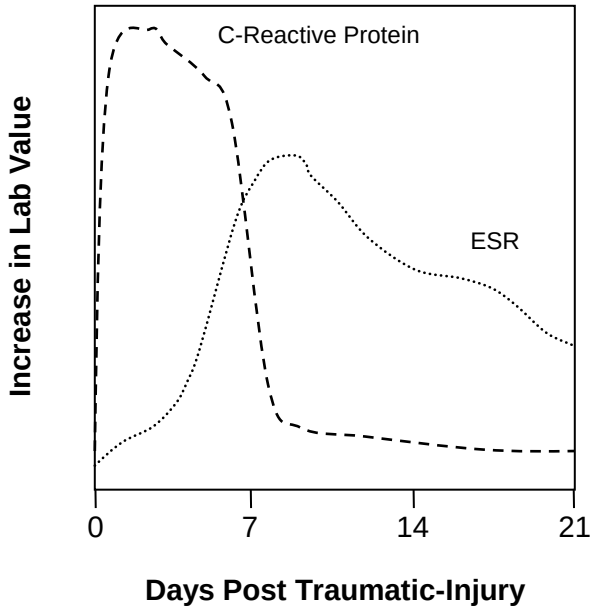
‡ (Deyo 1992, Staiger 1999) LBP in patients under 20 has been considered a red flag for organic causes. However, benign LBP in adolescents may be higher than first presumed ranging from 26-30% (Olsen 1992). A much smaller percent of these adolescents, 7-8%, actually seek care (Olsen 1992). A Finnish study indicated a significant difference in prevalence of reported LBP between the first and second decade of life (1% in 7-year olds and 6% in 10-year olds compared to 18% for 14- and 16-year olds) (Taimela 1997). A small study suggested that children younger than 11 with neoplasms were more likely to have motor weakness in addition to sensory and bilateral sciatica than children with herniated discs (Martinez-Lage 1997).

Appendix III: C-Reactive Protein (CRP)

Dennis Hoyer, DC (2007)

Most literature on screening for cancer and infections relating to LBP cites using the erythrocyte sedimentation rate (ESR). However, the practitioner may wish to consider ordering a CRP in cases where an inflammatory condition is suspected.

Levels of CRP increase rapidly in response to trauma, inflammation and infection, and decrease rapidly with the resolution of the condition. CRP is of value in diagnosis, treatment and monitoring of inflammatory conditions. CRP is a more sensitive and reliable indicator of inflammatory processes than the ESR. The serum CRP concentrations increase faster than that of the ESR. CRP levels fall very quickly once the source of inflammation is removed. It reaches normal levels several days before the ESR returns to normal. (The following graph illustrates these points.)



Some Musculoskeletal Disorders with Increased CRP

- **Meningitis.** Helps to discriminate between viral vs. bacterial meningitis. Higher levels indicate bacterial (this is a general trend in viral vs. bacterial infections).
- **Osteomyelitis and Septic Arthritis.** May indicate the need for arthrocentesis for suspected septic joint.
- **Rheumatoid arthritis.**
- **Gout.**

CRP and ESR Compared

CONDITION OR VARIABLE	CRP	ESR
Specimen requirements	Serum or plasma; stable in stored specimens	Fresh specimen of non-refrigerated whole blood; cannot be performed on stored specimen
Method of measurement	Direct quantification of acute phase response	Indirect measurement of fibrinogen elevation
Magnitude and rate of rise	Elevation begins within 4 to 6 hrs, closely parallels acute response with 4 to 7 hours half-life, allowing return to normal in 3 to 7 days after stimulus is withdrawn. Peak levels 100-1000% above base line.	Rises more slowly, may not return to normal for weeks, despite clinical improvement. Fibrinogen increases up to 400% above base line.
Effects of anemia, polycythemia, interaction of proteins and red blood cells, size, shape of red blood cells	Unaffected	False negative or false positive reactions, depending on abnormality
Age and gender	Minimal change from neonate to elderly	Rises with age*, higher values in women
Cost	More expensive	Less expensive

* Normal patient > 50 years; male = age ÷ 2; female = (age + 10) ÷ 2

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Appendix IV: Myofascial Trigger Points Mimicking Radicular Syndromes

Sean Herrin, DC (2007)

Leg pain may be the result of myofascial pain referral. Locate distribution of the patient's pain in the lower extremity and assess the muscles listed.

MFTP Table					
Muscle with MFTP	**Buttock Pain**	**Posterior Thigh Pain**	**Lateral Thigh Pain**	**Posterior Knee Pain**	**Posterior Leg Pain**
Biceps femoris				**X**	
Gastrocnemius				**X**	
Gluteus maximus	**X**		**X**		
Gluteus medius	**X**				
Gluteus minimus	**X**	**X**	**X**		**X**
Iliocostalis lumborum	**X**				
Longissimus thoracis	**X**				
Piriformis	**X**		**X**		
Plantaris				**X**	
Popliteus				**X**	
Quadratus lumborum	**X**		**HIP**		
Rectus abdominis	**X**				
Semimembranosus		**X**			
Semitendinosus		**X**			
Soleus	**X**				**X**
Tensor fascia lata			**X**		
Vastus intermedius			**X**		
Vastus lateralis			**X**		

Reference

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Appendix V: DDX Nerve Root from Peripheral Nerve

Nerve Root	Peripheral nerve	Key differences
L1	ilioinguinal genitofemoral neuropathies	Imaging of the lumbosacral spine or pelvis is often required to differentiate.
L2	lateral femoral cutaneous neuropathy (meralgia paresthetica) femoral neuropathy upper lumbar plexopathy	The presence of hip flexor weakness tends to rule out meralgia paresthetica. Femoral neuropathy and upper lumbar plexopathy may present similarly. If adductor weakness is present, the lesion is likely in the plexus or L2-L4 roots and not the femoral nerve.
L3	femoral neuropathy obturator neuropathy diabetic amyotrophy upper lumbar plexopathy	Combined weakness of hip adduction and hip flexion differentiates L3 radiculopathy from femoral and obturator mononeuropathies. Obturator neuropathy is associated with adductor spasm, medial thigh and knee pain. Leg weakness, wide based gait. Adductor weakness.
L4	lumbosacral plexopathy saphenous neuropathy	
L5	common peroneal neuropathy lumbosacral plexopathy sciatic neuropathy	Weakness of foot eversion (mediated by the L5/peroneal-innervated peroneus muscles) in conjunction with inversion (mediated by the L5/tibial-innervated tibialis posterior) places the lesion proximal to the peroneal nerve. The involvement of hip abductors (gluteus medius and minimus) indicates a lesion proximal to the sciatic nerve but does not differentiate L5 radiculopathy from lumbosacral plexopathy. Although there is no classic DTR abnormality associated with L5 radiculopathy, an asymmetric internal hamstring reflex can support its presence.
S1	sciatic neuropathy lower lumbosacral plexopathy	Both of these conditions are expected to affect L5-innervated muscles.

Appendix VI: Charting Disc Herniation in WSCC Clinics*

(Revised 2007)

Please chart lumbar disc herniations <u>exactly</u> as described on this page. Include ICD codes.

SCIATICA without DEFICITS

SAMPLE: *Probable L5-S1 disc herniation (722.10) with S1 sciatica (724.3) to right lateral foot associated with lumbar joint dysfunction.*

<u>Probable/presumed</u> herniated [name level by citing the vertebra above and below, e.g., L5-S1] *disc with* [name involved roots, e.g., L5 or S1] *sciatica† to* [describe the furthest distance of symptoms] *and associated with* [any biomechanical diagnosis, e.g., lumbar joint dysfunction].

SCIATICA with SOFT NEUROLOGICAL SIGNS

Use this in cases with only soft neurologic signs/symptoms (e.g., hypoesthesia/algesia, mild motor weakness, and/or diminished reflexes).

SAMPLE: *Probable L3-L4 disc herniation (722.10) with L4 sciatica (724.3) to medial lower leg and soft neurological signs associated with lumbar joint dysfunction.*

<u>Probable/presumed</u> herniated [name level by citing the vertebra above and below, e.g., L5-S1] *disc with* [name involved roots. e.g., L5] *sciatica* to* [describe the furthest distance of symptoms] *and soft neurologic signs, associated with* [any biomechanical diagnosis, e.g., lumbar joint dysfunction].

SCIATICA with FIRM NEUROLOGICAL SIGNS

Use this in cases of significant motor weakness (e.g., grade 3/5 or weaker), muscle atrophy, severe <u>intractable</u> pain and/or documented nerve damage (e.g., positive nerve conduction study).

SAMPLE: *Probable L4-L5 disc herniation (722.10) with L5 sciatica (724.3) to medial lower leg and firm neurological signs associated with lumbar joint dysfunction.*

<u>Probable/presumed</u> herniated [cite level] *disc with* [name involved roots] *sciatica* to* [describe the further distance of symptoms] *and firm neurologic signs associated with* [any biomechanical diagnosis, e.g., lumbar joint dysfunction].

CAUDA EQUINA SYNDROME

"<u>Probable/presumed</u> herniated disc [cite level] *with cauda equina syndrome."*

LOCAL COMPLICATORS

Local complicators can be added at the end.

SAMPLE: *Probable L4-L5 disc herniation (722.10) with L5 sciatica (724.3) to medial lower leg and firm neurological signs associated with lumbar joint dysfunction <u>complicated by spinal stenosis</u>.*

NOTE: *Probable* denotes the diagnosis is based on clinical grounds, *presumed* signifies that it is supported by imaging evidence, *confirmed* indicates found at surgery.

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* Based on Mootz (1993)

† In cases of upper lumbar disc herniations (T12-L1 to L3-L4), replace "sciatica" with radiculopathy or radiculitis (ICD code: 953.2).

Appendix VII-a: L4-L5 Disc Herniation

(L5 nerve root, L5 foramen, tibialis anterior)

Note: L4-L5 disc herniations may result in two root involvements (L5 and S1 roots).

MOST DISCRIMINATING FINDINGS

- Extensor hallucis weakness.
- Extensor hallucis weakness plus L5 sensory loss. An excellent predictor of L4-L5 disc even in the face of S1 dermatomal pain. (Kortelainen 1985)
- Distribution of sensory loss is over lateral calf, medial side of top of foot (both > 75% of L5 root cases); sensory loss sometimes presents as a continuous band from the buttock (sensitivity of 44% for L5 root cases). (Nitta 1993) Pure patch for sensory testing is the medial side of the dorsum of the first toe (82% probability). (Nitta 1993)
- L5 dermatomal pain distribution is a good indicator of L4-L5 herniation because of its common occurrence and diagnostic reliability (positive predictive value 0.80). (Kortelainen 1985)
- A good predictor of L4-L5 disc herniation (70%), even with S1 pain projection. (Kortelainen 1985)
- Ankle dorsiflexion weakness. (Spangfort 1972)
- 70 to 90 percent of patients with this weakness had L4- L5 herniations, (Spangfort 1972) but it has poor sensitivity (20-49%). (Hakelius 1970)
- L5 sensory deficit (outside of leg, top of foot, big toe).
- A good predictor of L4-L5 disc herniation (even when there is a diminished Achilles reflex or S1 sensory loss).

OTHER FINDINGS

- Weak heel walk
- Weak ankle everters (also weak with S1 root lesion)
- Weak gluteus medius (may sometimes be useful in differentiating from peroneal nerve entrapment causing ankle weakness)
- May have diminished medial hamstring DTR (Macnab 1977)
- Atrophy of the anterior compartment of the leg (Rothman 1975) of patients with L4/L5 disc herniation
- Decreased Achilles (S1 root) reflex, but reflex won't be completely absent.
- S1 dermatomal distribution of pain can be *either* an L5-S1 herniation (63% of cases) or L4-L5 (34%). (Kortelainen 1985)
- Patellar reflex is often depressed in L4-L5 and L5-S1 disc herniations.
- MacNab (1977) believed that anterior tibial tenderness in a disc herniation case suggested L5 root involvement.
- Groin pain may occasionally be present (4.1% of lower lumbar disc herniations in a series of 512 patients); more commonly in at the L4-L5 level, especially with central herniations. (Yukawa 1997)

Appendix VII-b: L5-S1 Disc Herniation

(S1 nerve root, S1 foramen, peroneal)

MOST DISCRIMINATING FINDINGS

- Plantar flexor weakness. High specificity (95%) but very poor sensitivity (6%). (Hakelius 1970)
- Decreased or absent Achilles reflex combined with S1 dermatomal pain. Eighty-percent specific for L5-S1 herniation; combined with S1 sensory deficit, it is 86% predictive. (Kortelainen 1985) **Note:** Decreased Achilles reflex as an isolated finding has poor discriminating power (can be any level herniation).
- Hypesthesia: outside of foot. Sixty-one percent predictive for L5-S1 disc, 39% predictive for L4-L5 disc. (Kortelainen 1985) **Note:** Sensory loss is very often a continuous band from the buttock down the posterolateral thigh and calf (92% of S1 root cases). Pure patch sensory testing for S1 is on the lateral side of the fifth toe (83% probability). (Nitta 1993)

OTHER FINDINGS

- Loss of great toe flexion against resistance may be earliest sign of S1 weakness (Macnab 1977, Supik 1994); toe flexors have minimal L5 innervation, whereas ankle eversion and plantar flexion has some L5 innervation (Andersson 1996); weak toe walk/repetitive toe raise (minimum of 10 raises). (Macnab 1977)
- Weak gluteus maximus, weak hamstring (may be useful to differentiate from peroneal nerve lesion).
- Atrophy of posterior compartment of the leg (Rothman 1975).
- S1 dermatomal distribution can be *either* an L5-S1 herniation (63%) or L4-L5. (Kortelainen 1985)
- Absent reflex has a higher specificity for S1 than impaired reflex. An additional neurologic deficit did not change the predictive value. (Andersson 1996) An absent reflex suggests multiple root involvement (including S1). A diminished Achilles reflex can be the result of lumbar disc herniation at almost any level.
- Pain distribution projects down back of thigh and leg to lateral foot about ⅔ of the time, suggesting an L5-S1 disc, but often can be L4-L5 disc instead. (Kortelainen 1985)
- MacNab (1977) believed that calf tenderness in a disc herniation case indicated S1 root involvement.

Note: Patellar reflex is often depressed in L4-L5 and L5-S1 disc herniations.

Appendix VII-c: Upper Lumbar Disc Herniations*

There are no strong discriminating findings. Upper lumbar disc herniations are less frequent and provide more difficulty in diagnosing than lower lumbar herniations. Herniations of L1-L2, L2-L3, and L3-L4 represent less than 5%, while L4-L5 and L5-S1 level herniations represent 90-97% of all lumbar disc herniations. Upper lumbar disc herniations are quite variable in presentation. Difficulties diagnosing upper lumbar disc herniations arise via the variation of location of pain, potential motor deficits, and sensory deficits.

OTHER FINDINGS:

- L3-L4 sensory loss sometimes presents as a continuous band from the low back across the buttock and down the leg to the foot (42% of cases of L4 nerve block). Pure patch for sensory testing is on the medial side of the lower leg (88% probability). (Nitta 1993) However, sensory deficits reveal conflicting results. Patients with L2-L3 herniations present with more L4 distribution deficits than patients with L3-L4 herniations. Patients with L2-L3 herniations may also have L5 nerve root symptoms.

- Motor deficits are variable. Almost 50% of patients have no motor deficit. Patients with L3-L4 herniations present with weak ankle extension (L4, L5 roots), tibialis anterior (L4, L5 roots), and/or weak knee extension (L3, L4 roots). Patients with L2-L3 herniations may have decreased strength in the quadriceps and/or iliopsoas muscles. In general, the motor examination may also include different levels of weakness in extensor hallucis longus, hamstring or gastroc-soleus muscles. These may be signs of lower lumbar herniations.

- Pain patterns are variable. Patients with L1-L2 herniation exhibit back and thigh pain. Patients with L2-L3 and L3-L4 herniations experience a variety of pain patterns. The majority of patients experience back and thigh pain but many have pain only in the back, thigh or leg, or back pain coinciding with thigh, leg or foot pain. This pain could potentially misdirect a physician looking for a more typical L4-L5 or L5-S1 herniation.

- Depressed patellar reflex occurs in 50% of L3-L4 herniations, but when this impairment is present, the herniation more often turns out to be at the L4-L5 or L5-S1 disc levels (67-85%). (Kortelainen 1985, Spangfort 1972)

- MacNab (1977) believed that quadriceps tenderness in a disc herniation case suggested L4 root involvement.

***** Based on Albert (1993)

Appendix VIII-a: Patient Positions – Side-Posture Rotation

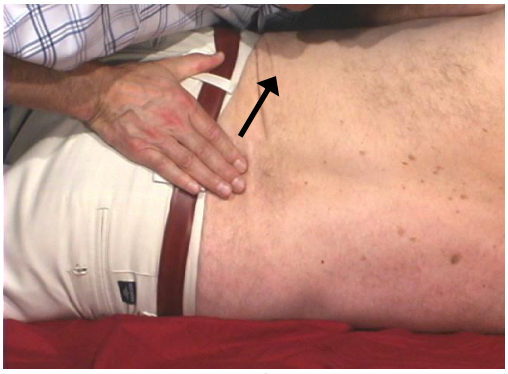
(Cassidy 1993, Hubka 1991)

If relief of symptoms or centralization is achieved by rotational positioning, consider side-posture rotational manipulation or mobilization.

rotation

Position the patient in side posture with the spine in neutral, minimize flexion (except in the rare cases where flexion has been noted to centralize the pain), and determine if tolerated. If possible, modify patient position to maximize relief of radicular symptoms. The practitioner may need to combine or emphasize lateral bending or extension, for example.

The superior vertebra of the spinal motion segment would be the typical point of contact. (Hubka 1991) A possible exception to this is when using a mammillary contact, in which case more effective rotational leverage may be obtained by contacting the inferior vertebra of the motion segment. (Bergmann 1993, Cassidy 1993)



rotation

Research has shown the pressure in the lumbar nucleus pulposus decreased or changed only slightly when the lumbar spine was rotated and underwent traction simultaneously, so simultaneous rotation and traction may be the safest manipulation for the lumbar spine. (Sheng 2002)

A pumping mobilization, muscle energy technique or high velocity manipulation may be utilized, depending on patient response and tolerance as well as the practitioner's discretion.

combined vectors
(e.g., rotation + extension)

Lisi (2001), in a case series, started with mobilization and progressed later to high velocity techniques in successfully treating lumbar radiculopathy.

If side posture increases radicular symptoms or is poorly tolerated, rotation in another position should be attempted. Otherwise, continue exploring side posture.

If a segment contact (spinous or mamillary process) at the involved motion segment is tolerated well, and mobilization/end play is tolerated well, then a HVLA thrust may be introduced in the same direction.

If possible, avoid axial compression of the joints, especially when using thrust maneuvers.

Rationale: Rotation may cause intact annular fibers to exert a centralizing force on the herniated nucleus, or to move the herniation away from the affected nerve root. Improving mobility of the motion segment may enhance imbibition of fluid and nutrients into the disc to assist healing. Reflex relaxation of local spasm may reduce intradiscal pressure.

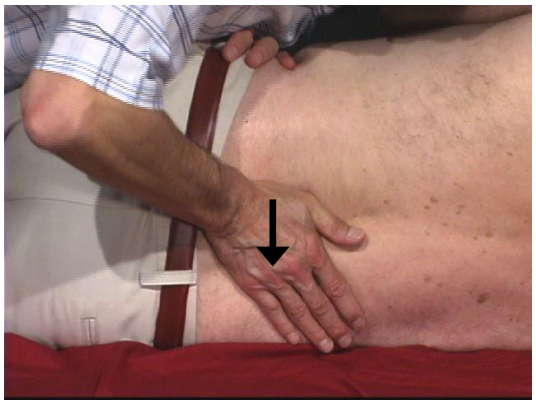
Appendix VIII-b: Patient Positions – Side-Posture Lateral Bending (Hubka 1991, Plaugher 1993)

If relief of symptoms or centralization is achieved by lateral bending positioning, mobilization or manipulation, then this positioning may be a useful component of treatment.

A contact may be made on the spinous process of the superior vertebra of the involved motion segment. A lateral-to-medial vector is used to introduce varying amounts of lateral bending to test the patient's tolerance. This procedure may progress to more vigorous mobilization, a pumping mobilization with the aid of a table which laterally bends, or high velocity manipulation depending on patient tolerance and response. Superimposing other vectors may be necessary to achieve the best result.

The prone position on an articulating table may be utilized in addition to the side-posture position. As noted previously, the direction of patient antalgia may be the most effective vector.

Rationale: Lateral bending away from the herniation may cause contralateral intact annular fibers to exert a centralizing force on the herniated nucleus, or to move the herniation away from the affected nerve root. Lateral bending increases the dimensions of the contralateral intervertebral foramen. Lateral bending toward the side of herniation, by approximating the lateral vertebral bodies, may allow the nucleus to migrate more medially, to centralize, or to draw away from the affected nerve root. Improving mobility of the motion segment may enhance imbibition of fluid and nutrients into the disc to assist healing. Reflex relaxation of local spasm may reduce intradiscal pressure.



lateral flexion

Appendix VIII-c: Patient Positions – Side-Posture Extension

(Hubka 1991, Plaugher 1993)

If relief of symptoms or centralization is achieved by extension positioning, mobilization or manipulation in this positioning may be a useful component of treatment.

extension

A contact may be made on the spinous process or mammillary process of the superior vertebra of the involved motion segment. The interspinous space or inferior vertebra may also be used (Bergmann 1993). A posterior-to-anterior vector is used to introduce varying amounts of extension to test the patient's tolerance. There should be little or no rotation involved. This procedure may progress to more vigorous mobilization or high velocity manipulation depending on patient tolerance and response. Lisi (2001) reported successful treatment of a disc herniation and radiculopathy case using side-lying extension mobilization.

extension

In the prone position, a spring-release or drop table may also be used. A knee-chest table on which the patient is kneeling with the lumbar spine suspended also facilitates extension. Additional caution should be exercised in applying the amplitude of force (that is, the depth of the thrust) when the patient is suspended in this position.

Rationale: Extension, by approximating the posterior vertebral bodies, may allow the nucleus to migrate more anteriorly, centralize or draw away from the affected nerve root. Fennell (1996) using MRI, showed anterior migration of the nucleus pulposus during lumbar extension.

Extension reduces intradiscal pressure by shifting more weight to the facet (zygapophyseal) joints. Improving mobility of the motion segment may enhance imbibition of fluid and nutrients into the disc to assist healing. Reflex relaxation of local spasm may reduce intradiscal pressure.

Appendix VIII-d: Patient Positions – Seated Manipulation

It can be advantageous to explore vectors that centralize pain by placing the patient in a seated position.

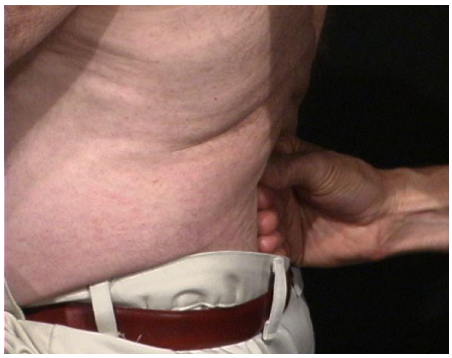
It is sometimes easier to maneuver the patient and passively load the joints at end range when the practitioner is positioned behind. The patient may even lean back against the practitioner, especially when exploring extension and combinations of extension and rotation or lateral bending.

Occasionally the patient will have leg pain only when seated (as opposed to lying), making this testing position crucial when using centralization as a key indicator.

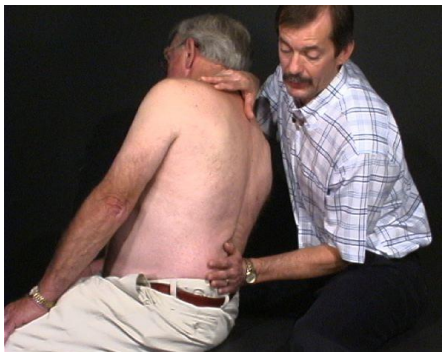
Manipulating for a disc herniation in the seated position is more controversial. Clearly there is a much higher loading penalty on the disc. However, if careful exploration reveals a vector that clearly centralizes the pain, then this could be an appropriate procedure.

Seated extension mobilization with sustained segmental pressure over the spinous process may also be useful, and tends to be very well tolerated. As the patient is passively extended over the doctor's hand, a normal lordosis is encouraged, with reduced loading of the disc. Segmental restoration of extension should facilitate global extension techniques, such as McKenzie.

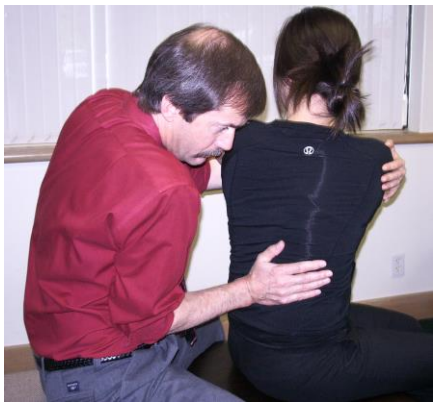
seated extension



seated extension



seated lateral flexion



seated rotation

Appendix IX: Flexion-distraction Protocol for Discogenic Pain

(minor revision 4/11)

The following flexion-distraction protocol is intended for treating patients with lumbar disc herniations and sciatica as well as disc derangements with deep referred pain into the leg. The procedure primarily applies both long axis distraction and decompression in slight non-weight-bearing flexion.

Since the practitioner cannot always tell how an individual patient is going to respond to repeated distraction/decompression until it is actually applied, a cautious, methodical approach is used and tolerance testing is performed before each treatment.

Anytime the patient indicates that the distraction/decompression applied is making him/her worse, the practitioner must stop and reevaluate his/her status (especially leg symptoms) and determine whether this particular therapy is appropriate at this time.

Clinical Warning! Because there is the potential risk of over distracting and flexing the patient, it is safer if the practitioner under treats rather than over treats during a visit, especially when starting with a new patient. The most common reason for causing a flare up is dropping the table into too much flexion.

CONTRAINDICATIONS

The following are contraindications to flexion-distraction therapy: Recent fracture, infection, surgical indications (i.e., cauda equina syndrome, progressive neurological deficits, positive image findings such as presence of a tumor), severe adhesions, displaced fragments, significant symptoms at rest, hypermobility at the segment to be treated, and cognitive difficulties in communication of symptoms.

PROTOCOL

STEP 1: Positioning the patient and adjusting the table

1. Check the table for safety. Be sure that all sections of the table are locked and the flexion tension is adequate to support the patient's lower extremities. Approximate the length of the table to accommodate the height of the patient.
2. Usually the acute patient is more comfortable at first lying in some degree of prone flexion. If lying prone is not well tolerated, configure the table to reproduce the patient's antalgic posture.
3. If the need for a post-treatment lumbar support belt is anticipated, the belt can be placed on the table underneath the patient before he or she lies down.
4. The practitioner should physically demonstrate to the patient how to get on and off table.
5. The patient should use his/her arms to lower the abdomen onto the table, standing on the asymptomatic leg and lifting the symptomatic leg onto the lower section. The patient maintains a neutral pelvis, performs an abdominal brace, squeezes the buttocks together, and hip hinges while going through the transition movements.
6. The patient's ASIS's should be 2" cephalad on the thoracic piece. It is better to have them too high (cephalad) on the table than too low (caudad) because the higher ASIS position, the less danger there is of over-flexing the lumbar spine.
7. Inform the patient that the table is going to be unlocked, the pelvic piece is going to be lowered, and s/he may feel a "stretch" in the back.
8. Stabilize the pelvic piece by holding it steady with one hand as you release the locking mechanism with the other. This helps protect the patient from any abrupt movement either in flexion or extension as the pelvic piece is unlocked.
9. Adjust the flexion tension as needed to allow the weight of the patient's lower extremities to be supported by the table without it moving up or down when you let go.

STEP 2: Tolerance testing

The purpose of this part of the protocol is to determine if the patient will tolerate the flexion-distraction procedure by applying various distractive forces to the spine and the legs. The depth is always 2" (2 inches) or less from the starting/taut position.

The patient is a candidate for this therapy if:

- the severity of the back or leg pain is reduced or at least not increased,
- leg pain centralizes or remains the same and,
- the quality of the leg or back pain remains the same or becomes more dull or diffuse.

If the patient cannot tolerate this testing, the doctor should proceed with other therapies. It may be useful to reevaluate at a later time to see if there is a change in their tolerance to the procedure.

1. **Central Distraction Testing:** With the patient not in the ankle cuffs.
   a. Without contacting (securing) the spine, slowly lower the table from the starting (taut) position into 2" of flexion and hold for four seconds. Repeat by moving down from L2-L5, one segment at a time.
   b. If there is no negative response, proceed to the next step.
2. **Single Leg Distraction Testing:** With the patient not in the ankle cuffs.
   a. Without contacting (securing) the spine, hold the ankle of the uninvolved side, push the table into 2" of flexion (from the starting [taut] position), and hold for four seconds. Repeat by moving down from L2-L5, one segment at a time.
   b. Repeat this process on the involved leg side.
   c. If there is no negative response, proceed to the next step.
3. **Foot Cuffs Testing:**
   a. Do not test or treat with foot cuffs on the first visit.
   b. If the patient tolerated the first treatment, test using the foot cuffs on the subsequent visit. Without contacting (securing) the spine, hold the ankle of the uninvolved side, push the table into two inches (2") of flexion from the starting (taut) position, and hold for four seconds. Repeat by moving down from L2-L5, one segment at a time.
   c. Repeat on the involved side.

You may find that a patient can tolerate one of these testing procedures but not the others. In that case you would treat using only the procedural step that the patient *can* tolerate.

STEP 3: Treatment

1. Select the spinal level for treatment based on your diagnosis of the location of the herniation. Contact the spinous process of the upper vertebra of the involved motor unit. If unsure of the involved disc, distract one level higher and work down rather than starting below the problem and working up.
2. If appropriate for the patient (as determined by Step 2 Tolerance Testing), apply the ankle cuffs, and configure the table into slightly increased axial distraction by separating the pelvic section from the lumbar section of the table (by crank or automatic).
3. Cautiously flex the table to get a sense of the starting point of joint distraction with the hand contacting the spine. This is the point when you first feel tension (tautness) across the spinal levels you wish to distract (e.g., the inter-spinous space between L4-L5). At the same time gauge the amount of flexion (equal to or less than 2" or 15 degrees) by sensing where the distal end of the pelvic piece is relative to your thigh/leg.
4. Be sure that the table does not swing lower than 2" or about 15 degrees below that spot where you first feel the starting point (tautness) across the desired spinal joint.
5. As a general guideline, 2" of flexion or the patient's head starting to move into extension is an indicator that there is probably enough distraction being applied.
6. From the starting/taut point:
   a. Slowly (4 seconds) pump the table into flexion. Repeat 5 times.
   b. Maintain a constant comfortable P-A and I-S pressure on the spinous process during the distraction.
   c. Let up the pressure slightly when the table is coming back up.
   d. Apply three sets.
   e. Between sets soft tissue goading (1-2 minutes) can be done (e.g., along the spine from T12-L5, the iliolumbar ligaments, gluteus medius and down the posterior/lateral thigh to the knee). The break between sets offers a chance to see if the patient will have a delayed reaction to the flexion distraction.

This protocol is continued over subsequent visits until the patient demonstrates at least 50% improvement and the centralization of radicular symptom is now cephalad to the knee. At this point other tractional loads are explored in the following order: lateral flexion, circumduction, rotation, and then extension.

NOTE: ***If distraction worsens symptoms anytime during therapy, stop and re-evaluate.***

STEP 4: Terminating the treatment session

1. Return the table to the original starting position and lock it in place.
2. If a support belt was placed on the table, secure it to the patient in the backwards position, before they get off the table. When they are up, loosen the belt and turn it around so it is on correctly.
3. Get the patient off the table using the same precautions used when getting them on: instruct the patient to maintain a neutral pelvis, abdominal bracing, hip hinging and have the patient "helicopter" spin off the table onto the asymptomatic leg.

Based on the patient's reaction to the treatment,re-evaluate if distraction is appropriate at this stage of care. Remember you may need to start out doing less than the full protocol depending on the patient's reaction to Step 2 Tolerance Testing.

Appendix X: Functional Capacity Evaluation for Lower Body

Name _____ Date _____

Note: Values/words in parentheses indicate normal responses. *…..* denotes likely clinical significance of negative response.

STANDING *(shoes off)*

Lumbar Active ROM *(T12-S2, by inclinometer)*	**Thoracic Active ROM** *(T1-T12, by inclinometer)*
Flexion (60°) _____°	Flexion (50°):
Extension (25°) _____°	a. T12 angle compared to T1 (flexed) _____°
Rt. Side Bend (25°) _____°	b. T12 angle compared to T1 (erect) _____°
Lt. Side Bend (25°) _____°	Angle of thoracic flexion (a minus b) _____°
Rt. Rotation (30°) _____°	Rt. Rotation (30°) _____°
Lt. Rotation (30°) _____°	Lt. Rotation (30°) _____°

	LEFT		RIGHT		
Single-Leg Stance Balance Time *(shoes off, raises foot at knee level, arms at side, head up)*					
Eyes Closed [Age 29-59 (21-29 secs) Age 60-69 (10 secs) Age 70-79] (4.3 secs)	*secs*		*secs*		*proprioception*
Eyes Opened [Age 29-59 (29-30 secs) Age 60-69 (22.5 secs) Age 70-79] (14.2 secs)	*secs*		*secs*		*proprioception*
Lateral shift of pelvis greater than one inch? (no)	Y	N	Y	N	*inhibited gluteus medius*
Squat Strength / Coordination					
Straight back maintained? (yes)	Y		N		*balance*
90° knee flexion with heels on floor? (yes)	Y		N		*tight soleus*
Number of repetitions (see reference values) (max 50 repetitions)	*reps*				*quadriceps strength*
Lunge Test *(going down on one knee)* **Forward Foot:**	**LEFT**		**RIGHT**		
Trunk vertical? (yes)	Y	N	Y	N	
Forward foot balance?	**LEFT:** ☐ Good ☐ Poor		**RIGHT:** ☐ Good ☐ Poor		
Stepping Test *(eyes closed, arms out in front and parallel to floor, wearing earmuffs, march with hips flexed 45° at moderate pace for 50 steps)*					
Does trunk rotate more than 30° excursion? (no)	Y	N	*faulty: proprioception/tonic neck; lumbar reflexes/sensory integration*		

SUPINE

Repetitive Sit-up Test *(knees flexed 90°, ankles fixed) (Patient sits up and touches thenar pads to knees then curls back down once every 2-3 secs)* (see reference values) (max 50 repetitions)	*reps*	*inhibited/weak abdominals*

Double Leg Raising Strength Test			
Hold posterior pelvic tilt w/both legs raised off table 60° or greater? (60% strength)	Y	N	*inhibited abdominals; possibly lower abdominals*
Hold posterior pelvic tilt w/both legs raised off table 40° or less? (80% strength)	Y	N	*inhibited abdominals; possibly lower abdominals*
Hold posterior pelvic tilt w/both legs 2-4 inches off table? (100% strength)	Y	N	*inhibited abdominals; possibly lower abdominals*

Modified Thomas Test	**LEFT**	**RIGHT**		**LEFT**	**RIGHT**
Hip extension (10°)	°	°	*tight psoas*	**Passive SLR** (70°-90°)	°	°
Knee flexion (135°)	°	°	*tight rectus femoris*	**Gastrocnemius Flexibility** (10°-15°)	°	°
Hip adduction (>10°)	°	°	*tight adductors*		(*ankle dorsiflexion with knee extended and hip extended)*	
Hip abduction (>15°)	°	°	*tight TFL*			

Respiration Coordination Test *(patient takes a deep breath in)*			
Does abdomen rise more than chest? (yes)	Y	N	*paradoxical/uncoordinated breathing*
Activity of accessory muscles? (no)	Y	N	*overactive SCM, scalenes, upper trap/inhibited diaphragm/faulty posture*

SIDE LYING

Hip Abduction Coordination Test (Hip Abduction to 30°) *(bottom leg knee flexed, top leg knee extended and abducted to 30°)*	**LEFT**		**RIGHT**		
Patient able to raise leg > 6 inches and hold > 2 seconds? (yes)	Y	N	Y	N	*weak gluteus medius, QL and/or TFL*
Without shaking or twisting of leg? (yes)	Y	N	Y	N	*inhibited gluteus medius*
Without hip flexion or external rotation? (yes)	Y	N	Y	N	*overactive/tight TFL or piriformis*
Without excessive hip hiking? (yes)	Y	N	Y	N	*overactive QL*
Without posterior iliac rotation? (yes)	Y	N	Y	N	*substitution by TFL*
Trunk Side Bridge Test *(legs extended, top foot forward, rest on elbow and feet)*					
Patient able to lift hips off mat, maintain straight trunk & legs? (yes)	Y	N	Y	N	*weak QL*
Time patient can hold hips off mat with trunk and legs straight. (see reference values) (max 120 seconds)	*secs*		*secs*		*inhibited/ weak QL*

PRONE

Trunk Stabilization Test *(arms at side; pressure unit under abdomen centered at navel & at level of ASIS; pressure unit filled to 70mmHg & stabilized) (Patient contracts transversus abdominis by drawing lower abdomen up & in off the pressure unit without breathing, i.e. corset effect)*

Pressure gauge reduction? (6-10mmHg) (yes)	*mmHg*		
Patient holds contraction for 10 secs? (yes)	Y	N	*inhibited transverses abdominis*
Patient repeats 10 times? (yes)	Y	N	* poor endurance of transverses abdominis*
Patients tilts pelvis or flexes spine? (no)	Y	N	*substitution of rectus and/or obliques*
Pressure drops < 2mmHg / no change / increased pressure? (no)	Y	N	*substitution of rectus and/or obliques*

Hip Rotation ROM	**LEFT**	**RIGHT**		**LEFT**	**RIGHT**
Internal Rotation (35°-45°)	°	°	**Passive Knee Flexion** (140°-150°)	°	°
External Rotation (35°-45°)	°	°	**Soleus Flexibility** (25°-30°) *(ankle dorsiflexion w/ knee flexed)*	°	°

Hip Extension Strength / Coordination Test	**LEFT**	**RIGHT**	
Hamstrings flex the knee? (no)	Y	N	***any or all of the following*** weak/inhibited gluteus max., short psoas, overactive hamstrings, overactive erector spinae, decreased hip joint extension
Anterior pelvic tilt? (no)	Y	N	
Hypertonicity of the thoracolumbar erector spinae? (no)	Y	N	
Contralateral shoulder hypertonicity? (no)	Y	N	*overactivity of contralateral upper trap/levator*

Trunk Extension Strength Tests *(trunk off table, hands at sides, feet restrained. Patient raises trunk up from 45° flexion to horizontal position and returns to flexed position for Repetitive Arch-up Test or holds in horizontal for Static Test)*

Repetitive Arch-up Test (see reference values) (max 50 reps)	*reps*	*inhibited/weak erector spinae, glut max*
Static Back Endurance Test (see reference values) (max 240 secs)	*secs*	*inhibited/weak erector spinae, glut max, multifidus: predicts first time and recurrence of LBP*

SITTING

Long Sitting Flexibility Tests *(knees extended, reach forward as far as possible; touch fingertips to toes or beyond)*

Ankle dorsiflexed to 90°? (yes)	Y	N	*tight gastroc-soleus*
Knees fully extended? (yes)	Y	N	*tight hamstrings*
Sacrum-tabletop angle 80°? (yes)	Y	N	*tight hamstrings causing posterior pelvic tilt*
Lumbar spine flexion (+5°)? (yes)	Y	N	*tight lumbar erector spinae*
Thoracic spine smooth/gradual contour? (yes)	Y	N	*stretched thoracic erector spinae*

INDICATORS OF POSSIBLE ALTERED MOVEMENT PATTERNS

	Hip Extension	**Hip Abduction**	**Trunk Flexion**
Muscle Imbalances	☐ Inhibited glut maximus ☐ Overactive psoas, rectus femoris ☐ Overactive erector spinae ☐ Overactive hamstrings ☐ Recurrent/chronic neck pain	☐ Inhibited glut medius ☐ Overactive adductors ☐ Overactive QL ☐ Overactive TFL ☐ Overactive piriformis	☐ Inhibited rectus abdominus ☐ Overactive erector spinae ☐ Overactive iliopsoas ☐ Overactive SCM ☐ Inhibited deep neck flexors
Symptoms	☐ LBP ☐ Buttock pain ☐ Coccyalgia ☐ Recurrent hamstrings pull ☐ Recurrent/chronic neck pain	☐ LBP ☐ Buttock pain	☐ LBP ☐ Buttock pain ☐ Neck pain
Postural Analysis	☐ Forward trunk ☐ Anterior pelvic tilt ☐ Hypertonic erector spinae ☐ Hypotonic glut max	☐ ITB prominence ☐ Lateral patella ☐ Foot flare ☐ Lateral shift pelvis in SLS ☐ Adductor notch	☐ Increased lumbar lordosis ☐ Protruding abdomen
Gait Analysis	☐ Decreased hip hyperextension ☐ Increased lumbar lordosis	☐ Hip hiking ☐ Asymmetric pelvic rotation ☐ Lateral shift of pelvis	☐ Increased lumbar lordosis
Trigger Points/Tight Muscles	☐ Gluteus maximus ☐ Coccyx ☐ Iliopsoas ☐ Erector spinae ☐ Contralateral upper trapezius ☐ Contralateral levator scapulae	☐ Gluteus medius ☐ Gluteus maximus ☐ Piriformis ☐ Quadratus lumborum ☐ TFL	☐ TFL
Joint Dysfunction	Hip: ☐ L ☐ R SI: ☐ L ☐ R Lumbar ☐ L/S junction ☐ T/L ☐ C/T ☐ Cervical spine ☐		
Other Imbalances	☐ Altered proprioception ☐ Weak QL/ external oblique	☐ Tight gastroc-soleus ☐ Inability to selectively activate deep abdominals	☐ Poor endurance erector spinae

Comments:

_____ _____

CLINICIAN **DATE**

REFERENCES (6/18/09)

Annotation of the references is still in progress. Working from original articles (not abstracts), chiropractic students under the direction of the lead authors are including pertinent details to supplement the citations in the text. Periodically, new annotated reference sections will be distributed as this work continues.

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Albert T. Upper lumbar disc herniations. J Spinal Disorders 1993;6(4):351-9. **[Retrospective observational study. Data collected from three spine centers from 102 males and 39 females that underwent upper lumbar disc (L1-2, L2-3, L3-4) surgery between 1980 and 1990. The mean age was 51.6 years. Chart notes, hospital records, and any imaging done on each patient were reviewed for objective findings. Patients were mailed a questionnaire to record a subjective rating of outcomes. A rating of Excellent meant complete recovery, Good meant a return to previous activity with some back or leg pain, Fair was partial recovery with modified daily activities, and Poor meant no improvement or worsening of symptoms. 57% of the subjects responded to the survey at an average of 2.2 years after surgery. 7/21 patients with L2-3 herniations had previous surgery, and 17/117 L3-4 patients had previous surgery. 115/141 had no sensory deficit. Seven patients in the L1-2 and L2-3 groups had sensory deficits; 6 of them were L4 deficits. Five of the L3-4 group had L4 deficits while 13 had L5 deficits. There was a statistically significant increase in incidence of L4 sensory deficits at L1-2 and L2-3 compared to L3-4 (P<0.05). Seventeen of the 141 subjects received compensation or had a legal claim related to their condition. Eleven of those subjects (64%) responded to the survey. 55% of those with no compensation or legal claim responded (66/121). 6/11 in the compensation group reported a Fair or Poor improvement, while only 9/66 in the no compensation group reported Fair outcomes (none of them reported Poor outcomes). This difference was statistically significant (P<0.01). L2-3 and L3-4 commonly present with radicular pain and/or thigh/groin pain. About 50% of upper lumbar herniations are accompanied by weakness and altered knee reflexes. These are related more commonly to L3-4 lesions. Fair-Poor outcomes are more common in those with pending legal claims or compensation related to their condition.]**

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Andersson BJG, Ortengren R, Nachemson A, et al. Lumbar disc pressure and myoelectric back muscle activity during sitting. Scand J Rehabil Med 1974;6(3):122-7. **[A laboratory observational study of four volunteer subjects (3 female, 1 male) between the ages of 20 and 40, to investigate the impact of a vehicles' driver seat positioning on the spine. Inclusion criteria were no history of prior back injury or disease. Using pressure transducers and electrodes, the myoelectric activity of both sides of the trunk/spine were measured as the subject was seated in different positions which varied in back-rest seat angle, lumbar support, and seat inclination. The backrest was inclined to either 90°, 100°, 110° or 120°; the lumbar support was always located at the level of L3, and ranged from 0 to 5 cm in 1 cm increments; the seat inclination set at either 10° or 14°. The participant's myoelectric activity and disc pressure were evaluated at every combination of these positions. Results of the study are based on the assumption that low myoelectric activity and low disc pressure are favorable. The lowest level of myoelectric activity and lowest disc pressure were found when the back-rest seat angle was 120°, the lumbar support 5 cm and the seat inclination 14°. The study also suggests auto manufactures should aim for these values in their design.]**

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Armon C, Argoff CE, Samuels J, Backonja MM. Assessment: Use of epidural steroid injections to treat radicular lumbosacral pain. Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Neurology 2007;68:723-9. **[Qualitative Systematic Review. Six studies were reviewed, ranging from 1985-2001. Two of the studies were Class I evidence (the highest quality), one was Class II, two were Class III (the lowest quality), and one study was**

rated in all three classes: Class I for primary outcome variable at 3 months, Class II for pain at earlier time points, and Class III for other outcome measures, multiple analyses, and small mean effect size. Epidural steroid injections are effective in treating radicular lumbosacral pain at the 2-6 week range, but do not effect impairment of function, the need for surgery, or pain relief for longer than three months. There is not enough evidence to recommend epidural steroid injections for the treatment of cervical radicular pain.]

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Atlas SJ, Keller RB, Chang YC, Deyo RA, Singer DE. Surgical and nonsurgical management of sciatica secondary to a lumbar disc herniation: Five-year outcomes from the Maine lumbar spine study. Spine 2001;26(10):1179-87. **[Prospective cohort study; assess 5-year outcomes for patients with sciatica caused by a lumbar disc herniation treated surgically or nonsurgically; 402 patients, mainly male and non-college graduates, were evaluated with baseline interviews with mailed follow-up questionnaires at 3, 6 and 12 months and annually thereafter; surgical treatment was associated with greater improvement than nonsurgical treatment at 5 years. But patients treated surgically were as likely to be receiving disability compensation, and the relative benefit of surgery decreased over time.]**

Atlas SJ, Keller RB, Wu YA, Deyo RA, Singer DE. Long-term outcomes of surgical and nonsurgical management of sciatica secondary to a lumbar disc herniation: 10-year results from the Maine lumbar spine study. Spine 2005;30(8):927-35. **[Prospective observational cohort study; 126 patients in single referral hospital in Norway recruited and evaluated with baseline interviews with follow-up questionnaires mailed at regular intervals over 10 years; satisfaction with the current state were similar in patients initially treated surgically or nonsurgically.]**

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Böttcher J, Petrovitch A, Sörös P, et al. Conjoined lumbosacral nerve roots: current aspects of diagnosis. Eur Spine J 2004;13(2):147-51. **[5 individual case studies of conjoined nerve roots observed during 1 year period; MRI recommended for detection, lumbar myelography with postmyelo-CT are also recommended in cases with questionable radiological findings.]**

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Brisby H, Balague F, Schafer D, et al. Glycosphingolipid antibodies in serum in patients with sciatica. Spine 2002;27(4):380-6. **[Cohort study. Three groups of subjects: Group IA had 68 people, 45 male and 23 female, ages 24-64; Group IB had 23 subjects, 16 male and 7 female, ages 29-68; and Group II, which had 37 subjects, 26 male and 11 female ranging from 23-63 years old. Group IA were subjects with acute severe sciatica, Group IB were patients from IA who had a 4 year follow up review, and Group II were all patients who were undergoing discectomy for sciatica with imaging-verified disc herniation. 71% of group IA had a positive antibody titer for at least one of the ten Glycosphingolipid (GSL) antigens that were tested for. Anti-3'LM1 and anti-GD1a were significantly higher in patients with positive neurologic tests (58%, P<0.023 and 42%, P<0.017, respectively) than those with negative tests. When compared with baseline, Group IB had significantly less pain (P<0.00003), less positive neurologic tests (P<0.04) and less positive SLR results (P<0.00004). 91% of Group IB had recovered at the 4-year follow-up, according to a given recovery index. Eight GSL antigens were tested for in IB and 61% of the subjects tested positive for antibodies for one or more. There were only two patients in this group who had not recovered. There was no significant difference between their GSL antibodies and those of the rest of the group. 61% of those who tested positive for one or more antibodies at baseline also tested positive at the 4-year follow-up. In Group II, there were 65% and 51% (10 and 8 antibodies tested, respectively) that showed a positive antibody titer to at least one antigen. These results had no correlation to any of the outcomes measured. In conclusion, more than one antigen is present in the immune reaction involved in sciatica, and more research is necessary to learn more about the pathogenesis of this inflammatory process and how that knowledge can be applied clinically.]**

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Burton AK, Tillotson KM, Main CJ, et al. Psychosocial predictors of outcome in acute and subacute low back trouble. Spine 1995;20:722-8. **[Prospective survey. 252 subjects, consecutively seen with new LBP in an osteopathic clinic in England. Patients were excluded if presenting symptoms suggested serious pathology. Three subgroups were established. Subjects were acute if their pain had lasted no more than 3 weeks, subchronic if more than 3 but less than 52 weeks, and chronic if more than 52 weeks. Researchers used a level of significance of 5%. 186 patients, or 74% of the original group responded to a 1-year follow-up. Results of the survey showed no significant difference in clinical or psychosocial variables. Between the subchronic and acute subgroups, the subchronic group had significantly higher mean scores on the Coping Strategies Questionnaire, the McGill Pain Questionnaire, and the Modified Zung Depression Inventory. The subchronic group had statistically significant lower mean scores on the Roland Morris Disability Questionnaire and the Pain Control scale of Pain Locus of Control. The authors conclude that the patient's cognitive coping strategies are highly predictive of clinical outcomes at the 1-year follow-up, whereas clinical variables have little predictive value.]**

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186 patients (108 men and 78 women) met the inclusion criteria, which were: A primary diagnosis of sciatica and age 20 to 70. Patients were excluded if they had had previous back surgery, malignancy, infection or "extraspinal sciatica." Patients were also excluded based on MRI results that were completely normal or if they had spondylolysis, spondylolisthesis, scoliosis, tumor, infection, inflammatory arthritis, or metabolic bone disease. MRI's were then measured at the level of greatest encroachment of the vertebral canal, consistent with the laterality of the patients' pain. They measured the area of herniated material in the spinal canal, the area of the spinal canal, the hemiarea of the herniated disc, and the hemiarea of the spinal canal. They also measured the longest anteroposterior disc length, midline anteroposterior canal length, width of the disc protrusion at the midpoint of its posterior excursion, and spinal canal width at the midpoint between the disc and the lamina. They then calculated percentage of the area of total canal occupied by the disc protrusion and the ratio of hemiarea of remaining canal. Of the original 186 subjects, 135 were contacted an average of 2.8 years after their MRI scans and a retrospective review of their medical charts was done along with an interview to record their current symptoms and rate the outcome of their treatment for sciatica. In the group of patients that was treated conservatively (nonsurgical), shorter symptom duration for current episode (P=0.002), less than 6 months symptom duration (P=0.02), and absence of litigation (P=0.04) were significantly correlated to a positive outcome. A smaller disc hemiarea to canal hemiarea ratio was the only MRI measurement correlated to a positive outcome (P=0.045). Those characteristics that were predictive of a positive outcome were shorter duration of symptoms for the current episode (P=0.0006), no involvement in litigation (P=0.045), and younger age (P=0.04). A larger disc hemiarea to remaining canal hemiarea ratio was predictive of a negative outcome (R=0.499). For those that did not undergo surgery, longer maximum anteroposterior disc length (P<0.0001, smaller hemiarea of remaining canal (P<0.0001), smaller maximum disc width (P=0.0016), and larger mid anteroposterior canal width (P=0.0019) were all predictors of a good outcome. Demographic and clinical measures are stronger outcome indicators in nonsurgical patients and MRI morphometric readings are better outcome indicators for surgical patients.]

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Cerny A, Shmid K. Tolerability and efficacy of valerian/lemon balm in healthy volunteers (a double blind, placebo-controlled, multicentre study). Fitoterapia 1999;70:221-8.

Cherkin D, et al. Predicting poor outcomes for back pain seen in primary care using patient's own criteria. Spine 1996;21(24):2900-7. **[Cohort study. Inclusion criteria: Age 20-69, presenting for the first time with their current episode of LBP. Exclusion criteria: Previous back surgery, systemic or visceral disease, known osteoporosis, corticosteroid therapy, pregnancy, cancer, unexplained weight loss, vertebral fracture or dislocation, progressive or severe neurologic signs, permanent disability or involvement in litigation, inability to speak English, and disabling coexisting problems. 219 subjects qualified and agreed to be entered in this study. Average age was "around 40 years," and gender was "about equally divided between men and women." Site of study was a suburban primary care medical clinic. The Symptom Satisfaction measure was used as an outcome measure for the progress of the subjects' pain at intervals of 1, 3, and 7 weeks, and 1 year since the initial visit to the physician. At the first visit 80% of subjects were prescribed one or more medications. Of this 80%, 69% were prescribed NSAIDs, 35% muscle relaxants, 12% narcotic analgesics, and 4% non-narcotic analgesics. It was the first visit for back pain for 1/3 of patients, 1 in 5 had pain for more than 3 weeks, and both pain and dysfunction ratings were moderate to high on the average. In the 7 weeks after the initial visit, 34% of patients saw a physical therapist at least once, 10% saw a physician, 7% a chiropractor, and 4% saw a surgeon. The proportion with good outcomes at week 1 was 33%; at week 3 it was 50%, and at week 7 it was 66%. The changes between weeks 1 and 3 and weeks 3 and 7 were statistically significant (P<0.0001). A good outcome in the first 7 weeks was highly predictive of a good outcome in the long term, but a poor short-term outcome was not predictive of the outcome at 1 year. About 87% of those with good outcomes at 3 weeks had good outcomes at 7 weeks and 1 year, whereas 50% of those with poor outcomes at 3 and 7 weeks also had poor outcomes at 1 year. Symptom satisfaction correlated moderately high (between r = 0.60 and 0.78) with symptom bothersomeness and dysfunction at all outcome intervals. Younger age, lower satisfaction with work, depression, previous treatment for back pain, pain below the knee, more severe symptoms, and greater back-related worry were all associated with poor outcomes after 7 weeks. Three of these remained associated after a multivariate analysis: Depression (OR=2.1; 95% CI, 1.4-3.4), pain below the knee (OR=3.6; 95% CI, 1.6-7.7), and age (OR=1.04; 95% CI, 1.01-1.07). Female gender, perceptions of being less healthy, depression, pain below the knee, and greater worry about one's back problem were all predictive of outcome after 1 year. Depression (OR=2.3; 95% CI, 1.4-3.6) and pain below the knee (OR=2.4; 95% CI, 1.1-5.0) remained associated after multivariate analysis. This study was limited by being conducted by one HMO clinic serving mainly white, well educated patients. It also only asked about symptoms in the last 24 hours in the Symptom Satisfaction questions, and did not include questions about recurrences between the initial follow-up period and the one year follow-up. The authors conclude that the fraction of patients with poor outcomes after reporting to their primary care physician for back pain is higher than previously thought.]**

Chou R and Huffman LH. Nonpharmacologic therapies for acute and chronic low back pain: A review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. Ann Intern Med 2007;147:492-504. **[Meta-analysis concluding that good evidence is available to support the efficacy of exercise, spinal manipulation, cognitive-behavioral therapy, and interdisciplinary rehabilitation in the treatment of chronic or subacute LBP, and fair evidence is available to support the efficacy of acupuncture, massage, yoga, and functional restoration for chronic LBP. For acute injuries, the only nonpharmacologic treatments found to be effective were superficial heat (good evidence) and spinal manipulation (fair evidence). Out of 1292 abstracts identified through Medline (through Nov 2006) and Cochrane Database of Systematic Reviews (2006, issue 4), 46 met inclusion criteria, spanning 2000-2007. Quality ratings using the Oxman scale fell into the**

following groups: [rating (# of studies)]: 1(1), 2(3), 3(5), 4(7), 5(3), 6(9), 7(12).]

Christensen M and Kollasch M (Eds). Job Analysis of Chiropractic. Greeley, CO: National Board of Chiropractic Examiners; 2005.

Clarke J, van Tulder M, Blomberg S, et al. Traction for low back pain with or without sciatica: An updated systematic review within the framework of the Cochrane Collaboration. Spine 2006;31(14):1591-9. **[Systematic review; 24 studies 1992 to 2004; found contradictory evidence regarding effectiveness of traction comparing to placebo, sham, no treatment or other treatments.]**

Clarke JA, van Tulder MW, Blomberg SEI, et al. Traction for low-back pain with or without sciatica. Cochrane Database of Systematic Reviews 2007, Issue 2. Art. No.: CD003010. DOI: 10.1002/14651858.CD003010.pub4. **[Updated qualitative systematic review following the updated guidelines of the Cochrane Back Review Group. This review explored the efficacy of treating low back pain with traction. It was not specific on what type of traction was used. It concluded that traction alone cannot be recommended as a treatment for patients with low back pain with or without sciatica. 24 articles were reviewed and classified as high or low quality based on how many of 11 selective criteria each article contained. Only 5 of the articles were determined to be "high" quality, measuring 6 or higher on a scale from 1-11. The time span of the articles was from 1970-2005.]**

Coppes MH, Marani E, Thomeer R, Groen GJ. Innervation of "painful" lumbar discs. Spine 1997;22(20):2342-9. **[Cross-sectional study. This study examined anterior segments of 10 lower lumbar intervertebral discs (L3-4, L4-5, or L5-S1) that were removed from patients undergoing anterior interbody fusion for chronic LBP. One segment was taken from each patient. The mean age was 37, with 6 females and 4 males, with a mean pain duration of 7 years. Two anterior disc segments were taken for controls from patients undergoing surgery for spinal metastases. Painful disc degeneration had previously been confirmed by discography and injection of a pain-inducing substance into the degenerated discs. Between 200-250 transverse sections were obtained from each disc and AchE enzyme histochemistry and NF 90 monoclonal immunocytochemistry was done on alternate sections. Substance P polyclonal immunocytochemistry was performed on 5 of the discs. Eight of ten degenerated discs had nerve fibers that penetrated deeper than the outer third of the anulus fibrosis, while the 2 controls only had nerve fibers in the outer third. Mechanoreceptors were present in 4 of 10 degenerated discs, but neither of the controls. A very small amount of substance P-positive fibers were found in the superficial layers of the discs. The authors conclude that this study lends support to a neuroanatomical basis for discogenic pain perception in degenerated discs.]**

Cox J, Feller JA. Chiropractic treatment of low back pain: A multicenter descriptive analysis of presentation and outcome in 424 consecutive cases. JNMS 1994;2(4):117-28.

Cox J. Low Back Pain, 5th ed. Baltimore, MD: Williams and Wilkins; 1990.

Cox JM, Feller J. Distraction chiropractic adjusting: Clinical application and outcomes of 1000 cases. Top Clin Chiro 1996;3(3):45-59.

Crawfurd EJP, Baird PR, Clark AL. Cauda equina and lumbar nerve root compression in patients with AIDS. J Bone Joint Surg (Br) 1987;69B(1):36-7. **[Case Series. 5 cases are reported in this series, each being HIV positive males. All five cases were patients who were referred to an orthopedic consultant. Each presented with peripheral neurological symptoms consistent with the distribution of the nerve roots of L3-S1. No corresponding neuropathy or compression was found in any of the five cases, and each responded positively to antibiotics. AIDS is a disease with symptoms that are still poorly understood and must be considered as a differential diagnosis in AIDS or HIV positive patients who present with symptoms normally associated with lumbar disc herniation or cauda equina syndrome.]**

CSPE Committee consensus, full agreement. (1999)

Cyraix JH. Textbook of Orthopaedic Medicine. London: Baillière Tindall; 1980.

Daniel DM. Non-surgical spinal decompression therapy: Does the scientific literature support efficacy claims made in the advertising media? Chiropractic & Osteopathy 2007;15:7.

Davis RA. A long-term outcome analysis of 984 surgically treated herniated lumbar discs. J Neurosurg 1994;80:415-21.

Deen HG Jr, Zimmerman RS, Swanson SK, et al. Assessment of bladder function after lumbar decompressive laminectomy for spinal stenosis: a prospective study. J Neurosurg 1994;80:971-4. **[Case Series. Ten men and ten women, age 60-80 were included in this study. All had been diagnosed with lumbar spinal canal stenosis confirmed by history of leg symptoms, neuroimaging studies positive for severe stenosis in at least one level, and positive myelographic studies. Subjects were given a pre- and post-operative questionnaire, a pre-operative cystoscopy, and urodynamic tests before laminectomy and 2 and 6 months after. Degree of pain relief was rated as excellent in 18 subjects and fair in 2 at 6 months post-surgery. At 2 month follow-up, 7 of the female patients and 5 of the male patients reported subjective improvement in urinary function after surgery. The remaining 8 were unchanged. Urological outcome did not correlate with age, sex, extent of laminectomy, or degree of prostatic hypertrophy. Nine of the 20 patients had high postvoiding residual (PVR) urine before surgery and 8 of those 9 had normal PVR urine post-surgery. One woman had a cystocele and was abnormally high pre- and post-surgery, although her PVR significantly decreased after surgery. The PVR was equally likely to improve in men as much as women. Four men had abnormally low urine flow rates before surgery, and all 4 improved to normal after laminectomy. Five of the women had improved urinary flow rates post-surgery. Decompressive lumbar laminectomy can improve bladder function early and significantly in patients with severe lumbar spinal canal stenosis. The parameters most likely to improve are PVR urine volume and maximum urine flow rate.]**

den Boer JJ, Oostendorp RAB, Beems T, Munneke M, Oerlemans M, Evers AWM. A systematic review of bio-psychosocial factors for an unfavorable outcome after lumbar disc surgery. Eur Spine J 2006;15:527-36. **[Meta-analysis of 11 studies concluding bio-psychosocial variables to be valuable in predicting outcome following lumbar disc surgery. Unfavorable outcome (measured in terms of pain, disability, work capacity, or a composite score) is found to be associated with lower level of education, higher pre-operative pain report, less work satisfaction, longer sick-leave duration, passive avoidance coping strategies, and higher anxiety and somatisation levels. Pre-selection of 29 articles found through electronic database searches of Medline, Psychinfo, CHINAL, and Embase lead to final inclusion of 11 articles spanning from 1986-1999.]**

Devillé W, van der Windt D, Dzaferagić A, Bezemer PD, Bouter LM. The test of Lasègue: Systematic review of the accuracy in diagnosing herniated discs. Spine 2000;25(9):1140-7. **[Meta-analysis. This review found a pooled sensitivity for the SLR of .91 and a pooled specificity of .26. The pooled diagnostic odds ration of the straight leg raise was 3.74. For the crossed straight leg raise, the pooled sensitivity was .29 and the specificity was .88. The pooled diagnostic odds ratio was 4.39. The studies that were reviewed were flawed in that they were retrospective and were susceptible to verification bias. When criteria were changed to only include studies with more valid designs, the DOR dropped significantly. Each of the studies only included patient populations which were surgical cases and not in a primary care setting. 15 articles were used in the**

review ranging from 1951-1996.]
Deyo R. Herniated lumbar intervertebral disc. Ann Internal Med 1990;112(8):598-603. **[Based on referenced expert opinion, peer-reviewed journal.]**
Deyo RA, Weinstein JN. Low back pain. N Engl J Med 2001;344(5):363-70. **[Narrative review article.]**
Deyo R. Low back pain, a primary care challenge. Spine 1996;21(24):2826-32.
Deyo RA, Diehl AK. Lumbar spine films in primary care: Current use and effects of selective ordering criteria. J Gen Intern Med 1986;1:20-5.
Deyo RA, Rainsville J, Kent DL. What can the history and physical examination tell us about low back pain? JAMA 1992;268(6):760-5.
Deyo RA, Tsui-Wu Y-J. Descriptive epidemiology of low-back pain and its related medical care in the United States. Spine 1987;12(3):264-8.
Deyo RA. Measuring the functional status of patients with low back pain. Arch Phys Med Rehab 1988;69:1044-53.
Donelson R, Aprill C, et al. A prospective study of centralization of lumbar and referred pain. Spine 1997:22(10):1115-22.
Donelson R, Silva G, et al. Centralization phenomenon, its usefulness in evaluating and treating referred pain. Spine 1990;15(3):211-3. **[Retrospective study of 87 out of 225 consecutive LBP patients who had pain below the knee to (N-44/87). Fifty-three had a positive SLR that reproduced or increased leg pain. Rapid centralization occurred in all patients (N-59) with excellent response to McKenzie therapy, 10/13 of those who had good results, 4/7 with fair results, 3/8 with poor results.]**
Dora C, Wälchli B, Elfering A, et al. The significance of spinal canal dimensions in discriminating symptomatic for asymptomatic disc herniations. Eur Spine J 2002;11(6):575-81. **[Case Control. Study included 30 symptomatic disc herniation patients and 45 asymptomatic controls who had been matched for age, sex and occupational risk factors. Confidence intervals were not given, but unpaired t-test demonstrated significance ranging from P<0.05 to P<0.001. MRI films were read by an independent general radiologist and a neuroradiologist. Both were blind to the condition of the subject. Inclusion criteria were symptomatic lumbar disc herniation, scheduled discectomy, radicular leg pain, must not have had previous back surgery and each must have failed to respond to 6-8 weeks of conservative treatment. Subjects were excluded if they were Swiss residents, had rapid progressive severe motor deficit, or cauda equina syndrome. The study population has been described more in-depth in a previous article referenced in the text of the current article. Study was set in a university medical center. No weaknesses of this study were discussed in the paper. The authors concluded that this study is sufficient to demonstrate that disc herniation symptoms do not depend on the size of the herniation, but the size of the resulting spinal canal dimensions. Future grading systems for disc herniations should include criteria for spinal canal dimensions.]**
Dubourg G, Rozenberg S, Fautrel B, et al. A pilot study on the recover from paresis after lumbar disc herniation. Spine 2002;27(13):1426-31.
Edgar M, Park W. Induced pain patterns on passive straight-leg raising in lower lumbar disc protrusion. JBJS 1974;4:658-67. **[Prospective study of 50 patients with acute disc herniations confirmed by surgery; 7 central herniations, 24 intermediate, 14 lateral; SLR, Bragard's and SLR + neck flexion were evaluated.]**
Elfering A, Semmer N, Birkhofer D, et al. Young Investigator Award 2001 Winner: Risk factors for lumbar disc degeneration: A 5-year prospective MRI study in asymptomatic individuals. Spine 2002;27(2):125-34. **[Cohort. 41 asymptomatic subjects, male and female, ranging from 20-50 years of age, were matched by age, gender, and occupational risk to 41 patients requiring surgery for disc herniation. Subjects were selected by phone interviews of 2000 patients who had been admitted to trauma due to extremity injuries and had fully recovered. Inclusion criteria: Never missed work or saw a doctor for low back pain, must be willing to participate. Two independent radiologists, blind to each subject's condition, evaluated baseline and follow-up MRI's. The range of the follow-up period was 54-72 months, with a mean of 62 months. A 95% confidence interval was used. Each subject received a thorough physical exam and participated in a self-reporting questionnaire at baseline and at follow-up. Weaknesses cited in this study are a small sample group and the inability to make strong associations due to the small sample. The authors conclude that the extent of disc herniation at baseline, lack of participation in sports activities, and night-shift work are significant risk factors for deterioration of disc degeneration.]**
Ellenberg M, Ross ML, et al. Prospective evaluation of the course of disc herniations in patients with proven radiculopathy. Arch Phys Med Rehabil 1993;74:3-8. **[Prospective study of 18 patients with herniated lumbar disc and radiculopathy, presenting with positive SLR, muscle weakness, DTR asymmetry consistent with CT evidence of herniation. Fifteen of 18 patients improved without surgical care; thirteen cases had repeat CT scan following full resolution of symptoms; patients were followed an average of 30.4 months with no recurrence of leg pain. 78% showed radiographic improvement of the herniation; there was no apparent relationship between symptom resolution and change on CT. Non-surgical treatment was not described.]**
Emmett J, Love J. Vesical dysfunction caused by protruded lumbar disc. J Urology 1971;105:86-91. **[Case Series of 35 patients, consisting of 5 males and 30 females age 15 to 72. Follow-up was between 1-3 years for 27 subjects and between 6-10 months for 8 subjects. At follow-up, 17 patients had good results, meaning complete resolution of urinary symptoms and disc pain. Seven patients were in improved condition and 11 were unimproved at follow-up. Good results "seemed" to be correlated with preoperative typical disc pain, radiculopathy, preoperative flank/lower abdominal/inguinal pain, large vesical capacity, and a positive or equivocal myelogram. No real conclusion was given.]**
Erhard RE, Welch WC, Liu B, Vignovic M. Far-lateral disk herniation: Case report, review of the literature, and a description of nonsurgical management. JMPT 2004;27(2):123-8. **[Case Report, Literature Review. Search methods for the literature review were not discussed in this paper, though several papers were cited in the body of this article. This is a case study of 1 healthy 60-year-old man with a 3-week history of right buttock and calf pain presenting to a spine specialty center. At time of presentation he rated his pain 9/10 on the Numerical Pain Rating Scale and he scored a 73/100 on the Oswestry Low Back Questionnaire. On the first visit, the patient was treated with a hydraulic Auto Trac table, manipulation to correct pelvic misalignment and self-care exercises. On the second visit the patient received Auto Trac treatment and a CASH brace. On the third visit he was treated with manipulation and returned to work part-time. Symptoms had improved, but subject still complained of intolerance to sitting. After a transforaminal epidural injection and 4 weeks of physical therapy, the patient rated his pain 0/10 on the Numerical Pain Rating Scale and 2/100 on the Oswestry Low Back Questionnaire. After a 6 week follow up period, both scores were at 0. Authors conclude that the conservative management of far-lateral disc herniation in this healthy 60-year-old male was successful due to full resolution of symptoms and restoration of function.]**

Evans RC. Illustrated Essential in Orthopedic Physical Assessment. St. Louis, MO: Mosby-Year Book, Inc.; 1994.

Fahrni WH. Observations on straight leg raising with special reference to nerve root adhesions. Can J Surg 1970;9:4-48. **[Case series. The first series involved 3 patients. None had undergone previous spine surgery. All showed signs of disc protrusion, especially by a +SLR. At surgery, all 3 had adhesions between the involved nerve root and the underlying disc, and no signs of disc protrusion. Since no surgical procedure was necessary, they were set up in an apparatus that would allow them to perform the passive SLR on themselves. Subjects were directed to lift the symptomatic leg to the point where pain occurred, then leave it there for about 5 minutes or until the pain subsided. Then they would lift it to the point of pain once more and repeat for 30 minutes. The 3 patients were each released from the hospital within 2-6 days after achieving a passive SLR of 80-90 degrees. They were directed to perform the exercise at home once each day and hold it for 10 seconds. One patient was followed up after 2 years and the other two at one year and all 3 were asymptomatic at the time. Another series was presented in which 3 patients who had a recurrence of radiculopathy after surgery for disc herniation, were operated on a second time only to find that the offending nerve root had adhered to the disc. One of these patients experienced the symptoms 2 years after the first surgery. The time after first surgery for the other two patients was not specified. All 3 patients were prescribed the same passive SLR exercises as the patients in the first case, and all 3 achieved 90 degrees of hip flexion and were released from the hospital in 2-3 days. One patient was asymptomatic at 8 months and follow-up times were not noted for the other two. The SLR is both a useful diagnostic tool and a means to prevent nerve root adhesions.]**

Fardon DF, Milette PC, North American Spine Society (NASS), American Society of Spine Radiology (ASSR), American Society of Neuroradiology (ASNR). Nomenclature and classification of lumbar disc pathology. Recommendations of the combined task forces of NASS, ASSR, and ASNR. Am J Neuroradiology 2001. Online: http://www.asnr.org/spine_nomenclature/ **[Case Reports. A list of definitions of lumbar disc pathology derived from a task force of neuroradiologists. The project is ongoing and endorsements by organizations other than those mentioned in the title of this article are pending. The goal is to improve the quality of care for patients with spinal disorders by providing a consensus of definitions of terms normally used in the diagnosis and treatment of spinal disorders.]**

Farfan HF, Cossette JW, Robertson GH, et al. The effects of torsion on the lumbar intervertebral joints: The role of torsion in the production of disc degeneration. J Bone Joint Surg 1970;52A:468-97.

Faust SE, Ducker TB, VanHassent JA. Lateral lumbar disc herniations. J Spinal Disord 1992;5(1):97-102. **[Case Series. 15 patients, male and female, ranging from 35-72 years old, diagnosed with far-lateral lumbar disc herniations in the 2 authors' private medical practices. All were treated conservatively with rest, analgesic medications, and steroidal and non-steroidal anti-inflammatory drugs. 3 of the 15 patients responded well to conservative care and were not referred for operation. The other 12 were operated on. 5 of the 12 had excellent results, meaning a complete resolution of symptoms and neurological deficits. 6 of the 12 were good, with only minor symptoms or objective findings after surgery and a subjective marked improvement. 1 was fair, with subjective improvement, but marked neurological impairment and/or limitation of activities. Inclusion and exclusion criteria were not mentioned, except for the diagnosis of far-lateral herniation. Statistical analysis was not performed due to the small sample number. Length of follow-up was over 2 years for the 12 surgical cases and over a year for the non-surgical cases. The authors stated that a small sample was the weakness of this series. Far-lateral herniation is more common than previously thought, and surgical results, at least from this study, seem to be similar to posterolateral herniations.]**

Fennell AJ, Jones AP, Hukins DW. Migration of the nucleus pulposus within the intervertebral disc during flexion and extension of the spine. Spine 1996;21(23):2753-7. **[Cross-sectional study. Three subjects volunteered to have MRI's taken of their lumbar spines in flexion, extension and neutral positions to observe migration of the nucleus pulposis. Two of the subjects were male, 18- and 46-years old, and the other a female, age 25. Tracings of the images were made on 6 different days to examine the reproducibility of the tracings. Tracings from L1-L4 were used for all positions. The L5-S1 nucleus could not be seen in all images, so it was left out. In extension, both the anterior and posterior margins of all 4 disc levels in each subject moved anteriorly. In flexion, 22 of 24 nucleus pulposis margins migrated posteriorly. This was statistically significant (chi-square=16.7; P<0.001). This study was limited by a small sample and the fact that the subjects' range of motion was limited by the bore of the MRI scanner. In conclusion, the nucleus pulposis of living individuals behaves as it does in cadavers. That is, in flexion, it moves posteriorly, and in extension it moves anteriorly. This movement is correllated with the angle of flexion or extension.]**

Fernbach JC, Langer F, Gross AE. The significance of low back pain in older adults. Can Med Assoc J 1976;115(9):898-900.

Findlay GF, Hall BI, Musa BS, et al. A 10-year follow-up of the outcome of lumbar microdiscectomy. Spine 1998;23:1168-71.

Fritz JM, Lindsay W, Matheson JW, et al. Is there a subgroup of patients with low back pain likely to benefit from mechanical traction? Results of a randomized clinical trial and subgrouping analysis. Spine 2007;32(26):E793-E800. **[RCT. 64 patients were included, 36 female and 28 male, with a mean age of 41.1 and median symptom duration of 47.5 days. The experimental group had 31 subjects and the control had 33. Eight subjects dropped out during treatment, 5 from the experimental group and 3 from the control. Inclusion criteria were age 18-60, pain or numbness radiating distal to the buttock in the last 24 hours, Oswestry score ≥ 30%, and signs of nerve root compression. Patients were excluded if they had red flags pointing to non-mechanical LBP, spine surgery in the previous 6 months, if they were pregnant, or if sitting relieved symptoms. The treatment period was six weeks, at which time a blinded practitioner performed a reassessment. Treatment was performed at four outpatient physical therapy units. The control group underwent an Extension-oriented Treatment Approach (EOTA), including prone and standing lumbar extension exercises at home and grade 3 or 4 mobilization during a maximum of 9 therapy sessions over the 6 week trial period. The experimental group underwent the same EOTA therapy as well as mechanical traction on a three dimensional traction table in a prone position that maximized centralization of pain. Extension exercises were performed on the table after traction was applied. Subjects received traction in a maximum of 4 visits during the first 2 weeks of trial, and then only received EOTA treatment during the last 4 weeks of the trial. Completers and intention to treat analyses revealed no significant difference between the groups after 6 weeks, although ANCOVA results showed 2 baseline findings that achieved greater reductions in OSW scores at 6 weeks. Subjects in the traction group whose pain peripheralized on extension at baseline had a 15.5 point mean difference in OSW score compared to the EOTA group (95% CI: 2.7-28.3). Subjects in the traction group who had a positive crossed SLR at baseline achieved a change in OSW score averaging 18.9 points greater than those in the EOTA group (95% CI: 1.5-36.4). There**

were 24 subjects at baseline with either a positive crossed SLR or peripheralization on extension, and these patients had a successful outcome rate of 84.6% in the traction group versus 45.5% in the EOTA group (P=0.04). Patients with centralization on extension achieved an average of 8.8 points greater change over those without centralization of pain independent of the treatment used (95% CI: 0.61-17.0, P=0.04). This study's weaknesses are a short follow up period, small sample sizes, and lack of blinding at follow up for 20% of patients. The results of this study suggest that traction with extension exercises is the "preferred intervention" in a subgroup of patients with sciatica, signs of nerve root compression, and either peripheralization with extension movements or a positive crossed SLR.]

Frymoyer J. Back pain and sciatica. NEJM 1988;318:291-300. **[Narrative Review. This review used 131 references ranging in date from 1934-1987. No quality rating was given of the studies used. The authors conclude that the frequency of low back injuries on the job can be prevented with pre-employment screening. People who are least fit are most prone to back injuries, but the most important predictors of disability are the duration of the current episode, history of previous disability, psychosocial factors, occupational requirements, job satisfaction, whether the worker has hired a lawyer or not.]**

Gagnier JJ, van Tulder MW, Berman B, Bombardier C. Herbal medicine for low back pain: A Cochrane review. Spine 2007;32(1):82-92.

Garfin SR, Rydevik B, Lind B, Massie J. Spinal nerve root compression. Spine 1995;20(16):1810-20.

Garfinkel D, Laudon M, Nof D, Zisapel N. Improvement of sleep quality in elderly people by controlled-release melatonin. Lancet 1995;346:541–4.

Gaspardi G, Balint G, et al. Treatment of sciatica due to intervertebral disc herniation with Chymoral tablets. Rheum Phys Med 1971;11:14-19.

Gatterman MI, Panzer D. Disorders of the Lumbar Spine. In: Gatterman MI (Ed). Chiropractic Management of Spine Related Disorders. Baltimore, MD: Williams & Wilkins; 1990.

Gay RE, Bronfort G, Evans RL. Distraction manipulation of the lumbar spine: A review of the literature. JPMT 2005;28(4):266-73. **[Narrative Literature Review. 30 articles were reviewed, ranging from 1968-2002. No quality rating was given. The reviewers concluded that more randomized studies must be done to explore the efficacy and safety of distraction manipulation of the lumbar spine. Additional research into the theories that drive distraction manipulation must be done to discover what is happening in a biomechanical, neurophysiological, and biochemical sense. These theories and the claims that clinicians make who use this technique are not supported well enough in the literature.]**

Gerhard U, Linnebrink N, Georghiadou C, Hobi V. Vigilance-decreasing effects of 2 plant-derived sedatives. Schweiz Rundsch Med Prax 1996;85:473-81.

Gersh MR. Electrotherapy in Rehabilitation. Philadelphia, PA: FA Davis Company; 1992. **[Based on referenced opinion, textbook.]**

Gibson JNA, Grant I, Waddell G. The Cochrane review of surgery for lumbar disc prolapse and degenerative lumbar disc prolapse and degenerative lumbar spondylosis. Spine 1999;24(7):1820-32. **[Meta-Analysis. 26 RCTs of lumbar disc prolapse and 14 RCTs of degenerative lumbar spondylosis were reviewed. Dates of the articles ranged from 1976-1997. A list of evidences was established in the conclusion, with each evidence having a grade of its strength. 'A' was strong, having consistent evidence in multiple high-quality RCTs. 'B' was moderate, with consistent evidence in one high-quality, or several low-quality RCTs. 'C' was limited, with inconsistent evidence in one or more RCTs. 'D' meant that there was no evidence in any of the trials. In short, strong evidence supported surgical discectomy over chemonucleolysis and placebo. Moderate evidence supported discectomy for patients who had sciatica caused by a prolapsed disc that had not responded to conservative care. There was no evidence supporting surgical decompression or fusion for degenerative lumbar spondylosis when compared with natural history, placebo, or conservative care.]**

Gibson JNA, Waddell G. Surgical interventions for lumbar disc prolapse. Cochrane Database of Systematic Reviews 2007, Issue 2. Art. No.: CD001350. DOI: 10.1002/14651858.CD001350.pub4. **[Meta-Analysis. 42 studies total. 40 were RCTs, and 2 were quasi-RCTs, which means their methods of randomization weren't technically random. Dates of the studies ranged from 1976-2006. Reviewers gave the quality of concealment of each trial a grade A, B, or C, which meant there was a clear randomization scheme, unclear but possible randomization, or no randomization at all, respectively. Three consistently reported clinical outcomes were used for analysis. These were the patients' success rating, the surgeon's rating of success, and whether or not the patient needed follow-up surgery. Results of these ratings were pooled into 2 categories: Success or Failure. Most lumbar disc prolapses will resolve with conservative management. For those patients who continue to have sciatica associated with lumbar disc prolapse even after conservative management, there is good evidence that microdiscectomy is effective at relieving symptoms. The long-term effects of surgery on the natural history of the disc disease are not yet clearly understood. There is also a lack of evidence exploring the best timing for surgical intervention.]**

Gibson T, Dilke TFW, et al. Chymoral in the treatment of lumbar disc prolapse. Rheumatol Rehab 1975;14:186-90.

Gifford L. Acute low cervical nerve root conditions: symptom presentations and pathobiological reasoning. Man Ther 2001;6(2):106-15.

Gnatz SM. Increased radicular pain due to therapeutic ultrasound applied to the back. Arch Phys Med Rehab 1989;70:493-4.

Goupille P, Mulleman D, Mammou S, Griffoul I, Valat JP. Percutaneous laser disc decompression for the treatment of lumbar disc herniation: A review. Semin Arthritis Rheum 2007;37(1):20-30.

Greenhalgh S, Selfe J. Red Flags: A Guide to Identifying Serious Pathology of the Spine. Churchill Livingstone, Elsevier; 2006.

Gudavalli M, Cambron J, McGregor M, et al. A randomized clinical trial and subgroup analysis to compare flexion-distraction with active exercise for chronic low back pain. Eur Spine J 2006;15(7):1070-82. **[RCT. This study included 235 subjects, 123 being randomized to the flexion distraction (FD) group and 112 to an active trunk exercise program (ATEP). They were included if they had a primary low back complaint in the area between L1-S1 disc levels, their low back pain had lasted longer than 3 months, there was tenderness over at least one lumbar zygapophyseal joint on palpation, they were willing to not take narcotics during the trial, and they would not use NSAID's 24 hours before the baseline assessment or any outcome assessment. A long list of exclusion criteria is listed in the article. FD group received prone flexion distraction in sessions lasting 3-6 minutes by a chiropractor certified in the flexion distraction technique. They also received modalities such as ultrasound and ice. ATEP group went through four phases of exercise. Phase 1 consisted of flexion or extension exercises followed by flexibility exercises and modalities such as ice and ultrasound, and personal cardiovascular exercise program. In phase 2 they added upper and lower extremity weight training. Lumbar extension training was added in phase 3 and an additional cardio program and more weight training were added in phase 4. These sessions done with licensed physical therapists and lasted 30-45 minutes each. Both groups received treatment 2-4 times per week for 4 weeks, at**

which time the outcomes were assessed. Outcome measures used were a 100mm VAS, the Roland Morris (RM) questionnaire, and the SF-36. All 3 were significantly different in both groups from pre- to post-treatment (VAS: t=12.58, P<0.01; RM: t=10.73, P<0.01; SF-36 physical component score: t=11.50, P<0.01; SF-36 mental component score: t=4.08, P<0.01). FD showed a greater difference than ATEP in VAS scores at follow-up, which was also statistically significant (F=6.18, P=0.01). No significant difference was found between the 2 groups for the RM and SF-36 scores. A bias of patients to the treatment that was rendered was cited as a possible weakness of this study, as patients knew beforehand what the 2 treatment options were before they were randomized to their specific treatment. In conclusion, for perceived pain, those in the FD group improved more than those in the ATEP group.]

Gudavalli MR, Cox JM, Cramer GD, Baker JA, Patwardhan AD. Intervertebral disc pressure changes during low back treatment procedures. Proceedings of the 1998 International Conference on Spinal Manipulation: FCER 1998;Jul:111-3.

Haas M, Jacobs GE, et al. Low back pain outcome measurement assessment in chiropractic teaching clinics: Responsiveness and applicability of two functional disability questionnaires. JMPT 1995;18:79-87. **[Longitudinal investigational study. This study included 663 new patients presenting to either the outpatient teaching clinics of Western States Chiropractic College (WSCC) or Cleveland College of Chiropractic, L.A. (CCCLA). Patients over 18-years old were included if they had LBP with or without associated leg pain. Patients meeting these criteria were asked to fill out a consent form, patient characteristics questionnaire, a visual analog scale (VAS) for pain assessment, a Revised Oswestry Disability Questionnaire (ODQ), and a Dallas Pain Questionnaire (DPQ). Patients completed a follow-up questionnaire at each subsequent visit for as long as 6 months after initial intake. The mean standardized change scores {EQ 1} for the ODQ were similar throughout all follow-ups at WSCC, ranging from .70-.83 standard deviations. The ODQ showed a slight increase in responsiveness compared to the DPQ in 6 of 8 follow-ups at WSCC (RE = 1.00-1.35). At CCCLA, where there was sufficient data for only 3 months of follow-up, responsiveness of the ODQ was greater at week 2 (RE = 4.11) and smaller at 1 month (R = .45). The activities of daily living dimension and ODQ were more responsive than the anxiety/depression and social activities dimensions at 2 weeks, 1 month, and the final follow-ups ({EQ 1}'(A/D) = .26-.40, {EQ 1}'(Soc) = .17-.32). The ODQ, activities of daily living, and work/leisure scales all correlated positively with the VAS (r = .44-.68). Social activities had a weaker correlation (r = .36-.53) and anxiety/depression even weaker (.20-.40). Two weaknesses of this study were pointed out. The first is that patients who did not return for care during the trial were not sampled at the follow-up intervals. The other is that some patients had been receiving treatment for their conditions before the trial began, so their pain may have already decreased significantly before they began the study. The authors conclude that the ODQ and ADLs and work/leisure sections of the DPQ are useful for monitoring cases of LBP in chiropractic teaching clinics, whereas the social and anxiety/depression dimensions were not responsive and not recommended for use.]**

Hagen KB, Hilde G, Jamtvedt G, Winnem MF. The Cochrane review of bed rest for acute low back pain and sciatica. Spine 2000;25(22):2932-9. **[Meta-Analysis. 9 studies were reviewed, dating between 1961 and 1999. Four criteria were used to determine validity of the studies. Five of the studies met the criteria and were given a low risk of bias. This review concludes that bed rest is either not any better than, or may be worse than exercise in the treatment of low back pain. There is also evidence that shows that bed rest of 7 days is no better at treating LBP than bed rest for 2-3 days.]**

Hagen KB, Hilde G, Jamtvedt G, Winnem, MF. The Cochrane review of advice to stay active as a single treatment for low back pain and sciatica. Spine 2002;27(16):1736-41. **[Meta-Analysis. Review included 4 studies from 1980-1995. All 4 studies compared advice to stay active to advice to stay in bed. One study compared staying active to performing exercises for LBP treatment. Two of the studies had a low risk of bias according to the reviewers, and the other two had a moderate to high risk of bias. This review drew the conclusion that advice to stay active is no more effective in the treatment of LBP than bed rest or exercises. On the other hand, there is no evidence suggesting that staying active has any adverse effects on LBP patients. Since bed rest may possibly have detrimental effects, staying active is a better option for LBP sufferers.]**

Haimovic IC, Beresford HR. Dexamethasone is not superior to placebo for treating lumbosacral radicular pain. Neurology 1986;36:1593-4. **[RCT; 33 patients. Subjects were included in this study if they had at least one of several different symptoms (severe low back pain at rest, lumbar or sacral dermatomal pain, radicular pain when bearing down, nocturnal LBP), and at least one of several signs (aberrant motor, sensory, or reflex function localized to a specific nerve root, positive Lasegue's sign at 30o or less). None of the patients had known complicating factors to their LBP other than degenerative disease in their lumbosacral spine and/or intervertebral discs. Each patient was confined to bed rest for 7 days, during which they were given either dexamethasone or placebo once daily. Subjects and investigators were both blinded. Follow-up evaluations were done after the initial week of treatment and 1-4 years after treatment. Pain was rated by the patients using a scale from 0 (no pain) to 6 (constant, severe pain). Neurological tests were also performed as were evaluations of whether the patients were working, if their job performance was limited, and how many days of work they had missed due to low back pain. 7/21 dexamethasone patients and 4/12 placebo patients reported early improvement, which meant they definitely felt less pain after completing the 7 day treatment. Chi-square analysis revealed these results were not statistically significant. 6/21 dexamethasone patients and 4/12 placebo patients reported late improvement, with a pain score of 3 or less 1 year after treatment. In the last follow-up, 1-4 years after treatment, 8/16 dexamethasone patients and 7/11 placebo patients reported sustained improvement in their symptoms. Small study size and lack of strict adherence to the inclusion criteria were admitted weaknesses in this trial. In conclusion, dexamethasone is not any better than placebo in the treatment of lumbosacral radicular pain.]**

Hakelius A. Prognosis in sciatica. A clinical follow-up of surgical and non-surgical treatment. Acta Orthop Scand 1970;129(Suppl):1-76.

Haldeman S, Rubinstein SM. Cauda equina syndrome in patients undergoing manipulation of the lumbar spine. Spine 1992;17(12):1469-73.

Harding IJ, Davies E, Buchanan E, Fairbank JT. The symptom of night pain in a back pain triage clinic. Spine 2005;30(17):1985-8.

Harrington FJ Jr., Sungarian A, Rogg J, Makker VJ, Epstein MH. The relation between vertebral endplate shape and lumbar disc herniations. Spine 2001;26(19):2133-8. **[Case series; 72 patient studies were included. Patients ranged in age from 18-60 years, did not have an abnormal number of lumbar vertebrae or any transitional vertebrae, and they had no previous lumbar disc surgery or spondylolisthesis. The studies were CT myelograms taken of L4-L5 and L5-S1. The study took place in a medical school setting. The neuroradiologists who analyzed the films were blinded to the original radiologic evaluations and to the presence or absence of disc herniation. One weakness of this study is that the weight and height of only 64% of patients could be determined, making the statistical analysis less robust. Also, thickness of the annulus was**

not determined, and this could be a factor contributing to disc herniation in individuals with larger endplate area. With all the variables considered in this study, only the shape of the endplates at L4-L5 (P<0.0012) and L5-S1 (0.00001) are significantly related to the incidence of herniation at those disc levels.]

Hassan FOA, Shannak A. Primary pelvic hydatid cyst: An unusual cause of sciatica and foot drop. Spine 2001;26(2):230-2. **[Case Report. The subject was a 23-year-old male reporting to the orthopedic unit of a hospital. The patient presented with radicular pain in the right lower extremity and foot drop associated with numbness below the knee. He had no back pain and full range of motion in the lumbar spine. CT scan of the lumbar spine was clear of disease, while a CT scan of the pelvis showed a lesion with a well-defined wall extending from the S1 neural foramen to the coccyx, eroding the roof the S2 sacral foramen. The cyst was removed by surgical means and lab tests confirmed it was a primary pelvic hydatid cyst. The author concludes that intrapelvic disease must be considered in the diagnosis of radicular pain associated with foot drop.]**

Heliövaara$_a$ M, Impivaara O, Sievers K, et al. Lumbar disc syndrome in Finland. J Epidemiol Community Health 1987;41(3):251-8. **[Cross-sectional study. A sample of 8000 people were selected from a two-stage cluster sample of the Finnish population. A total of 7,217 people (90% of the sample) participated in the study. In the first phase, subjects were asked to come in for screening. A questionnaire was sent out with the screening invitation to inquire about previous diseases, surgeries or hospitalizations. It also asked about any impairments in work and functional capacity that may have taken place due to disease. Those who showed a history of disease, symptoms or findings suggesting musculoskeletal disease were asked to participate in a re-examination. Out of 3,775 subjects who had at least one of the criteria for musculoskeletal disease, 3,437 were re-examined. The proportion of men in this study with lumbar disc syndrome (LDS) (5.1%) was significantly higher than that of the women (3.7%; p<0.005). The prevalence of other types of LDS in this group was estimated at 4.8%. Results of the questionnaires for men and women were combined, and showed that 3.5% of the reductions in daily activities apart from work and 4.7% of the reductions in leisure-time activities were attributable to LDS. The questionnaire and the physicians' assessments showed that 15% of subjects with LDS under 65 years of age were totally unable to work at there current or past occupation. LDS contributed to 6% of work disability. The number of patients with LDS needing long-time care was 51%. Those patients with LDS had visited a physician within the last 12 months an average of 3.8 times, those with other low back conditions 3.4 times, and those without back diagnoses 2.3 times. Of those with LDS, 32% had been hospitalized previously and 21% had undergone operations for low back conditions. The authors conclude that lumbar disc herniations are a common finding in asymptomatic individuals and that few people with herniations will develop sciatica. Even fewer of those with sciatica will remain chronic, and a small minority of chronic patients will develop severe disability.]**

Heliövaara$_b$ M. Body height, obesity, and risk of herniated lumbar intervertebral disc. Spine 1987;12:469-72. **[Longitudinal study done from the results of a follow-up of 34 Finnish population samples examined at a mobile clinic run by the Social Insurance Institution. Baseline exams were done between 1966-1972 on 57,000 people. Prior to the baseline exam, patients filled out a questionnaire about history of disease, symptoms, occupation and smoking. Height, weight and the thickness of the triceps skin fold on the right arm were all measured as part of the physical exam. Body mass index (BMI) was calculated to be used as a measure of obesity. Records from this examination were cross-referenced with records from the hospital discharge register. All patients who had been discharged between 1970 and 1980 with a diagnosis of herniated lumbar intevertebral disc were identified and matched with four controls each by sex, age and place of residence. Those younger than 20, older than 59, those who had severe back pain or sciatica, and those who had been pregnant at the baseline exam were excluded. Body height was a significant predictor of disc herniation, with an increase in relative risk of 5% in men (RR = 1.048; 95% CI, 1.022-1.076) and 4% in women (RR = 1.037; 95% CI, 1.000-1.074) per centimeter increase in height. BMI was predictive for risk of herniated disc in men but not women. Highest risk was in the 28.0-29.9 kg/m² category (RR = 3.1; 95% CI, 1.6-6.1). The authors concluded that height was significantly predictive of severe lumbar disc syndrome in the general public and BMI was predictive of lumbar disc herniation in men.]**

Hellstrom PA, Tammela TL, Niinimaki TJ. Voiding dysfunction and urodynamic findings in patients with lumbar spinal stenosis and the effect of decompressive laminectomy. Scand J Urol Nephrol 1995;29:167-71. **[Case series of 18 patients, 12 men and 6 women between ages 34-65. Patients presented consecutively to orthopedic division of a medical hospital with severe symptoms of spinal stenosis. Nine of the men and six women underwent an operation and both pre- and post-surgery urodynamic examinations. Two patients chose to forego surgery and one opted out of the post-surgery urodynamic examination. All cases of stenosis were verified by CT scan. The mean duration of symptoms was 90 months (range 6-480). Follow-up assessments were conducted 12-36 months after the operation. Pre-operatively, 12/18 patients had some kind of bladder dysfunction. Only 3 had bladder symptoms post-operatively. In the pre-operative phase, 13 patients fell in the normal range of urological findings, whereas 8 patients were normal post-operatively. Calculations of the urodynamic results from all patients showed that there were no changes in micturition or cytometry results. The urethral pressure profile was the only test that showed a change, which was a rise in the maximum urethral pressure and urethral closure pressure (p<0.05 for both). The conclusion is that urodynamic findings in spinal stenosis patients are ambiguous. More electrophysiological studies must be done in conjunction with urodynamic studies to understand more about bladder and urethral function in stenosis patients.]**

Hernandez-Perez, PA. Analysis of the Lumbar Disectomy Complications. Neurocirugia 2005;16(5):419-26.

Herzog$_a$ R. The radiologic assessment for a lumbar disc herniation. Spine 1996;21(24S):19S-38S. **[Narrative review. The review included 90 studies from 1950-1995. The authors concluded that MRI and CT are both very useful diagnostic tools but that MRI has significant advantages over CT. For example, MRI does not use ionizing radiation and it produces multiplanar images with more resolution than CT. They also concluded that these imaging modalities are most useful in the selection of surgical candidates and for further investigation into conditions that do not respond to conservative therapy.]**

Herzog$_b$ W. Mechanical, physiologic, and neuromuscular considerations of chiropractic treatments. In: Lawrence DJ, Cassidy JD, McGregor et al. (Eds) Advances in Chiropractic, Vol 3. New York: Mosby-Year Book. 1996:69-285.

Hofferberth B, Gottschaldt M, Grass H, Buttner K. The usefulness of dexmethasonephosphate in the conservative treatment of lumbar pain—a double-blind study. Arch Psychiatr Nervenkr 1982;231:359-7. **[German]**

Hooper PD. Physical Modalities: A Primer for Chiropractic. Baltimore, MD: Williams & Wilkins;1996. **[Based on referenced opinion, textbook.]**

Hubka MJ, Taylor JAM. Lumbar disc herniation: Chiropractic management using flexion, extension, and rotational manipulative therapy. Chiro Tech 1991;3(1):5-12. **[This is a case study of a 28 y.o. male dancer who presented to the Los Angeles Chiropractic College health center with LBP and right posterior thigh pain radiating to the right posterior calf. A diagnosis of L5-S1 disc herniation with associated muscle and joint dysfunction was made. An MRI showed that the medial portion of the herniation was contained but the lateral portion was noncontained. The medial portion of the herniation was compressing the S1 nerve root. The patient was treated with conservative chiropractic care 2x/day for 16 days. The outcomes measured were: Pain relief, restoration of function, and prevention of recurrence. On days 1-4 the patient was treated with Cox flexion-distraction at L5-S1, supine posterior to anterior manipulation of the T12-L1 segment, and post-isometric relaxation of the iliopsoas and rectus femoris muscles. On days 5-11 flexion-distraction mobilization continued, and side posture rotation adjustments in the pain-free direction as well as rocker board exercises were implemented. At day 7 his calf pain was gone and he had only moderate LBP. He had slight sensory loss in his right calf, and the Achilles reflex was +2 and sluggish (baseline was +1 and sluggish). On day 12 the patient was tested again for directional preference. Lumbar flexion and rotation were improved, but not extension, although the extension did not recreate his calf pain as it did at baseline. From day 12-16, the patient was given lumbar extension exercises per the McKenzie method and post-contraction stretching instead of post-isometric relaxation. On day 16 the patient was discharged with no low back or leg pain and a +2 sluggish Achilles reflex being his only neurological deficit. At 6-month follow-up, the patient had returned to his professional dancing career with full functional capacity and no recurrence of pain. The authors conclude that in this case, several adjustive techniques were effective in the treatment of an L5-S1 disc herniation, along with stretching, strengthening and balance exercises.]**

Hudson-Cook N, Tomes-Nicholson K, et al. A revised Oswestry Disability Questionnaire. In: Roland MO, Jenner JR (Eds). Back Pain: New approaches to rehabilitation and education. New York: Manchester University Press; 1989.

Hurley DA, McDonough SM, Dempster M, Moore AP, Baxter GD. A randomized clinical trial of manipulative therapy and interferential therapy for acute low back pain. Spine 2004;29:2207-16.

Hurley DA, Minder PM, McDonough SM, Walsh DM, Moore AP, Baxter DG. Interferential therapy electrode placement technique in acute low back pain: a preliminary investigation. Arch Phys Med Rehabil 2001;82:485-93.

Hurwitz EL, Morgenstern H, Harber P, Kominski GF, Yu F, Adams AH. A randomized trial of chiropractic manipulation and mobilization for patients with neck pain: Clinical outcomes from the UCLA Neck-Pain Study. Am J Public Health 2002;92(10):1634-41.

Jagbandhansingh MP. Commentary: Most common causes of malpractice lawsuits. JMPT 1997;20(1):60-4.

Jarzem PF. Transcutaneous electrical nerve stimulation (TENS) for chronic low back pain, presented at the annual meeting of the American Academy of Orthopaedic Surgeons, San Francisco, 1997. Backletter 1997;12(4):42-3.

Jaskoviak PA, et al. Applied Physiotherapy: Practical Clinical Applications with Emphasis on the Management of Pain and Related Syndromes, 2nd ed. Arlington, VA: The American Chiropractic Association; 1993. **[Based on referenced opinion, textbook.]**

Jensen MC. Magnetic resonance imaging of the lumbar spine in people without back pain. NEJM 1994;331:69-73. **[Cross-sectional study including 98 asymptomatic individuals between 20 and 80 years old. Volunteers were excluded if they had had a history of back pain lasting at least 48 hours and/or a history of lumbosacral radiculopathy. MRI's were taken of all 5 lumbar intervertebral discs. Twenty seven MRI's from symptomatic individuals were included with those from the 98 subjects in this study and they were all evaluated by two neuroradiologists who were blinded to the clinical status of the subjects. The subjects rated their level of physical activity on a scale from 0-4, as follows: 0=no exercise, 1=occasional exercise, 2=weekend exercise, 3=three to four workouts/week, and 4=five or more workouts/week. Disc abnormalities were found in 64% of asymptomatic subjects and 38% of them had multi-level abnormalities. Sex was not statistically related to bulges and age was not related with protrusions. Age did, however, correspond to disc bulges (P<0.001) and having more than one disc abnormality. In the 50 and over age group, 67% (18/27) had more than one abnormality, compared to 27% (19/71) of those who were younger than 50 years (P<0.001). In the 48 people with a physical activity score of 3 or 4, 16% had protrusions at L5-S1, compared to 4% of the 50 with scores of 2 or less (P=0.05). Other defects noted were Schmorl's nodes in 19 percent of the 98 subjects, annular defects in 14%, facet arthropathy in 8%, spondylolysis in 7%, spondylolisthesis in 7%, spinal canal stenosis in 7%, and intervertebral foramen stenosis in 7%. The authors conclude that individuals without back pain often have disc bulges and protrusions, but not extrusions. These findings suggest that MRI results in individuals with back pain must be considered carefully in conjunction with their clinical presentations.]**

Jensen TS, Albert HB, Soerensen JS, Manniche C, Leboeuf-Yde C. Natural course of disc morphology in patients with sciatica: An MRI study using a standardized qualitative classification system. Spine 2006;31(12):1605-12. **[Cohort study. No confidence interval stated, no blinding done. 154 patients were involved, both male and female, ranging in age from 18-65 years. Subjects were consecutive patients who were referred to the Backcenter Funen, in Denmark, between November 2001 and January 2003. Patients were included if they had radicular pain to the knee or below (unilateral or bilateral), leg pain ≥ 3 on an 11 point box scale that had persisted between 2 and 52 weeks, and age between 18- and 65-years old. Exclusion criteria were cauda equina syndrome, pending workers litigation claims, non-Danish first language, inability to follow treatment protocol due to concomitant disease, past back surgery, spinal tumor, or pregnancy. These patients were included in a RCT and were randomly allocated into an experimental group that received an exercise regimen (McKenzie, stabilizing, or dynamic exercises), and a control group that performed sham exercises. MRI films were taken of all lumbar discs at baseline and at 14 months (12 months post-treatment). Criteria used for outcome assessment were a set of grading terminology for herniated discs that were given as recommendations from the Combined Task Forces of NASS, ASSR, and ASNR. At baseline, asymptomatic disc levels could be found in 139 of 154 patients. At 14 months, disc contour improved in 47% of symptomatic discs, did not change in 49%, and worsened in 4%. Nerve root compromise improved in 60%, was unchanged in 31%, and increased in 9%. A combined 41% of the two less substantial types of disc protrusions improved, whereas 75-100% of the three more serious protrusions improved. The authors cited several potential weaknesses, such as the atypical patients that might present to RCTs in secondary care centers, the use of a low-field scanner instead of a high-field scanner, and interpreter bias by the radiologist. They concluded that the classification system recommended by the Combined Task Force can be used to describe the MRI status of intervertebral discs over time. They also concluded that more prominent herniations have better MRI prognoses, and that the types of exercises prescribed to the patients in this study do not affect the long term MRI prognosis in these types of patients.]**

JointLetter. Presented at the 1997 annual meeting of the American Academy of Orthopaedic Surgeons. 1997;3(3):27. **[Based on unpublished randomized, controlled, double-blind trial of daily treatment for one month. 324 patients were broken up into**

sham TENS (N=83, conventional TENS (N=84), acupuncture TENS (N=78) and biphasic or "nu-wave" TENS (N=79).]

Jonsson$_a$ B, Stromqvist B. Neurologic signs in lumbar disc herniations: Preoperative affliction and postoperative recovery in 150 cases. Acta Orthop Scand 1996;67(5):466-9.

Jonsson$_b$ B, Stromqvist B. Clinical appearance of contained and noncontained lumbar disc herniation. J Spinal Disorders 1996;9(1):32-8. **[In this prospective and consecutive study, 200 surgical patients were categorized into noncontained (extruded or sequestered), prolapsed and focal disc protrusions. Clinical signs and symptoms were analyzed.]**

Kaminski M, Boal R. An effect of ascorbic acid on delayed-onset muscle soreness. Pain 1992;50:317-21. **[A double-blind, randomized, cross-over study of 19 subjects, comparing delayed onset muscle soreness in patients taking Vitamin C compared to a lactose placebo. A difference of 25-44% in muscle soreness was reported.]**

Kanamiya T, Kida H, Seki M, Aizawa T, Tabata S. Effect of lumbar disc herniation on clinical symptoms in lateral recess syndrome. Clin Ortho & Related Research 2002;398:131-5. **[Case-control study. No confidence interval was given. 149 patients who had surgery to treat L5 radiculopathy were included in this study. They were placed into two groups: both groups had lateral recess syndrome caused by bony entrapment of the nerve root by the superior articular process, but the patients in one group had combined disc herniation. In the pure bony entrapment group, there were 90 subjects, 47 men and 43 women of age 19-83 years. There were 59 subjects with associated lumbar disc herniation; 43 were men and 16 were women, aged 19-85 years. Patients were excluded if they had spondylolisthesis. An analysis was done on these two cohorts to elucidate any sort of clinical differences between them. Results showed statistically significant differences in age of onset, post-operative outcomes, effects of lumbar motion on symptoms, nerve tension tests, and motor tests. The results concluded that in this study, symptoms caused by pure bony entrapment occur later in life than those caused by combined herniation. The most common post-operative outcome for the group without disc herniation was no change in lower extremity symptoms. In the herniation group the most common outcome was a change from low back pain to lower extremity symptoms. Pain caused by lumber motion was rated in 3 categories: Pain caused by flexion, pain caused by extension, and pain caused by flexion and extension. In the herniation group, symptoms were exacerbated by flexion in 59%, extension in 58%, and both in 46% of patients. Results of the pure bony group were 17%, 30% and 10%, respectively. 1% of patients without herniation had positive nerve tension tests compared to 42% of those with herniations. The herniation positive group also had a significantly higher rate of level 4 paralysis when motor tested, 47% compared to 29% of those without herniation. No weaknesses of this study were identified by the authors. They concluded that there are different causes of nerve root compression in the lateral recess and that these causes can result in different clinical presentations.]**

Kappeller P, Fazekas F, Krametter D, et al. Pyrogenic infectious spondylitis: Clinical, laboratory and MRI features. Eur Neurol 1997;38:94-8. **[Case Series. 41 patients with Pyogenic Infectious Spondylitis were included in this series. These were consecutive patients that were diagnosed with PIS confirmed by MRI by the Neurology Group at the MR Center of Karl Franzens University in Austria from 1989-1995. 27 were male and 14 were female. 30 out of 41 were over the age of 50. Subjects were excluded if they had prior back surgery. This series was done to report the clinical and laboratory findings in these patients. Focal back pain was found in 37 subjects. In 22 patients, pain had persisted for more than 30 days. Radicular signs were found in 24, spinal cord symptoms in 12, and fever in 25 subjects. 10 of them had diabetes mellitus. ESR was greater than 30 mm/Hg in 31 individuals and leukocyte count was higher than 10,000/mm^3 in 25 out of 41 subjects. No weaknesses in this study were mentioned by its authors. They concluded that the incidence of PIS is higher than previously thought, and that since this disease commonly presents with neurological symptoms, neurologists should be quick to order spine MRI when focal back pain is accompanied by fever and laboratory signs of inflammation.]**

Karppinen J, Malmivaara A, Kurunlahti M, et al. Periradicular infiltration for sciatica: A randomized controlled trial. Spine 2001;26(9):1059-67. **[Double-blind RCT. Subjects were included if they had unilateral leg pain at least as severe as their back pain that radiated dermatomally from the back to below the knee for between 3 and 28 weeks. They were excluded if they had a prior back operation, an application for early retirement, clinical depression, anti-coagulant therapy, unstable diabetes, if they had an epidural injection in the 3 months preceding the study, if they were pregnant, allergic to the treatment ingredients, or if they had rare causes of sciatica like synovial cysts and non-degenerative spondylolisthesis. Subjects were recruited from nearby general medical practices to the University Hospital of Oulu, Finland. Patients rated their back and leg pain on a 100mm visual analog scale (VAS) and their disability with the Oswestry Low Back Disability Questionnaire. They used the Nottingham Health Profile to rate quality of life on a scale from 0 (best) to 100 (worst). The physical examination included the straight leg raise (SLR) with a goniometer, lumbar flexion measured by the modified Schober method, tendon reflexes, sensibility and motor function. The patients, physicians and radiologists that gave injections were all blinded. All patients received periradicular infiltration with either a methylprednisolone-bupivicaine combination or isotonic sodium chloride at the L4, L5 or S1 nerve roots. 80 patients were in each treatment group. Follow-up was conducted immediately after the injection and at 2 weeks, 1, 3 and 6 months, and 1 year. Immediate results showed that leg pain in the placebo group was reduced by 44% and back pain by 53%, while the steroid group decreased by 61% and 52%, respectively. Reduction in leg pain in the steroid group was significantly better than placebo (11.9; 95% CI, 2-21.8; P=0.02). Significant improvements from baseline were seen at 2 weeks in all categories except lumbar flexion. Steroids were significantly better than placebo in the leg pain (12.5; 95% CI, 1.6-23.4; P=0.02), SLR (6; 95% CI, 1-12; P=0.03), lumbar flexion (0.4; 95% CI, 0.1-0.8; P=0.05), and patient satisfaction (12.1; 95% CI, 1.2-23; P=0.03) categories. There were no significant between-group differences at 4 weeks. The only significant difference at 3 months was in reduction of back pain with the placebo being more effective than steroids (-12.2; 95% CI, -23.5 to -1.0; P=0.03). The placebo was also more effective at reducing back pain (-13.5; 95% CI, -24.6 to -2.4; P=0.02) and leg pain (-16.2; 95% CI, -26.8 to -5.6; P=0.003) at 6 months. There were no significant differences between placebo and steroid group at one year. The authors did not cite any weaknesses in this study. They concluded that the study suggests that the methylprednisolone-bupivicaine injection only provides short-term benefit and is no better than saline in the long term.]**

Kelsey JL, Githens PB, O'Conner T, et al. Acute prolapsed lumbar intervertebral disc. An epidemiologic study with special references to driving automobiles and cigarette smoking. Spine 1984;9(6):608-13. **[Case-control study. Subjects ranged in age from 20-64. Inclusion criteria were divided into 3 different groups: surgical cases, probable cases, and possible cases. Surgical cases either had a prolapsed disc that was seen during surgery, a history suggesting pain distribution along the sciatic nerve, and/or a positive straight leg raise (SLR) or other nerve tension test. The probable cases did not include those whose**

protrusions were seen during surgery, but did include those with sciatic pain in both the thigh and lower leg or sciatic pain in one part and numbness in another. Those in the possible group had either pain in the lower leg or thigh, but not both. They were also put in the possible group if their leg was numb and the SLR increased low back pain. Subjects were excluded if they had a previous lumbar or cervical prolapsed disc, previous neck, back, leg or arm problems causing activity restriction for more than 4 weeks, or if current symptoms > 1 year. Controls were selected by matching each subject with a person in the same 10-year age group (20-29, 30-39, etc.) who presented with conditions not related to the spine. Controls were selected from the same participating hospitals and clinics as the experimental cases and were subject to the same exclusion criteria. Controls could not be found for 84 of the 325 cases because of lack of funding or failure to pass the exclusion criteria. Questionnaires and diagnostic tests were taken by trained nonmedical personnel either in the hospital or in the homes of 72% of eligible cases and 79% of matched controls. Cases were more likely than controls to have smoked cigarettes in the past year (OR=1.7; 95% CI 1.0-2.5). Cases also spent more time in automobiles per week, at 10.2 hours compared to 8.3 hours per week in controls (P=0.008). The authors conclude that cigarette smoking, automobile driving, and lifting while twisting (discussed in a previous paper) are all risk factors for lumbar disc prolapse and are all preventable.]

Kelsey JL, White AA 3rd. Epidemiology and impact of low-back pain. Spine 1980;5(2):133-42. **[Narrative review of 115 studies dating from 1939-1978. No quality ratings were given. The authors conclude that LBP has a significant impact on the individual as well as the society and that more resources should be allocated to researching low back conditions to lessen that impact.]**

Kennedy J, Mullett HJ, O'Rourke K. Cauda equina syndrome. Contemp Spine Surg 2001;2(4)23-6.

Kerr RS, Cadoux-Hudson TA, Adams CB. The value of accurate clinical assessment in the surgical management of the lumbar disc protrusion. J Neurol Neurosurg Psychiatry 1988;51(2):169-73.

Keskimäki I, Seitsali S, Österman H, Rissanen P. Reoperations after lumbar disc surgery: A population-based study of regional and interspeciality variations. Spine 2000;25(12):1500-8. **[Follow-up study. Discharge records from Finnish hospitals were searched for patients who underwent lumbar spine surgery more than once in the period from 1987-1995. The first operation done on each patient was labeled as the index procedure. Those whose index procedure was a lumbar discectomy were included in this study. Patients who underwent spinal fusion as well as discectomy were excluded from the study. During the study period 25,366 patients underwent lumbar disc surgery, with 3,118 of them having at least one reoperation. Average follow-up time was 4.1 years. Types of reoperations were discectomies (76.5%), another type of decompression (20.8%), and fusion (2.7%). Mortality rate during follow up was 1.8% (n=449). Nine-year cumulative risk of reoperation was 18.9%. Those under age 50 had a significantly higher risk of reoperation than those above 50 (20.2% compared to 14.3%, respectively). Patients whose index operation was between the years 1987-1989 had a risk of reoperation of 9.7%. From 1990-1992 the risk was 10.8%, and from 1993-1995 the risk was 12.5%. Relative risk of reoperation for surgeries performed in neurosurgical settings versus those done in orthopedic settings was 1.57 (95% CI, 1.17-2.10). The weakness of this study is that no clinical data were available on patients regarding medical and surgical histories, severity, disc level, or side of involvement. The authors conclude that this study and previous studies show that the reoperation risk after lumbar discectomy is between 10-20%.]**

Khoromi S, Patsalides A, Parada S, Salehi V, Meegan JM, Max MB. Topiramate in chronic lumbar radicular pain. J Pain 2005;6:829-36. **[A prospective, double-blind, randomized crossover study of 42 volunteers with lumbar radiculopathy, to assess the efficacy of the anti-convulsant topiramate in treatment of chronic sciatica vs. active placebo diphenhydramine. Inclusion required being 18-75 years old, experiencing average leg pain of at least 4/10 intensity for the preceding month, refraining from changing dose or intake of non-study medications for sciatica, and having evidence of lumbar radiculopathy. Radiculopathy was based on pain in one or both buttocks or legs for 3 or more months for at least 5 days per week, along with at least one of the following signs/symptoms on the side of the leg pain: 1) sharp and shooting pain below the knee, 2) pain with straight leg raise at 60 degrees or less, 3) decreased/absent ankle reflex, 4) weakness of muscles below the knee, 5) L5/S1 sensory loss, 6) EMG evidence of L4, L5, or S1 root degeneration, or 7) MRI or CT/myelogram evidence of lower lumbar nerve root compression. The following patients were excluded: pregnant or lactating, those with pain of greater intensity in any other location other than the low back or leg, and those with fibromyalgia, polyneuropathy, or peripheral vascular disease. Primary outcome measure were intensity of leg pain, (0-10 pain scale), global pain scores (leg and back pain combined), Beck Depression Inventory, Oswestry Low Back Pain Disability Questionnaire, and 36-item Short Form of Health Survey (SF-36). Of the 29 patients who completed the study, topiramate reduced average leg pain (based on primary outcome marker) by 19% (CI 41% to -3%) compared to placebo. In addition, patients reported significant global pain relief on topiramate (54% rating pain relief as moderate or better vs. 23% with placebo). Beck Depression scores, Oswestry scores, and SF-36 scores showing no significant difference between topiramate and placebo. Adverse effects of topiramate which caused subjects to withdraw from the study included: acral paresthesia (2 subjects), nausea/anorexia (2 patients), sedation/amnesia (3 patients), depression/anxiety (1 patient), rash (1 patient). In study completers, 86% experienced side effects on topirinate vs. 72% on placebo, most commonly being paresthesia (38% topiramate, 21% placebo) and fatigue/weakness (34% topiramate, 31% placebo), with significantly more patients experiencing sedation (34%) and diarrhea (30%) on topiramate vs. placebo (3% and 10% respectively), and greater percentage of patients experiencing leg cramps on placebo (17%) vs. topiramate (7%). In conclusion, the authors do not rule out the possibility that apparent pain reduction was due to chance or dropout bias, but consider it to be more likely that topiramate has a small analgesic effect on chronic lumbar radiculopathy. The authors find that topiramate is best utilized as a second-line treatment due to prominent side effects, frequent drop out, and modest level of pain improvement.]**

Kibler WB, Herring SA. Functional Rehabilitation of Sports and Musculoskeletal Injuries. Gaithersburg, MD: Aspen; 1998.

King L, Mior SA, et al. Adolescent lumbar disc herniation: A case report. J Can Chiropr Assoc 1996;40:15-18. **[Case Report; A 14-year-old female presenting to a chiropractic clinic with bilateral LBP and right buttock and lateral thigh pain. Onset was insidious. Pain was increased by sitting and coughing, while lying supine or standing alleviated the pain. Neurological signs were all negative. The SLR produced leg pain on the right at 20 degrees. Left leg raise produced right buttock pain. Lumbar flexion was significantly restricted. External rotation of the right hip (passive and resisted) produced pain in the right buttock. Radiographs were negative. Patient was diagnosed with L5-S1 nerve root irritation associated with L5-S1 disc herniation, and treated with side posture lumbar spinal manipulation, and lumbosacral soft tissue and interferential**

current therapy. Symptoms worsened in the first week of treatment, after which the patient was referred to a neurologist who prescribed anti-inflammatory medicine and referred the patient back to the chiropractor. After two more weeks of conservative treatment with no improvement, the patient underwent surgery for removal of the protruded disc. After a follow-up of 4 weeks, the patient reported no pain and unrestricted daily activities. No weaknesses of this study were mentioned, nor were any statistical analyses done. The author concluded that adolescent disc herniation can present differently than it does in adults, and that this case demonstrates some of the difficulties in assessing and treating adolescent disc herniations.]

Klecamp J. Results of elective lumbar discectomy for worker's compensation patients. Presented at the annual meeting of the American Academy of Orthopaedic Surgeons, San Francisco, 1997. The BackLetter 1997;12(5):51.

Klenerman L, Slade PD, Stanley IM, et al. The prediction of chronicity in patients with an acute attack of low back pain in a general practice setting. Spine 1995;20:478-84. **[Case Series. 151 males and 149 females were included on two conditions: First, they had to present with a first or new episode of low back pain that was benign and musculoskeletal in nature, and second, the onset of their pain had to occur a week or less before the time they presented to their general practitioner. These patients were selected from general medical practices according to these inclusion criteria and were asked to complete questionnaires at the acute stage and at 2 and 12 month follow ups. At the acute stage patients completed a questionnaire that included questions about their demographics, the history of their LBP, and the four fear-avoidance contextual variables. These variables are Stressful Life Events, Personality, Previous Pain History, and Pain Coping Strategies. At two months, they were asked again about these four variables and some additional measures, such as Pain Drawing, Modified Zung Depression Inventory, Oswestry Disability Scale, and Inappropriate Signs and Symptoms. A physical examination was also performed on each of the subjects at this time. Only 196 of the original 300 were available for the two month follow up and three of them refused the physical exam. At 12 months, subjects were asked to fill out a mailed questionnaire that included all of the questions from the two month follow up as well as an additional inquiry into the course of their back pain during the 12 month study period. 138 individuals responded to this mailing. Then they were sorted into three groups – those with no pain, intermittent pain, and constant pain. Statistical comparisons were made between all three subgroups using data collected at the acute stage. 123 subjects were present at all three stages of the study. This study concludes that if a patient's low back pain does not subside or significantly improve in two months, then the patient will become a chronic low back pain sufferer. The biggest predictor of the outcome of these patients' treatment in the first two months is the Fear-Avoidance model.]**

Kobayashi S, Shizu N, Suzuki Y, Asai T, Yoshizawa H. Changes in nerve root motion and intraradicular blood flow during an intraoperative straight-leg-raising test. Spine 2003;28(13):1427-34. **[Case Series. Subjects included were 9 males and 3 females, age 19-63 years. Each had lumbar disc herniation for which they underwent a microdiscectomy. Patients were chosen for surgery because their sciatica was not alleviated by conservative approaches like analgesic medications and epidural blocks. Exclusion criteria were not mentioned. The mean duration of sciatic pain was 6 months. Eight patients were operated on at L4-L5 disc and four at L5-S1. Preoperative SLR was performed to measure the angle at which sciatic symptoms occurred. Then intraoperative SLR was performed in the prone position while the nerve root blood flow was observed using a microscope and a laser Doppler flow meter. At the L4-L5 nerve root, flow decreased during the intraoperative SLR by an average of 33.3% at 20 seconds and 27.2% at 50 seconds after starting the test. At the L5-S1 root, flow was decreased by averages of 30.5% and 26.1% at 20 and 50 seconds, respectively. After the intraoperative SLR test, flow recovered at L4-L5 by averages of 103.8% at 20 seconds and 101.7% at 50 seconds. L5-S1 recovery was an average of 104.3% after 20 seconds and 105.3% at 50 seconds after the end of the SLR test. These procedures were repeated 3 times to confirm reproducibility of the results. Nerve root movement was also observed by microscope. In all 12 patients, the hernia had adhered to the dura of the nerve root. At the L4-L5 root, movement was 0-2mm and at L5-S1, the root moved 0-1mm. Then the hernias were removed. This time, nerve roots moved an average of 3.8mm at L4-L5 and 4.1mm at L5-S1. After microdiscectomy there was no significant decrease in intraradicular blood flow. In 7 of the 12 subjects, blood flow increased post-SLR by 110% or more. One week after the operation, all 12 subjects had negative SLR test results. The authors did not mention any weaknesses in this study. They concluded that adhesions between herniated discs and nerve roots can cause mechanical stress and restriction of movement of the nerve roots, thereby causing a reduction in intraradicular blood flow and sciatic pain. Inflammatory reaction is necessary for the natural involution of herniated discs, but it is important to control this inflammation in the treatment of patients with herniated discs.]**

Koes BW, van Tulder MW, Ostelo R, et al. Clinical guidelines for the management of low back pain in primary care: an international comparison. Spine 2001;26:2504-13.

Koes BW, van Tulder MW, Peul WC. Diagnosis and treatment of sciatica. BMJ 2007;334(7607):1313-7. **[Qualitative systematic review; 25 articles were included; they were published between 1983 and 2006. No quality ratings were given for the articles that were reviewed. The authors conclude that future research must be done on conservative treatment for L4-L5 disc herniation, since none exists for or against it. It was also stated that lifestyle changes and multidisciplinary treatment have not yet been studied. Overall, more research must be done to explore how important signs and symptoms are in the prognosis of sciatica and how it responds to different treatments.]**

Komori H, Shinomiya K, Nakai O, et al. The natural history of herniated nucleus pulposus with radiculopathy. Spine 1996;21(2):225-9. **[Case series. 48 men and 29 women were included in this retrospective study of patients with unilateral leg pain caused by a lumbar disc herniation. All patients were treated conservatively with one or more of the following: rest, drugs, and pelvic traction. Six patients were treated with selective radicular block. 19 subjects were treated in a medical hospital due to the severity of their symptoms, while the rest were treated in an outpatient clinic. The exclusion criteria were lumbar canal stenosis, spondylolysis, and spondylolisthesis. Each patient was examined by MRI at least twice during treatment. The first follow-up MRIs were taken at the first change in leg symptoms. If the improvement related to a change that could be seen on the MRI, no additional follow-up scans were done. If there were no recognizable differences on the first follow-up MRIs, then additional images were taken 3-6 months after the first follow-up. The mean interval between the baseline MRI and the last MRI was 262 days. Blinding was achieved by excluding clinical information from the observer who analyzed the morphologic changes between each patient's MRIs. The changes were put into four categories: Disappearance of the herniated nucleus pulposus, a marked decrease in herniation, slight decrease in herniation, and no change in size. There were 3 types of herniated nucleus pulposus (HNP) identified. Type 1 had continuity of low signal area along the posterior**

margin of the disc. Type 2 did not have a continual posterior margin, and Type 3 was a migrating hernia. Physical exam results were recorded as follows: Excellent, if radicular symptoms disappeared and neurologic signs improved; good, if radicular pain decreased with improving neurologic signs; poor if neither radicular pain nor neurologic signs showed improvement. The mean clinical follow-up period was 577 days. In hernia classification only one case was classified differently between observers, and there were no discrepancies in the intraobserver test. In rating the morphologic change between MRI, 3 cases were graded differently between observers, and one case was graded differently by the same observer. The MRI changes corresponded to clinical outcomes in 64 patients. These results were statistically significant (P<0.001). The cases that showed the greatest morphological change had a significantly shorter duration of leg symptoms than those showing the least change (P<0.01). The authors concluded that morphologic changes on MRI generally correspond to clinical improvement, but the clinical improvements tend to happen before the morphological change. Also, migrating herniated nucleus pulposus disappears more frequently than any other type of HNP.]

Kopp JR. The use of lumbar extension in the evaluation and treatment of patients with acute herniated nucleus pulposus. Clin Orthop Related Research 1986;(202):211-8. **[Case Control. 67 patients, ages 17-62, were included according to these criteria: acute onset or worsening of LBP with pain radiating to the calf or foot, at least one sign of nerve root irritation, sufficient documentation of lumbar extension in their medical records, absence of other etiological factors. Exclusion criteria were: other causes of LBP, wrong diagnosis of herniated nucleus pulposus (HNP), inadequate description of lumbar extension in chart notes. The subjects were grouped into two categories, surgical and nonsurgical. 35 patients were in the nonsurgical group, which meant they were discharged from the hospital, their neurological signs and radiating pain resolved, and they returned to normal activity. The surgical group of 32 subjects did not respond to conservative treatment. 34, or 97%, or nonsurgical subjects achieved full lumbar extension at presentation or 1-5 days after. Only 2, or 6.2%, or surgical cases achieved full lumbar extension at any time prior to surgery. These results were statistically significant (P<.005). In this study, patients who achieved full lumbar extension did not need surgery. Further research should be conducted to investigate the efficacy of lumbar extension exercises for treatment of HNP.]**

Kortelainen P, Puranen J, et al. Symptoms and signs of sciatica and their relationship to the localization of the lumbar disc herniation. Spine 1985;10:88-92. **[A prospective descriptive study of 403 patients with sciatica who underwent surgery and had disc excisions, L2-3 discs in 3 cases, L3-4 in 7 cases, L4-5 in 229 cases and L5-S1 in 164 cases. There were no controls. Mean age 41 years; males 62%; 35% heavy manual occupations, 30% light manual occupations; this is one of the studies cited in the AHCPR guidelines.]**

Kosteljanetz M, Esperen JO, Halaburt H, Miletic T. Predictive value of clinical and surgical findings in patients with lumbago-sciatica. A prospective study (Part 1). Acta Neurochir 1984;73(3-4):213-21. **[Prospective study. 49 females and 51 males were included. Inclusion criteria: Low back pain with at least one symptom of root compression, lumbar rigidity, no satisfactory improvement after 3 weeks of conservative treatment. Exclusion criteria: bilateral symptoms, previous back surgery and previous myelogram. All patients underwent partial hemilaminectomy. Herniations were classified into five categories: Complete herniation, incomplete herniation, soft disc, hard disc, and normal disc. A follow-up exam was performed on all patients by a neurosurgeon 5-24 months post-surgery. Outcomes were reported as excellent, improved, unchanged, or worse. 42 patients had an excellent outcome, 35 improved, 23 had a poor outcome, 19 unchanged, and 4 worse. Only male sex and scoliosis were associated with a good outcome (either excellent or improved, P<0.01). 90% of those with a typical Lasegue's sign had root compression confirmed by surgery, compared to only 66% of those with an atypical Lasegue's sign (P<0.01). The result of Lasegue's sign had no correlation with outcome. The only hernia classification that was related to a good outcome was a complete herniation. This is the most significant predictor of surgical outcome. No clinical finding is diagnostic of disc herniation or surgical outcome.]**

Koures DS, Loupassis G, Stamos K. Results of discectomy: A study using 15 different evaluation methods. Eur Spine J 1992;1:20-24.

Kraemer J. Presidential address: Natural course and prognosis of intervertebral disc diseases. International society for the study of the lumbar spine. Spine 1995;20(6):635-9. **[Address given by the president of the International Society for the Study of the Lumbar Spine. In summary, the author states that intervertebral discs are osmotic and live by motion. Three factors are considered in the natural course of disc disease: Disc degeneration, morbidity of the disc, and the individual pain curve of discogenic sciatica. Morbidity is highest in middle age, unlike degeneration. Most acute back pain and sciatica will self-resolve if given enough time. The author refers to this as the waiting list phenomenon, stating that few patients actually undergo back surgery because their pain curve drops during the time they have to wait for their scheduled surgery. The author also states that Post-discotomy Syndrome (PDS) is the largest spine disorder. Therefore, open discotomy is the most important back surgery and proper patient selection and good technique in microsurgery are very important to minimize the development of PDS.]**

Kuisma M, Karppinen J, Niinimäki J, et al. Modic changes in endplates of lumbar vertebral bodies: Prevalence and association with low back and sciatic pain among middle-aged male workers. Spine 2007;32(10):1116-22. **[Diagnostics]**

Kumar A, Varghese M, Mohan D, et al. Effect of whole-body vibration on the low back: A study of tractor-driving framers of North India. Spine 1999;24(23):2506-15. **[Retrospective cohort study on 50 tractor-driving farmers (TDFs) and 50 non-tractor-driving farmers (NTDFs) in North India. Groups were matched for age, gender, ethnic group, land-holding, and work routine. The only significant differences between groups were weight and abdominal girth, with the TDFs being larger in both categories (P=0.046 and 0.006, respectively). Twenty-eight TDFs had ever had back symptoms, with 20 of them complaining of regular backaches. Sixteen NTDFs had ever had back symptoms and 9 had regular backaches. Both the number of lifetime back symptoms and recurring symptoms were significantly different between groups (P=0.015 and P=0.015). Knee jerk reflexes were absent bilaterally in 7 TDFs and 0 NTDFs (P=0.021). There were no differences, however, in quadriceps strength between groups. MRIs of both groups were evaluated by 3 experts and no differences were found between groups. One weakness of this study is that it did not examine psychogenic sources of pain. The authors conclude that in this study the TDFs had a higher rate of self-reported back pain, but there were no clinically objective differences between the two groups.]**

Lauridsen HH, Hartvigsen J, Manniche C, Korsholm L, Grunnet-Nilsson N. Responsiveness and minimal clinically important difference fro pain and disability instruments in low back patients. BMC Musculosk Disord 2006;7:82. **[A prospective, cohort study of 191 patients to compare clinically meaningful change (responsiveness) and minimal clinically important difference (MCID) for subpopulations of LBP patients, using 4 commonly utilized functional status questionnaires and 3 pain scales when**

applied to 4 separate patient subpopulations. Patients were recruited from 7 chiropractic practices and an outpatient hospital back pain clinic. Inclusion criteria consisted of the following: >18 yo, LBP and/or leg pain, ability to read/understand Danish. Patients were excluded if pathology or trauma of the spine was suspected. A questionnaire booklet was given to each patient containing the Oswestry Disability Index, Roland Morris Disability Questionnaire (RMQ), Low Back Pain Rating Scale (LBPRS), and SF-36 with follow up data tracked at 1, 8 and 9 weeks. Patients were subdivided into 4 groups based on pain location (LBP only vs. leg pain/LBP) and severity of condition as determined by entry point into health care system (chiropractic clinic vs. hospital). Confidence intervals were reported at 95%. Limitations of the study include the fact that ODI and RMQ should not be solely viewed as disability questionnaires since they contain functionally related questions, while SF-36 measures ADLs and LBPRS partly measures pain related functional disability, which may also present a problem. A second reported problem was the lack of adequate ability to further subdivide the patient populations for less wide-spectrum grouping. Third, a global retrospective appraisal of change may present recall bias problems, as well as the problem of combining improvement and importance, though this is a concept central to MCID. RMQ was found to be more responsive in LBP patients, with ODI and RMQ being equally responsive in those patients with leg pain. No difference was found based on severity of condition. LBPRS was inconclusive in all subpopulations, with all pain scales showing similar responsiveness. MCID was only slightly affected by severity of condition and pain location, with increasing baseline entry increasing the MCID size in the LBP patients and those in the lower severity group, leading to a need for researchers to calculate MCIDs relevant to individual study populations.]

Leathwood PD, Chauffard F, Heck E, Munoz-Box R. Aqueous extract of valerian root (Valeriana officinalis L) improves sleep quality in man. Pharmacol Biochem Behav 1982;17:65-71.

Lejeune JP, Hladky JP, et al. Foraminal lumbar disc herniation. Spine 1994;19(17):1905-8. **[Retrospective study of 83 patients undergoing surgery for lumbar disc herniation for whom CT demonstrated a "foraminal" or "extra-foraminal" herniation, to develop clinical and radiologic diagnoses, evaluate interlaminar and extra-articular exposures, as well as evaluate postoperative results. Patient population included 56 men and 27 women age 24-75 years. Subjects were selected from 1968 patients who underwent surgery between January 1986 and June 1990 at Hospital B in Lille, France. Two-year follow-up was obtained for all patients involved. Clinical, radiologic and surgical findings were reviewed for similarities. Similarities in clinical findings revealed 90% patient complaint of LBP. Severe radicular signs were noted, with 100% complaint of leg pain which was unresponsive to conservative measures, and which was found to always involve the nerve root above, or simultaneously at and above, the level of the herniation. Dermatomal deficits were more frequently present when compared with a 100 case series of posterolateral herniation patients, including sensory impairment (42/83 patients vs. 29/100 posterolateral herniation patients), motor weakness (40/83 vs. 15/100), as well as biradicular symptoms (34/83 vs. 11/100). Radiologic review found that 86% of study patients had herniations at the L4-L5 and/or L5-S1 levels. Surgical review revealed that interlaminar exposure with partial resection of the upper lamina and medial facet was adequate visualization in 88% of patients. Complete postoperative relief was reported by 76% of patients, with the remaining 20 patients reporting improvement but with mild residual radicular pain. The authors conclude that a characteristic clinical picture is often present in foraminal herniations, including severe radicular signs and symptoms, with diagnosis requiring high resolution CT, CT discography, or MRI. Visualization of most foraminal herniations is possible through interlaminar exposure without total facetectomy, while extra-articular exposure should be reserved for far-lateral herniations.]**

Lenehan KL, Fryer G, McLaughlin P. The effect of muscle energy technique on gross trunk range of motion. J Osteop Med 2003;6(1):13-18.

Lesiak A, Zarski S, et al. Critical assessment by Lasegue test of effects of spine traction and manual therapy in treating L4/L5 and L5/S1 disc lesions. Manual Medicine 1992;6:185-8.

Lewit K. Manipulative Therapy and Rehabilitatioin of the Locomotor System. London & Boston: Butterworths;1985:178.

Liebenson C (Ed). Rehabilitation of the Spine: A Practitioner's Manual, 2nd ed. Baltimore, MD: Lippincott Williams & Wilkins; 2007.

Lindal E, Stefansson SO. Connection between smoking and back pain, findings from an Icelandic general population study. Scand J Rehab Med 1996;28:33-8. **[Epidemiology study, 862 participants; a subpopulation of 114 smokers with back pain were compared to 160 ex-smokers (quit at least a year previous); 52% of smoking males had invertebral disc problems compared to 34.5% of male ex-smokers; sciatica, however, showed no such correlation; in fact, female smokers had a lower incidence compared to female ex-smokers.]**

Lindsley JG, Hartmann EL, Mitchell W. Selectivity in response to L-tryptophan among insomniac subjects: A preliminary report. Sleep 1983;6:247-56.

Linton SJ. Psychological risk factors for neck and back pain. In: Nachemson AL, Jonsson E (eds.) Neck and Back Pain: The Scientific Evidence of Causes, Diagnosis, and Treatment. Philadelphia, PA: Lippincott, Williams & Wilkins; 2000. **[Textbook]**

Lisi AJ, Holmes EJ, Ammendolia C. High-velocity low-amplitude spinal manipulation for symptomatic lumbar disk disease: A systematic review of the literature. JMPT 2005;28(6):429-42. **[Qualitative systematic review of 16 articles, ranging from 1969-2001. The studies were evaluated for quality according to the guidelines set forth by Harris et al. Patient-based outcomes were used in 14 of the studies. Of these studies, 1 was rated at level I (fair), 1 level II-2 (fair), 7 level III (good), 3 level III (fair), and 2 level III (poor). Two of the studies used intermediate outcomes. One of them was level II-1 (fair) and the other was level II-2 (good). The authors conclude that the existing evidence suggests that high velocity low amplitude spinal manipulation (HVLASM) may be effective for symptomatic lumbar disc disease. The available evidence does not support the notion that HVLASM may be unsafe for patients with SLDD.]**

Lisi AJ. The centralization phenomenon in chiropractic manipulation of discogenic low back pain and sciatica. JMPT 2001;24(9):596-602. **[Case series describing 3 cases of discogenic low back and leg pain, in which the centralization phenomenon was used in determining chiropractic treatment and prognosis. All 3 patients were male, including a 36-, 37-, and 61-year old, with intervertebral disc disease evidenced by MRI. All patients complained of LBP and sciatica, had positive SLR, mild neurologic deficits, and evidence of discogenic disease. Two out of the 3 patients exhibited centralization of pain with provocation. All 3 patients were treated with chiropractic manipulation in side posture, following provocation testing and mobilization as indicated by the McKenzie system. In addition, all patients were treated with ultrasound, manual stretching, and/or massage of the lumbosacral region. Patients reported that the ancillary therapies did not affect leg pain. Each patient was treated for a different length of time based on presenting severity. The 61-year-old patient sought care following a motor vehicle accident 4 months prior, and reported a constant pain of 8/10 on a numerical rating scale (NRS).**

Previous MRI showed left lateralized disc bulges at L3-L4 and L4-L5, with an L5-S1 central subligamentous disc protrusion. This patient was treated with mobilization for 4 visits, followed by High Velocity Low Amplitude (HVLA) manipulation for 4 visits, all spanning a 21-day period at which point he reported LBP to be at 1/10 NRS with decreased but persistent paresthesia in one thigh. Follow-up consisted of 2 treatments over a 4-month period without any significant exacerbations. The 36-year-old patient sought care following heavy lifting/carrying of luggage for the previous 2-week period. He reported LBP of 10/10 NRS and leg pain of 8/10 NRS. Patient was referred to an orthpedic surgeon, and MRI revealed evidence consistent with annular tears at L2-L3, L3-L4, L4-L5, with a posterior central disc protrusion at L5-S1. The patient was treated with pain medication and began chiropractic care 2 days later, beginning with mobilization for 1 visit, followed by HVLA manipulation 4 times over 8 days, at which point the patient reported resolution of his low back and leg pain. Follow-up consisted of 4 visits over 14 months for mild LBP exacerbations with no exacerbation of leg pain. The 37-year-old patient presented following a progressive onset of low back and leg pain of 2 weeks duration which had been worsened by sit-ups 3 days prior. The patient reported constant pain at 8/10 NRS. The patient was treated with mobilization on the first visit and given prone press-up exercises. He was treated with HVLA on the second day, though he had been unsuccessful in centralizing the symptoms with press-ups. The patient returned 1 week later reporting exacerbation of low back and leg pain following business travel. Provocation showed peripheralization of pain in multiple directions. MRI was ordered, showing disc protrusion at L5-S1 and L4-L5, and was suggestive of free fragments at both levels. The patient underwent microdiscectomy at both levels. Weaknesses cited in this study include: small size, no control for ancillary therapy effects, and gold standard used to classify patients being MRI instead of discography. The authors conclude that assessment of centralization phenomenon provided valuable prognostic and diagnostic information in this series with regards to side posture manipulation, with the patients whose leg pain centralized upon provocation experiencing better outcomes than the patient whose pain did not.]

Long D. Persistent back pain and sciatica in the United States: Patient characteristics. J Spinal Disord 1996;9(1):40-58. **[2,374 patients with persistent or intermittent back or leg pain averaging 30 months were followed in this prospective, multi-center study, followed up at 3, 6, 12, 24, 36, 48, and 60 month intervals; 36.7 % had a herniated disc diagnosis.]**

Loupasis GA, Stamos K, Katonis PG, et al. Seven- to 20-year outcome of lumbar discectomy. Spine 1999;24(22):2313. **[Follow-up study of 117 patients who underwent surgery at one level for a prolapsed lumbar disc between 1973-1986 at the Orthopaedic Clinic of Athens University, Greece. All patients were contacted by mail in 1991 to complete a questionnaire, of which 109 responded. The respondents included 76 men (70%) and 33 women (30%) ranging from 15-65 years of age at the time of operation with a mean of 43. The questionnaire's reliability was tested by sending it out a second time in 1993. At that time, the mean follow-up time was 12.2 years, with a range from 7-20. Eight of 109 patients underwent follow-up surgery at a mean of 5.9 years after the initial surgery. Surgical outcomes were assessed using the modified Stauffer-Coventry's criteria. An excellent result was achieved in 40 patients (37%), good in 30 (27%), fair in 26 (24%), and poor in 13 (12%). A satisfactory outcome (excellent or good) was achieved in 74% of men and 48% of women (P<0.02). Twenty-eight of 101 patients who underwent primary surgery still had back or leg pain. Satisfactory (excellent or good) pain relief was achieved in the back in 79% and the legs in 85% of patients. The satisfactory group had significantly fewer symptoms than the unsatisfactory group (P<0.02 for back and P<0.03 for leg). There were 71 patients who were very satisfied with surgery, 31 who were satisfied, and 6 who were dissatisfied. Patients who did heavy manual labor for employment before surgery had less satisfactory results than those who did light work (P<0.01) and those who did medium-strenuous work (P<0.05). Those who did heavy manual labor also had significantly greater complaints of LBP (P<0.04), and leg pain (P<0.05), than those who performed lighter work. Heavy laborers also had a higher mean disability score (35.5 vs. 14.4, P<0.01). This group was also less likely to return to work than those in the light work (P<0.001) and the medium work groups (P<0.02). Seventy-eight percent of those with undergraduate or graduate degrees had a satisfactory result compared to 57% of those with high school diplomas or less (P<0.03). Weaknesses of this study were the retrospective analysis of records, using patient-completed questionnaires to obtain data, and the lack of reliability tests on radiographic measurements. The authors conclude that this group of patients has not had a high rate of success of surgery in the 7 to 20 years of follow-up time. It is suggested that patients with strenuous occupational activity and a low educational status be well informed and properly evaluated to increase the likelihood of satisfactory surgical results.]**

Luijsterburg PAJ, Verhagen AP, Ostelo RWJG, et al. Effectiveness of conservative treatments for the lumbosacral radicular treatment syndrome: A systematic review. Eur Spine J 2007;16(7):881-99. **[Qualitative systematic review concluding that there is no evidence that one type of conservative treatment is superior to any other in treatment of radicular syndrome. Corticocosteroid injection and traction are not recommended due to lack of evidence of effect. No evidence was found on acupuncture. No conclusion could be drawn from the studies on physical therapy, bed rest, manipulation, or medication (NSAIDs). Thirty RCTs were included in this study spanning 1970-2005, with 12/30 being regarded as high methodologic quality.]**

Lurie JD, Sox HC. Principles of medical decision making. Spine 1999;24(5):493-8.

Macnab I, McCulloch J. Backache. Baltimore, MD: Williams and Willkins;1977. **[Based on referenced expert opinion, textbook.]**

Magee DJ. Orthopedic Physical Assessment, 3rd ed. Philadelphia, PA: WB Saunders; 1997. **[Based on referenced expert opinion, textbook.]**

Maigne R. Orthopedic Medicine: A New Approach to Vertebral Manipulations. Liberson WT (Trans., Ed.) Charles C Thomas Pub Ltd; 1978: 300.

Malter AD, McNeney B, Loeser JD, Deyo RA. Five-year reoperation rates after different types of lumbar spine surgery. Spine 1998;23:814-20.

Martínez-Lage JF, Martínez Robledo A, López F, Poza M. Disc protrusion in the child. Particular features and comparison with neoplasms. Childs Nerv Syst 1997;13(4):201-7. **[Retrospective case series of 17 pediatric patients with diagnosed lumbar disc herniation, and 16 patients with neoplasm of the lumbosacral region, to ascertain features that may aid in DDX of these conditions and allow for earlier referral. Patients <18 y.o. at onset of symptoms were included. Excluded were those patients with S.B.O., spondylolisthesis, trauma, discitis, spinal tumor in C1-T10, or metastasis to the spine. Data was collected on cases spanning 1975-1995 from University Hospital in Murcia, Spain and included: epidemiologic findings, clinical features (from onset through treatment), radiographic/neuroimaging findings, histopathologic diagnoses and operation protocols, and outcome (based on patient records or phone inquiry). The information was analyzed through a**

statistical program and compared to an adult lumbar disc herniation study done at the hospital spanning the same 20 year period in order to determine differences in clinical manifestation. The authors conclude that lumbar disc herniation is infrequent in children, with no child under age 11 harboring a herniation in this study; and they found that pediatric disc herniation typically presents with LBP, unilateral sciatica, spinal spasm, and few neurological findings, with motor deficit or impaired reflexes strongly favoring a neoplastic diagnosis.]

Mathews W, Morkel M, et al. Manipulation and traction for lumbago and sciatica: Physiotherapeutic techniques used in two controlled trials. Physiotherapy Practice 1988;4(4):201-6.

Matsubara Y, Kato F, Mimatsu K, Kajino G, Nakamura S, Nitta H. Serial changes on MRI in lumbar disc herniations treated conservatively. Neuroradiology 1995;37(5):378-83. **[32 patients with herniated discs under conservative care received serial MRI in the acute stage, then 6 months and 1 year later. The disc decreased in size in 19 patients, the larger the initial size of the herniation, the more it decreased. "Conservative care consisted of bed rest, pelvic traction, epidural block, anti-inflammatory and analgesic drugs, thermotherapy, physiotherapy, surgical corset, etc." Amount of decrease in disc size did not correlate with symptom resolution.]**

Maus TP. Imaging of the spine and nerve roots. Phys Med Rehab Clinics N Am 2002;13(3):483-544. **[Narrative review of 76 articles ranging from 1952-2001. No quality ratings were given. There is no conclusion as this is just an informative summary of imaging of the spine and nerve roots.]**

Mayer T, McMahon MJ, et al. Socioeconomic outcomes of spine surgery followed by functional restoration in compensation injuries. Presented at the annual meeting, North American Spine Society, Washington, DC, 1995. The BackLetter 1997;12(5):51.

Mazanec DJ, Segal AM, Sinks PB. Identification of malignancy in patients with back pain: Red flags. Arthritis Rheum 1993;36(suppl):S25.

McCall IW. Lumbar herniated disks. Radiol Clin North Am 2000;38(6):1293-309. Review.

McCullough JA. Chemolysis. JBJS 1977;159B:45-52. **[Clinical criteria used in a prospective study of 480 patients undergoing chemonucleolysis to identify 158 patients diagnosed as having disc herniation. With few exceptions, myelography preceded chemonucleolysis to verify the level and extent of disc herniation. Using a positive myelogram as a fifth possible criteria, any low back syndrome with two or less of the criteria was not considered to be due to disc herniation, but rather disc degeneration or stenosis. There were no controls and insufficient data to calculate the sensitivity and specificity of this set of criteria.]**

McDowell I, Newell C. Measuring health: A guide to rating scales and questionnaires. New York, NY: Oxford University Press; 1987.

McGee S. Evidence-Based Physical Diagnosis. Philadelphia, PA: Saunders; 2001.

McGill S. Low back biomechanics in industry: The prevention of injury through safer lifting. In: Grabiner M (Ed) Current Issues of Biomechanics. Champaign, IL: Human Kinetics; 1993.

McGill S. Low Back Disorders: Evidence-Based Prevention and Rehabilitation. Canada: University of Waterloo; 2007.

McGill SM. Low back exercises: Evidence for improving exercise regimens. Physical Therapy 1998;78(7):754-65.

Merriam WF, Quinnell RC, Stockdale HP, et al. The effect of postural changes on the inferred pressures within the nucleus pulposus during lumbar discography. Spine 1984;9(4):405-8. **[Observational study of intradiscal pressure in 21 normal discs and 19 degenerate discs in 20 total human subjects. No inclusion or exclusion criteria are mentioned. Intradiscal pressure was measured on each subject in the standing, seated, then prone positions. Discograms were then done on each disc to categorize its pathologic state. In 20 of 21 normal discs, pressure was least in the prone position and highest in the seated position. The normal disc that behaved abnormally had the highest pressure when standing, followed by seated and then prone. Out of the degenerated discs, 8 of 19 exhibited normal pressure behaviors, and the others did not fall into any pattern consistent with the group that they were in. In conclusion, lack of a predictable change in intradiscal pressure in degenerated discs suggests that the clinical use of such pressure readings is of little value.]**

Meszaros TF, Olson R, Kulig K, Creighton D, Czarnecki E. Effect of 10%, 30%, and 60% body weight traction on the straight leg raise test of symptomatic patients with low back pain. JOSPT 2000;30(10):595-601. **[Research Report]**

Michlovitz SL, Wolf SL, et al. Thermal Agents in Rehabilitation, 2nd ed. Philadelphia, PA: F. A. Davis Company; 1990. **[Based on referenced opinion, textbook.]**

Millisdotter M, Stromqvist B, Jonsson B. Proximal neuromuscular impairment in lumbar disc herniation. Spine 2003;28:1281-9.

Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimaki H. Individual factors, occupational loading, and physical exercise as predictors of sciatic pain. Spine 2002;27(10):1102-9. **[Prospective cohort study of 2404 forest industry workers both with (n=327) and without (n=2077) sciatic pain, to evaluate the effects of certain risk factors on persistence and incidence of pain. All subjects were employees of a large forest industry company, and were only excluded if they were part-time or had rheumatoid arthritis. Data was collected through response to a modified version of the Nordic Questionnaire sent annually for 3 years following baseline. Questions centered around frequency of sciatic pain, symptoms in other regions of the body, individual risk factors, physical loading factors, work characteristics, and physical exercise. Only those responding to all questionnaires were ultimately included in the study (2404/7000). Results were analyzed using a multivariable logistic regression model with CI of 95%. Based on these results, the authors conclude that a higher risk of sciatic pain was consistently present with older age, mental stress, smoking, walking (though decreased risk with jogging), and repetitive trunk-twisting movements while working. Age, mental stress, and poor job satisfaction were found to be predictors in persistence of sciatic pain.]**

Modic MT, Obuchowski NA, Ross JS, et al. Acute low back pain and radiculopathy: MR imaging findings and their prognostic role and effect on outcome. Radiology 2005;237(2):597-604. **[Prospective, double blind, randomized controlled trial of 246 patients with acute onset LBP or radiculopathy, to determine the MRI findings, prognostic role of these findings, and effect of diagnostic information on outcome. Patients were randomized into 2 groups, one receiving MRI results within 48 hours, and the second where both patients and physicians were blinded to MRI results. All patients underwent conservative care for 6 weeks. Based on pre-, mid-, and post-treatment outcome measurements of Roland function score, VAS, SF-36, self-efficacy score, and fear avoidance questionnaire, no relationship was found between herniation size, type or behavior over time and outcome, and patient knowledge of imaging findings may be associated with a lesser sense of well-being.]**

Möller H, Sundin A, Hedlund R. Symptoms, signs, and functional disability in adult spondylolisthesis. Spine 2000;25(6):683-9. **[A cross-sectional RCT of 54 female and 57 male patients to determine whether specific symptoms, signs and functional disability are associated with adult spondylolisthesis, as compared to 39 patients with non-specific LBP. Inclusion criteria consisted of lumbar isthmic spondylolisthesis of all grades with at least 1 year of LBP or sciatica, and severely restricted**

functional ability, in patients age 18-55 years. Patients were excluded if symptoms were mild, previous spine surgery had occurred, or alcohol or drug abuse was admitted. Patients were referred to the spine units of 2 university hospitals for standardized physical and neurologic exam, along with questionnaires concerning clinical history and symptoms, pain drawings, and VAS scales to quantify Disability Rating Index (DRI) based on 12 different ADLs. This data was compared with the pre-operative data of 23 female and 16 male patients who had undergone lumbar fusion due to non-specific LBP, with or without sciatica for > 1 year in conjunction with restricted functional ability. Clinical findings were found to be similar between the spondylolisthesis group and the control (non-specific LBP), with the control group reporting more functional disability. Sciatica in spondylolisthesis patients was not found to be associated with a positive SLR. Within the patient group, those with a pain drawing described as nonorganic (widespread, non-specific) were more likely to be blue collar workers, take sick leave, and report reduced mental condition, sexual function, and functional ability than those reporting a localized, specific pain. Overall, the signs and symptoms of the patient group were not distinguishable from the control group, leading to the possible conclusion that, given the presumed mechanical effects on the spine of spondylolisthesis, non-specific LBP may be also be of mechanical origin.]

Mootz R, Waldorf V. Chiropractic care parameters for common industrial low back conditions. Chirop Tech 1993;5(3):119-25. **[Based on expert opinion, peer-reviewed journal. This was a system used at The Advantage Occupational and Sports Medicine Center in San Leandro, California, in 1991.]**

Morelli S, Carmenini E, Caporossi A, et al. Spondylodiscitis and infective endcarditis. Spine 2001;26(5):449-500.

Morris CE (Ed). Low Back Syndromes: Integrated Clinical Management. New York: McGraw-Hill Companies, Inc.; 2006.

Murphy DR, Hurwitz EL, Gregory AA, Clary R. A non-surgical approach to the management of lumbar spinal stenosis: A prospective observational cohort study. BMC Musculoskeletal Disorder 2006;7(16):1-8

Murray RO, Jacobson HG, et al. The Radiology of Skeletal Disorders: Exercises in Diagnosis. New York, NY: Churchill Livingstone; 1990.

Nachemson A, Elfstrom G. Intravital dynamic pressure measurements in lumbar discs. A study of common movements, maneuvers and exercises. Scand J Rehabil Med 1970;1(Suppl):1-40. **[Observational study. Nine individuals were included in the study, 3 males and 6 females, ranging in age from 14-60. Six of the volunteers had no history of back pain, one had idiopathic scoliosis which had been operated on, one had a previous 3 month span of LBP, and another had a previous episode of sciatica lasting 2 months with a negative myelogram. Intradiscal pressures were measured in these individuals in the L3-L4 intervertebral disc while performing a variety of movements, exercises, and while in supine and standing traction. There was no blinding, no confidence intervals were given, and the inclusion and exclusion criteria were not mentioned. Significance was determined by using Student's *t*-test. Forward bending 30 degrees with 10kg weights in each hand, lifting 20kg by bending the back, and lifting 20kg by bending the legs all increased intradiscal pressure significantly higher than standing in an upright position while holding two 10kg weights (*t*=12.3, 11.5, and 7.0, respectively). Lifting with the back bent as opposed to bending the knees was significantly higher (*t*=5.0). Sit ups with knees extended (*t*=5.6) and knees bent (*t*=5.9) both raised intradiscal pressure significantly from standing with two 10kg weights. Coughing, straining, jumping, bilateral straight leg raising, isometric contraction of abdominal muscles, and active back hyperextension did not raise pressure significantly above standing with two 10kg weights. All activities increased pressure significantly above standing upright without weights. The difference between standing with weights and without weights was significant (*t*=4.2). A weakness of this study that the authors mentioned was a potential evaluator error when reading the pressure recording. The authors conclude that these results can guide the practitioner in the selection of exercises appropriate for patients with LBP.]**

Nachemson A, Morris JM. In vivo measurements of intradiscal pressure discs. J Bone Joint Surg 1964;46:1077-92. **[Prospective trial of 16 patients with normal lumbar discs to assess the intradiscal pressure under a variety of loads. Pressure values were obtained in 18 normal 3rd and/or 4th lumbar discs of 16 patients, as well as 2 patients who had undergone posterior fusion from L4 to sacrum. Values were obtained: in the sitting position w/out additional loading (n=16), w/additional loading (n=10), standing position (n=6), reclining position (n=13 discs of 12 subjects), during valsalva, and while wearing an inflatable corset (n=4). Potential error, as cited by the authors, relates to validity of the formula developed to accommodate for the differences in body weight and surface area of different patients, which have been previously demonstrated to affect intradiscal pressure. Based on pressures while sitting, discs are under an avg. of 30% less pressure while standing with an additional 24% decrease if also wearing an inflatable corset, 50% less while reclining, and increased pressure during valsalva and if given additional load to carry in hands. Patients with posterior vertebral fusion were shown to have decreased load when compared to a normal disc in a similar weight patient; however, when an additional load was given to these patients, the patient who was shown to have pseudoarthrosis showed a disproportionate increase in pressure with increase in load vs. the patient who had healed normally and showed a proportionate relief of pressure with increasing load.]**

Nachemson A. Lumbar intrediscal pressure: Experimental studies on postmortem material. Acta Orthop Scand 1960;43:1-104.

Nachemson A. The load on lumbar discs in different positions of the body. Clin Rel Res 1966;45:107.

Newman NH. Outpatient conventional laminotomy and disc excision. Spine 1995;20(3):353-5.

Ng LCH, Tafazal S, Longworth S, Sell P. Cauda equina syndrome: An audit. Can we do better? J Orthop Med 2004:26(2):98-101. **[This study is a survey that was sent to all orthopedic spine surgeons and neurosurgeons who were members of the British Association of Spinal Surgeons. Results reported in this article were obtained from responses between Jul 1 – Dec 31, 2001. Time period between onset of cauda equina syndrome (CES) symptoms and decompression surgery was separated into three stages: time from onset to presentation to the general practitioner (GP); time from presentation to GP to referral to the surgical team on-call; and time from MRI scan to surgery. Forty-five cases of CES were reported in the 6-month period listed above. The longest stage in the process from onset to decompression was from the initial onset of symptoms to consultation with a GP (mean 58 hours). Half of the cases did not present until more than 24 hours after onset. 18% of cases were referred to the surgical team in less than one hour, whereas 31% took more than 24 hours to be referred. Nine patients had to wait more than 24 hours between MRI scan and surgery. The author concludes that CES is a very serious disease with sometimes permanent consequences and because of this there is a great need to improve the time intervals analyzed in this paper. This improvement hinges on a "greater awareness" among GPs and a reduction in time between MRI scanning and surgery.]**

Nitta H, Tajima T, Sugiyama H, Moriyama A. Study on dermatomes by means of selective spinal nerve block. Spine 1993;18:1782-6. **[Based upon a clinically relevant uncontrolled descriptive study, prospective. 71 patients with lumbosacral symptoms; dermatomes mapped using light touch after 86 selective nerve blocks (19 L4 roots, 41 L5 roots, 26 S1 roots).]**

Nyiendo JA. Comparison of low back pain profiles of chiropractic teaching clinic patients with patients attending private clinicians. JMPT 1990;13:437-47. **[Cohort study. 387 patients from 6 different chiropractic college teaching clinics (TC patients) and 132 patients from clinics in the field (FD patients) were included in this study. Patients were included if their responses to the New Patient Questionnaire and their physical signs and symptoms were indicative of LBP. In the subgroup of nonspecific back pain, 24% of TC patients were acute cases whereas 45% of FD patients were acute (P=0.0003). On the Present Pain Intensity scale, 21% of TC patients rated their pain as either distressing, horrible, or excruciating. 37% of TD patients rated their pain in one of those 3 categories. This difference was significant (P<0.01). The evaluative quality on the MPQ questionnaire was the only one that differed significantly between the two groups (P<0.01). FD patients consistently chose words with a higher rank value (which equals higher pain intensity) to describe their pain. The FD patients also scored higher than TC patients in all but one of the quantitative measures of the MPQ. In conclusion, FD patients were more likely than TC patients to present with acute LBP and to have a higher pain intensity. Despite the differences observed between these two groups in this study, TC patients can still be useful in clinical studies if proper controls are implemented.]**

O'Hara LJ, Marshall RW. Far lateral lumbar disc herniation. JBJS [Br] 1997;79-B(6):943-7. **[Qualitative case series of 20 patients (16 men, 4 women, age 26 to 78 years) requiring operation for far lateral lumbar disc herniation, to describe the experience of a muscle splinting, intertransverse surgical approach instead of the commonly utilized interlaminar approach. Patients included in the series presented to the Royal Berkshire Hospital over a 4-year period complaining of intense, unilateral radicular pain of either sciatic (25%) or femoral (75%) origin, with symptoms averaging 23 weeks in duration. Far lateral disc herniations were evidenced by MRI in all patients; 19 patients had a neurological deficit (17 sensory loss, 14 motor weakness). Visual Analogue Scale was utilized to determine pre- and postoperative pain levels. Results of follow-up from 6 months to 4 years postsurgery indicated no residual discomfort in 12 patients, minor leg or back pain with no functional impairment in 6 patients, no improvement in 1 patient, and improved neurologic function but increased radicular pain in 1 patient, with mean leg pain score improving from 8.0 preoperatively to 1.5 post operatively. Neurological improvement was found in 17/19 patients. The authors recommend the use of this muscle splinting intertransverse approach for far lateral disc herniation in order to avoid total resection of the facet joint, which could compromise the subsequent stability of the spine.]**

Oliphant D. Safety of spinal manipulation in the treatment of lumbar disc herniations: A systematic review and risk assessment. JMPT 2004;27(3):197-210. **[Meta-analysis of 8 review articles, 9 prospective/retrospective studies, and 2 surveys of the adverse effects of lumbar spinal manipulation. The quality of the studies was rated using modified criteria from Koes, et al. and the quality of the reviews was rated using a system of criteria made by the author of this review that was based on Koes' criteria. Of the prospective/retrospective studies, 1 was high quality, 3 were moderate quality, and 2 were poor quality. Three of the reviews were high quality, 3 were moderate, and 1 was poor quality. The dates of the studies and reviews used ranged from 1978-2000. The author concludes that the risk of worsening a disc herniation or cauda equina syndrome is less than 1 in 3.7 million manipulations. There is no significant reason to recommend against lumbar spinal manipulation in cases of disc herniation and manipulation should be recommended in a trial of conservative care prior to the recommendation of surgery.]**

Olsen TL, Anderson RL, Dearwater SR, et al. The epidemiology of low back pain in an adolescent population. Am J Public Health 1992 Apr;82(4):606-8.

Onel D, Tuzlaci M, et al. Computed tomographic investigation of the effect of traction on lumbar disc herniations. Spine 1989;14(1):82-90.

Oregon Chiropractic Practices and Utilization Guidelines, Vol 1, Common Neuromusculoskeletal Conditions; 1991. **[Based on standard of care.]**

Ostelo RWJG, de Vet HCW, Waddell G, Kerckhoffs MR, Leffers P, van Tulder MW. Rehabilitation after lumbar disc surgery. Cochrane Database of Systematic Reviews 2002, Issue 2. Art. No.: CD003007. DOI: 10.1002/14651858.CD003007. **[Qualitative Systematic Review. 13 studies were included – 11 RCTs and 2 CCTs. Dates of studies ranged from 1986-2000. Six RCTs were high quality, according to the Cochrane Back Review Group criteria list. The authors' conclusion is threefold: There is no evidence that patients' activities must be limited following lumbar surgery, at short-term follow up intensive exercise programs are more effective than moderate programs in return-to-work and functional status, and at long-term follow up both intensive and moderate exercise program show the same improvement. They also state that there is no increase in re-operation rate due to implementation of these exercise programs.]**

Ozturk B, Gunduz OH, Ozoran K, Bostanoglu S. Effect of continuous lumbar traction on the size of herniated disc material in lumbar disc herniation. Rheumatol Int 2006;26(7):622-6. **[RCT. 22 men and 24 women, all hospitalized for lumbar disc herniation confirmed by CT, were included. Inclusion criteria: Low back pain (LBP) or sciatica from lumbar disc herniation and L3-S1 radiculopathy, less than 6 months duration, consistency in signs and symptoms, and no past physical therapy. Exclusion criteria: LBP due to causes other than disc herniation, emergency surgery, spinal stenosis, pregnancy, prior vertebral surgery, structural abnormalities, unfit for physical therapy, degeneration of lumbosacral vertebrae on X-ray, and duration of LBP longer than 6 months. The treatment group consisted of 14 men and 10 women who received traction along with a hot pack, continuous ultrasound, and diadynamic currents. In the control group, there were 8 men and 14 women who received the same physical therapy program without the traction. All subjects received 400mg Ibuprofen tid and a muscle relaxant 450mg tid. Two patients discontinued Ibuprofen due to side effects. Baseline measurements and outcomes were assessed using the Visual Analog Scale (VAS) for pain, a modified Schober test for range of motion, the Straight Leg Raise, a % loss for motor deficits, L4-S1 dermatomes for sensory loss, and patella and Achilles reflex tests. CT scans were assessed by a blinded expert radiologist who used a herniation index to score the size of disc herniation. Statistically significant differences between groups were achieved in the presence of sciatica, SLR angle, and percent motor loss (p<0.05). Seven traction patients had decreased patellar reflexes at baseline. Four of them recovered fully and 1 partially, while none of the 8 control patients with decreased patellar reflexes improved (p<0.01). The herniation index in the traction group changed from 276.6 to 212.5 (p<0.01). In the control group, it changed from 293.4 to 285.4, but this was not statistically significant (p<0.05). The authors conclude that traction is an effective treatment for lumbar disc herniations,**

but may be more effective on those with larger herniations compared to those with smaller ones.]

Papadopulos, EC. Outcome of revision discectomies following recurrent lumbar disc herniation. Spine 2006;31(13):1473-6.

Perner A, Andersen JT, et al. Lower urinary tract symptoms in lumbar root compression syndromes: A prospective survey. Spine 1997;2(22):2693-7. **[A prospective, observational survey of 108 male pre-surgical patients with lumbar disc herniation or stenosis. 51% of the disc herniation patients had lower urinary track symptoms including irritative, obstructive and retention symptoms. Median herniations were more likely to have urinary symptoms but there was no correlation with severity of pain, age or disc level.]**

Peul WC, van Houwelingen, van den Hout WB, et al. Surgery versus prolonged conservative care for sciatica. N Engl J Med 2007;356:2245-56. **[RCT. Inclusion criteria: 18-65 years old, confirmed disc herniation, incapacitated for 6-12 weeks by lumbosacral radiculopathy diagnosed by an attending neurologist. Patients were excluded if they presented with cauda equina syndrome, muscle paralysis, or if they could not resist against gravity. 141 patients were randomized to a treatment of early surgery (microdiscectomy), and 142 were assigned to conservative treatment for 6 months. In the end, 125 underwent surgery and 87 completed the conservative treatment. Outcomes were assessed using the Roland Disability Questionnaire for sciatica, the 10cm Visual Analog Scale (VAS) for leg pain, and the 7-point Likert scale of global perceived recovery. A 95% Confidence Interval was used to compare all outcomes. After a 52-week follow-up, there was no significant difference in mean score on the Roland Disability Questionnaire. The mean VAS score for back pain did differ significantly (P<0.001), with early surgery scoring an average of 1.42cm and conservative treatment scoring an average of 1.65 cm. All three outcomes had almost equal rates of recovery between the two groups at 52 weeks. The median recovery time for early surgery was 4.0 weeks compared to 12.1 weeks for the conservative treatment group. The authors conclude that early surgery is a valid option for treatment of disc herniation even though surgery and conservative treatment have similar long term outcomes.]**

Picavet HSJ, Vlaeyen JWS, Schouten JSAG. Pain catastrophizing and kinesiophobia: Predictors of chronic low back pain. Am J Epidemiol 2002;156:1028-34. **[Cohort Study. Data were taken from a Musculoskeletal Complaints and Consequences Cohort study done in the Netherlands. A questionnaire was sent to a random sample of 8,000 people age 25 or older who were not institutionalized. Respondents were excluded if they were over 65, or if they had a severe disease (cancer, heart disease, fibromyalgia, rheumatoid arthritis). 1,845 subjects were sent a follow-up questionnaire after 6 months, and 1,571 subjects responded to the follow-up. They were asked questions about low back pain (LBP) using these indicators for analysis: current LBP, LBP with limitation, chronic LBP, severe LBP, and LBP with disability. A Dutch Pain Catastrophizing Scale was used to measure pain catastrophizing. Kinesiophobia was measured using a modified Tampa Scale. No significant "interaction" was found between kinesiophobia and pain catastrophizing. If a patient had LBP at baseline, a high pain catastrophizing score was highly predictive of current LBP at follow up (95% CI: 1.0, 2.8). It was also predictive of chronic LBP (95% CI:1.0, 2.8), LBP limitation (95% CI: 1.9,7.3), severe LBP (95% CI: 1.7, 5.2), and LBP with disability (95% CI: 1.7, 5.4). A high level of kinesiophobia was also highly predictive of these outcomes at follow-up. In the cohort without LBP at baseline, a high pain catastrophizing rating was predictive of severe LBP (95% CI: 1.0, 5.0), chronic LBP (95% CI: 1.1, 3.9), and LBP with disability (95% CI: 1.1, 8.7). A high level of kinesiophobia in this group was only predictive of LBP with disability (95% CI: 1.3, 8.7). One weakness of this study is that it did not account for the type or history of LBP at baseline. This could be a compounding factor and weaken the relationships found in this study. Despite this weakness, the author concluded that high levels of pain catastrophizing or kinesiophobia increase the risk of developing chronic LBP and disability. This is true both for populations with existing LBP and those without.]**

Plaugher G. Textbook of Clinical Chiropractic, A Specific Biomechanical Approach. Baltimore, MD: Williams & Wilkins; 1993.

Porsman O, Friis H. Prolapsed lumbar disc treated with intramuscularly administered dexamethasonephospate. A prospectively planned, double-blind, controlled clinical trial in 52 patients. Scand J Rheumatol 1979;8(3):142-4. **[This is a double-blind RCT including 52 patients admitted to the rheumatology department of two hospitals in Copenhagen, Denmark from 1976-1978. Forty-nine patients finished the study, 33 males and 16 females, ranging in age from 21-67 years. Duration of symptoms varied from a few days to 6 months. Inclusion criteria were radicular pain, paresthesia, muscular weakness, sensitivity disturbances, reflex changes, and a positive Lasegue test. Exclusion criteria were severe psychological or psychiatric problems, patients with contraindications to corticosteroid therapy, complicated arterial hypertension, diabetes mellitus, and incompensated heart disease. Treatment was administered for seven days, with 4 doses of 16mg on the first day, 4 doses of 8mg the second, 3 doses of 8mg on the third, 3 doses of 4mg on the fourth, and 2 doses of 4mg on the fifth through the seventh days. Doses were supplied in 2ml vials of 4mg/ml Dexamethasonephosphate or 0.9% sodium chloride solution. There were 25 patients in the Dexamethasonephosphate (treatment) group and 24 patients in the sodium chloride (control) group. Sex, age, work, and length of hospitalization were comparable between the two groups. In the treatment group, steroid therapy had an effect on 13 people, and no effect on 12. In the control group, 14 had an effect and 10 had no effect. The authors conclude that intramuscularly-administered Dexamethasonephosphate is not supported in this study for the treatment of prolapsed lumbar disc.]**

Porter R, Miller C. Back pain and trunk list. Spine 1986;11(6):596-600. **[100 back and leg pain patients with trunk list, 20 of whom required surgery and position of herniation could be compared to direction of list and leg pain.]**

Postacchini F. Management of herniation of the lumbar disc. J Bone Joint Surg Br 1999;81-B(4):567-76. **[Narrative review. 70 studies, published between 1967 and 1999, were used in this review. There is no general conclusion to this review, as the author examines many different topics relating to lumbar disc herniation. The topics discussed include the natural history of lumbar disc herniation, the efficacy of conservative vs. surgical treatment, the different types of surgery, results of surgery, lateral herniations, and recurrent herniations.]**

Postacchini F. Results of surgery compared with conservative management for lumbar disc herniations. Spine 1996;21(11):1383-7. **[Narrative Review. The author cites 19 articles, dating from 1970-1995. Surgical treatment of lumbar disc herniation yields satisfactory results in less time than conservative management, but as time progresses both types of treatment have similar outcomes.]**

Price C, Arden N, Coglan L, Rogers P. Cost-effectiveness and safety of epidural steroids in the management of sciatica. Health Technol Assess 2005;9(33):1-58. [**This is a double-blind RCT including 228 subjects presenting with sciatica to one of three district hospitals or one teaching hospital in south England. Subjects were included based on these criteria: back pain with unilateral sciatica extending below the knee, symptom duration between 4 weeks and 18 months, normal blood**

count, normal erythrocyte sedimentation rate, normal basic bone biochemistry, and lumbar x-rays ruling out other causes of radicular pain. Patients were excluded due to prior back surgery, bleeding disorders, bilateral symptoms, prior epidural injections, current litigation concerning the sciatica, and significant psychological disorders. The subjects included 108 female and 120 male patients between the ages of 18 and 70. The experimental group received a lumbar epidural injection of 80 mg triamcinolone acetonide and 10 ml 0.125% bupivacaine. The control group received a 2 ml injection of saline into the interspinous ligament. Follow up was done at 0, 3, 6, 12, 26, and 52 weeks by a trained, blinded investigator. Outcome measures used at each follow up included: Oswestry Disability Questionnaire (ODQ), Short Form 36 (SF-36), visual analog scale (VAS), McGill Pain Questionnaire (MPQ), Hospital Anxiety and Depression Scale (HAD), analgesic intake, work status, standardized objective tests of physical function, SLR and neurological deficit tests, and side effects from the injections. Quality-adjusted life-years (QALY) were calculated to measure the cost-effectiveness of the study. At 3 weeks the trial group had achieved a significant improvement in ODQ score compared to the control group (10.3 vs. 6.6, p=0.017). No significant difference was seen at any of the subsequent follow up intervals, and at 52 weeks there was no difference in improvement between groups. Adverse events were not common and there was no difference in occurrence between groups. Epidural steroid injections failed the QALY threshold set by the National Institute for Health and Clinical Excellence. The authors conclude that epidural steroid injections are safe but are not cost-effective due to high cost and only transient improvement in outcomes in a small group of people.]

Porchet F, Wietlisbach V, Burnand B, et al. Relationship between severity of lumbar disc disease and disability scores in sciatica patients. Neurosurgery 2002;50(6):1253-60. **[Cross-sectional study of 249 men and 145 women with a mean age of 46 years. The inclusion criteria were all consecutive patients between 18 and 75 years old presenting with sciatica with or without LBP. The clinic was a university hospital neurosurgical outpatient clinic and all patients were either referred there for a consult for radicular pain, hospitalized for other reasons but needed a consult for radicular pain, or they were referred to the emergency center for consult regarding radicular pain. The exclusion criteria were previous lumbar surgery, spinal stenosis, spondylolisthesis, and a history of lumbar fracture. LBP and radicular pain were measured using a Modified Roland-Morris pain scale and a visual analog scale (VAS). Health-related quality of life was measured using the 36-item Short Form Health Survey (SF-36), and functional and economic capacity were measured using the functional-economic outcome rating scale from Prolo et al. Disc disease was rated by neurosurgeons according to criteria established by Jensen et al, Modic, and Spengler et al. Inter-examiner reliability was determined using 50 imaging studies read by an independent neuroradiologist and was rated with a kappa value of 0.91. Of the 394 subjects, 9.6% had no disc disease, 3.3% had a disc bulge, 11.4% had disc protrusion, 68.5% had a disc extrusion, and 7.1% had disc sequestration. No significant linear association was found between disc disease severity and LBP. There was a linear trend between leg pain severity and severity of disc disease (CI=5-7.8, P<0.001). A positive correlation was also found between the Roland-Morris disability score and disc disease (CI=14.9-18.4, P<0.001). SF-36 scores for physical functioning and bodily pain were significantly related to disc disease severity as well (CI=22.1-53.8, P<0.001 and CI=13.1-28.5, P<0.001 respectively). After multivariate logistic regression, it was found that a "poor" functional state on the Prolo scale correlated with 3 times the risk of severe disc disease (OR 2.9, 95% CI, 1.7-4.9). Regression also showed that every centimeter increase on the VAS meant a 16% increased likelihood of radiological evidence of severe disc disease (OR 1.16, 95% CI, 1.07-1.26). The VAS for back pain was a negative predictor of disc disease, with every centimeter increase lowering the likelihood of severe disc disease by 10% (OR 0.90, 95% CI, 0.82-0.98). The authors conclude that increasingly severe disability is associated with increasingly severe disc disease.]**

Rabin A, Gerszten PC, Karausky P, Bunker CH, Potter DM, Welch WC. The sensitivity of the seated straight-leg raise test compared with the supine straight-leg raise test in patients presenting with magnetic resonance imaging evidence of lumbar nerve root compression. Arch Phys Med Rehabil 2007;88(7):840-3. **[Cohort Study. 58 patients, consecutively referred to an outpatient neurosurgery clinic. Inclusion criteria: At least 18 years of age, low back pain (LBP) with pain or paresthesia in one or both legs radiating past the knee for ≥ four weeks. Patients were excluded if they had had spine surgery in the previous six months, fused lumbar vertebrae, metastatic disease, far lateral disc rupture, severe vascular disease, or infection of the lumbar spine. All patients underwent MRI before evaluation and were included based on a positive MRI result, which meant they had confirmed lumbar disc herniation with nerve root compression. A seated and supine Straight Leg Raise (SLR) was performed on each patient, first on the non-involved side, then on the involved side. A positive test was defined as the reproduction of radicular symptoms upon raising the leg and the disappearance of the same symptoms when the knee was then bent. A second examiner performed the same test on a subgroup of 20 patients to test inter-examiner reliability. Sensitivity of the supine SLR was .67 (95% CI: .29-.55). Sensitivity of the seated SLR was .41 (95% CI: .29-.55). This difference was statistically significant (P=.003). The inter-examiner reliability was .69 for the supine SLR and .60 for the seated SLR, as measured by the Cohen κ. The two weaknesses were that specificity could not be determined due to the study design, and that MRI was used to confirm nerve root compression, which can produce false positives. This risk was lessened by the fact that each patient had at least one clinical sign that correlated with nerve root compression. The author concludes that the supine SLR is significantly more sensitive than the seated SLR.]**

Rainville J, Jouve C, Finno M, Limke J. Comparison of four tests of quadriceps strength in L3 or L4 radiculopathies. Spine 2003;28(21):2466-71. **[Cohort Study. Included in this study were 33 patients with L3-L4 radiculopathies and 19 patients with L5-S1 radiculopathies. Inclusion criteria for L3-L4 radiculopathy were unilateral symptomatic lumbar radiculopathy with nerve root compression confirmed by MRI or CT. Patients were included for L5-S1 radiculopathy by the same criteria as for L3-L4, plus they had to be 40 years of age or older. Exclusion criteria were: bilateral radiculopathy, neurologic or muscular disease of the lower extremity, symptom magnification as described by Wadell, symptomatic hip or knee arthritis, active cancer, psychiatric impairment or cognitive dysfunction, non-ambulatory status, inability to read or write English. Four tests were performed on each patient, with one of three results: Normal in both legs, impaired on the symptomatic side only, or impaired in both legs. The tests performed were the single leg sit-to-stand test, the step-up test, the knee-flexed manual muscle test (MMT), and the knee-extended MMT. A second examiner performed the same tests when available and was blinded to the MRI findings and findings of the first examiner. For the sit-to-stand test, 11 of the L3-L4 patients tested normal, while 20 showed impairment in one leg and 2 were impaired in both legs. In the step-up on stool test, 24 were normal, 9 impaired on one side, and 0 bilateral. In the knee flexed MMT, 19 were normal, 14 impaired in one leg, and 0 impaired in both. In the knee straight MMT, 30 were normal and 3 were impaired unilaterally with none**

bilaterally. The only test that was positive for the L5-S1 group was the knee flexed MMT, with 1 impaired unilaterally and 1 bilaterally. The interrater reliability results were reported as Kappa coefficients and were given as follows: Single leg sit-to-stand was .85, step-up on stool was .83, knee flexed MMT was .66 and the knee extended MMT was .08. The author concludes that the single leg sit-to-stand test is very reliable and effective at identifying unilateral weakness in the quadriceps of people with L3-L4 radiculopathies.]

Rhee JM, Schaufele M, Abdu WA. Radiculopathy and the herniated lumbar disc: Controversies regarding pathophysiology and management. An instructional course lecture, American Academy of Orthopaedic Surgeons. J Bone Joint Surg (Am) 2006;88-A(9):2070-80. **[Instructional course lecture. This lecture discusses the anatomy, pathophysiology, epidemiology, and natural history of lumbar disc herniations. In addition, it outlines various non-operative treatments and discusses several topics involved with lumbar disc surgery. The authors conclude that effective non-operative treatments are observation and epidural steroid injection, and that the most important indicator of surgery, beside cauda equina syndrome and progressive weakness, is refractory radicular pain. When radicular pain is intractable, surgery provides a much more rapid relief of pain than do any of the nonsurgical interventions.]**

Riew KD, Park JB, Cho YS, et al. Nerve root blocks in the treatment of lumbar radicular pain: A minimum five-year follow-up. J Bone Joint Surg 2006;88-A(8):1722-5. **[Five year follow-up of previous RCT. There were 55 patients in the original trial. Twenty-seven patients were randomized to a treatment that consisted of a nerve root block using bupivacaine (control group), and 28 received a block of bupivacaine and betamethasone (experimental group). Of the original 55 subjects, 29 did not require surgery in the original follow-up period of 13-28 months. A questionnaire was sent to those 29 subjects, and 21 responded. Nine of these were from the original control group, and twelve from the experimental group. The mean follow-up period was 67 months. Out of 21 respondents, four had had lumbar disc surgery. Three were from the experimental group and one from the control group. This difference was not significant (P=.422). At five year follow-up the 17 patients who avoided surgery showed significant improvement in neurological symptoms (p=0.019) and back pain (p=0.009). The patients with herniated nucleus pulposus had a significant decrease in back pain (p=0.030) and those with spinal stenosis had significant improvements in neurological symptoms (p=0.036). The number of subjects in this study was small and that could explain why few significant differences were found between experimental and control groups. Even without a preponderance of statistical evidence, the authors concluded that lumbar nerve root blocks of bupivacaine with or without corticosteroids are an effective intervention for lumbar radiculopathy.]**

Riew KD, Yin Y, Gilula L, et al. The effect of nerve-root injections on the need for operative treatment of lumbar radicular pain. A prospective, randomized, controlled, double-blind study. J Bone Joint Surg Am 2000;82:1589-93. **[Prospective, randomized, controlled, double-blind study of 55 patients requesting operative intervention for lumbar radicular pain due to diagnosed nerve root compression, to evaluate the efficacy of selective nerve root corticosteroid injection in alleviating the request for surgical intervention by the patient. Inclusion criteria consisted of subjects referred to 4 spinal surgeons at one institution over 1 year's time who were >21 y/o, with degenerative lumbar radicular pain and herniation, or spinal stenosis as confirmed by MRI. All patients were at the point where surgical intervention was the next step in treatment as agreed upon by both patient and physician. Excluded patients were those whom had experienced acute trauma, cauda equina syndrome, progressive neuro deficit, pathologic or infectious etiology, were nonoperative candidates, had worker's comp claims, hx of adverse corticosteroid reaction, lack of radiographically confirmed abnormality, lack of radicular pain, or necessity for >3 separate injections to alleviate symptoms. Twenty-seven males and 28 females chose to participate in the study. Patients and treating surgeons were blinded to treatment, with study patients (n=28) given injections of bupivicaine with betamethasone, while control patients (n=27) were given bupivicaine alone. Outcome markers included a pre- and post-treatment nerve-root-injection questionnaire indicating pain level on 0-100 scale, a North American Spine Society questionnaire, and ultimately the decision of the patient whether or not to elect surgery. Follow-up questionnaires were filled out at minimum 1-year post-treatment, with follow-up 15-28 months after injection to determine whether the patient had elected to have surgery. Small study size and relatively short follow-up were cited as possible study weaknesses with emphasis on the fact that stenosis tends to worsen with time. This study concluded that selective nerve root injection was significantly more effective than control for up to 28 months following injection, with 26/55 patients opting to proceed with operation (18/27 control and 8/28 study patients).]**

Roland M, Morris R. A study of the natural history of back pain. Part I. Development of a reliable and sensitive measure of disability in low back pain. Spine 1983;8(2):141-4.

Ross J, Jameson R. Vesical dysfunction due to prolapsed disc. Brit Med J 1971;3:752-4. **[Qualitative case series of 5 patients with bladder dysfunction due to prolapsed disc, to discuss the need for full investigation of any young- or middle-aged female developing urinary retention in absence of a determined gynecological cause due to the possibility of neural disturbance of micturation as a result of disc prolapse. This study classifies patients with bladder dysfunction due to prolapsed disc who present with either musculoskeletal or urinary tract symptoms into 3 categories: (1) bladder dysfunction of a temporary nature (including transient post-operative), (2) occult with minimal or absent back/leg pain, and (3) permanent dysfunction not relieved by treating disc lesion (or) permanent developing post-surgery, with the most commonly encountered dysfunction to be that of the 1st category. The 5 cases illustrated were as follows: a 49 y/o male with 4 week hx of LBP and sciatica followed by an acute onset of LBP and urinary retention, who was diagnosed with a large L4-L5 herniation and after subsequent removal was able to void normally; a 40 y/o male with acute lumbar strain developing urinary retention within a few hours, an L4-L5 disc protrusion was subsequently found and treated with bed rest and traction along with catheterization for 1 week which led to resolution of symptoms; a 50 y/o obese female suffered permanent bladder dysfunction that was not relieved by removal of a prolapsed disc, leading to a diagnosis of hysterical urinary retention and an additional subsequent finding of a weak detrusor muscle and eventual endoscopic resection of the bladder neck, which lead to normal bladder emptying; a 62 y/o female with prolonged hx of urinary frequency and retention complaints along with LBP, which resolved following removal of disc protrusions at L3-L4 and L4-L5; a 45 y/o female with temporary bladder dysfunction whose symptoms resolved following treatment with spinal support after discovery of osteoarthritis at L3 through S1 disc spaces. This study recommends a myelogram in cases of urinary dysfunction in young- or middle-age females where gynecological etiology is excluded in order to rule out disc prolapse as a potential cause.]**

Rothman RH. The Spine, Vol. 2. Philadelphia, PA: WB Saunders; 1975. **[Based on referenced expert opinion, textbook.]**

Saal J. Natural history and nonoperative treatment of lumbar disc herniation. Spine 1996;21(45):2S-9S. **[Qualitative analysis of the literature pertaining to the impact of nonoperative care of disc herniation, as well as impact of time frame and processes which may enhance or impede natural history. Forty-five studies were referenced spanning 1972-1996, concluding that lumbar disc herniation patients typically have a favorable diagnosis, with active care more favorable than passive care, and relief of pain being the primary goal in acute care. Likelihood of resorption increases with size of herniation and distance of migration, and a favorable natural history is found for neurological motor deficit except in the case of cauda equina syndrome and progressive neurological loss. Imaging and neuroloical deficit should not be the sole criteria for surgery, and with regard to treatment the authors suggest that surgery is rarely indicated before 6-12 weeks due to favorable natural history. Prolonged bed rest is not indicated, failure of passive conservative care is not an automatic indicator for surgical intervention, and the use of manipulative therapy is questionable.]**

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine 1990;15(7):683-6. **[Prospective study of 11 patients with documented disc extrusion and radiculopathy, to evaluate the natural history of morphologic change within the lumbar spine. In addition to radiculopathy and documented disc extrusion, inclusion criteria for the study consisted of patients with a primary complaint of leg pain, along with a positive SLR <60 deg. Patient population was chosen from a group previously evaluated in a nonoperative treatment trial by the authors. Evaluation of patients was done through pre-treatment CT, which were compared with follow-up MRI following nonoperative treatment (type of treatment was not reported) 8-77 months after initial presentation. Evaluation criteria included disc size and proportion, thecal sac effacement, nerve root enlargement, and evidence of central canal stenosis. In addition, follow-up MRI evaluated disc hydration, change in fragment size, and presence of perithecal or perineural fibrosis. Based on findings in this study, a clear demonstration of morphologic change consistent with resorption was present in lumbar disc extrusions treated nonsurgically, although clinical improvement and morphologic change were not found to follow the same timeline.]**

Saal JA, Saal JS. Nonoperative treatment of herniated lumbar intervertebral disc with radiculopathy: An outcome study. Spine 1989;14:431-7. **[64 patients with radiculopathy due to verified herniated disc had a 90% success rate, verified at one year. Treatment was a functional restoration program and psychology intervention.] [This is a retrospective cohort study of 58 patients, 36 men and 22 women with a median age of 35.5 years. Inclusion criteria were: Diagnosis of herniated nucleus pulposus supported with CT or MR imaging, a primary complaint of leg pain with a secondary complaint of back pain, positive EMG findings suggestive of lumbar radiculopathy, positive straight leg raise (SLR) with leg pain at less than 60 degrees, and a treatment program that included back school, postural exercises, trunk and upper body exercises, flexibility exercises, epidural injections and/or nerve root blocks when needed for pain control. Exclusion criteria were: previous surgery in the lumbar spine, stenosis, or spondylolisthesis. Questionnaires were mailed out to 64 patients. Of the 58 that responded, 6 had undergone surgery since receiving conservative treatment. The mean follow up time since treatment was 31.1 months. Of those 52 who did not undergo surgery, 50 had successful outcomes as determined by a score of 'good' or 'excellent' self-rated score on the mailed questionnaire. Of the non-operative cases, 92% returned to work, with the average sick-leave time being 3.8 months and 26 of them missed 1 week or less of work. Overall, 15 patients scored themselves as excellent, 35 as good, 2 as fair, and 0 as poor. The median Oswestry score was 16.6 in the excellent group, 20 in the good group, and 32 in the fair group. Eighteen patients underwent a surgical second opinion. Fifteen of those patients were non-operative treatment successes, each of them returning to work with an average sick-leave time of 3.4 months. All 18 of these patients had been told they needed surgery immediately to avoid long term complications. Fifteen of the patients had extruded discs on CT/MRI scans. Thirteen of them were non-operative successes. The average sick-leave time for these thirteen was 2.0 months, with nine of them missing less than one week. The authors conclude that non-operative treatment of herniated lumbar discs provides a high degree of success, even in the presence of weakness and extruded disc material. The decision to operate on patients with herniated lumbar discs should be made on the determination of the patient's functional status and if that status can be improved by non-operative treatment. Physical exam and imaging findings are not sufficient to make a surgical decision.]**

Saal JA. Spinal injections: past, present and future. Spine J 2001;1(6):387-9. **[This is an editorial. No sources are cited and the author concludes there is evidence suggesting that epidural injections might help a significant number of patients to avoid spinal surgery, but evidence supporting therapeutic facet injections is very limited. Injections have been widely misused in the past and should be used as a means to facilitate physical rehabilitation.]**

Saal JA. The new back school prescription: Stabilization training, part II. Occupational Medicine: State of the Art Reviews 1992;7(1):33-42.

Samuel SS, Peter AA, Ramanathan K. The association of active trigger points with lumbar disc lesions. J Musculosk Pain 2007;15(2):11-18. **[A prospective, single blind, cross-sectional study of 60 subjects scheduled for lumbar disc prolapse surgery, to assess the association between trigger points and lumbar disc lesions. Patient population included 44 males and 16 females between the ages of 22-61 years who had MRI confirmed lumbar disc prolapse, were referred by the Dept of Orthopedic and Accident Surgery Unit at a teaching hospital for surgical intervention within one week, and had severe pain. Those suffering from any condition likely to compromise the dependant variable were excluded. A complete physical therapy exam was performed by an examiner blinded to the MRI results, which then was analyzed for prevalence rate of active trigger points in each tested muscle for all levels of disc herniation. Limitations to the study included small sample size and absence of documentation of presence of trigger points prior to onset of disc disease. Data from this study affirms a possible myofascial pain syndrome component with lumbar disc disease corresponding to the myotome at the level of the lesion.]**

Santilli V, Beghi E, Finucci S. Chiropractic manipulation in the treatment of acute back pain and sciatica with disc protrusion: A randomized double-blind clinical trial of active and simulated spinal manipulations. Spine J 2006;6(2):131-7. **[RCT. Out of 485 consecutive ambulatory patients seen in the two medical rehab centers involved in this study, 53 were randomized to spinal manipulative therapy (SMT) and 49 were allocated to a sham manipulation. There were 64 men and 38 women from 19-63 years old. The rest of the original 485 declined to be included or did not meet the inclusion criteria. These criteria were: Acute LBP (duration of less than 10 days with no pain in last 3 months) scoring at least 5 on a 10cm visual analog scale (VAS), pain radiating to one leg that was at least 5 on the VAS, and positive MRI findings for disc protrusion at the involved level. Exclusion criteria were: Body mass index >30, lumbar scoliosis >20°, leg length inequality >1.5cm,**

spondylolisthesis, previous spinal surgery, diabetic neuropathy, osteoporosis, any lesion requiring surgery, classes 4B or 4C disc herniation, chronic LBP, and previous spinal manipulation. The SMT was performed with the patient in side posture as a push or pull in the pain-free direction. The sham treatment was a low velocity thrust on soft tissue. Patients were treated 5 days/week with a 20 treatment max. The two primary outcome measures were number of patients who were pain-free at the 180-day follow-up, and treatment failure, or discontinuing treatment due to lack of pain relief. Patients were given a diary to record secondary outcome measures during the 30-day treatment period. In it, they recorded number of pain days, number and type of NSAIDs, and number of drug prescriptions. Patients were also assessed for pain relief by physiatrists blinded to the treatment at days 15, 30, 45, 90 and 180. After 180 days, 28% of SMT patients were free of local pain vs. 6% of sham patients (p<0.005). For radiating pain, 55% of SMT subjects were pain-free vs. 20% of shams. The experimental group also had fewer total days of pain (23.6 vs. 27.4; p<0.005), with days of moderate to severe pain equaling 13.9 and 17.9, respectively (p<0.05). VAS 1 and VAS 2 scores were significantly lower for the experimental group at 45 and 90 days (p<0.0001 and p<0.001, respectively). At follow up, the MRI findings were unchanged from baseline. The two weaknesses reported in this study were the absence of an exit interview to verify that patients were truly blinded to their treatment groups, and the external validity, given that the patients only came from two different institutions. The conclusion is that actual spinal manipulation is more effective than sham manipulation at relieving low back pain and sciatica caused by disc herniation.]

Sasso RC, Macadaeg K, Nordmann D, Smith M. Selective nerve root injections can predict surgical outcome for lumbar and cervical radiculopathy. Comparison to magnetic resonance imaging. J Spinal Disord Tech 2005;18(6):471-8. **[Case Series. 101 patients were included in the review. Each had Selective Nerve Root Injections (SNI), MRI, nerve root decompression surgery and >12 month follow-up between 1996 and 1999 at the Indiana University School of Medicine. 91 patients had positive SNI results and 10 negative at the level that was operated on. 88% overall, and 91% of patients with positive SNI's had a good surgical outcome. Six of the ten patients with negative SNI's had good surgical outcomes. 86 patients had positive MRI findings, while 13 were negative. 75 of the patients with positive MRI's and 11 of the negative ones had good surgical outcomes. The negative likelihood ratio for SNI was .22 and that of the MRI was .83 (P<0.05). The MRI and SNI findings differed in 20 patients. 16 of them had a good surgical outcome. 69% of those with a good surgical outcome had surgery at the level that had positive SNI results. Out of the 4 patients with a poor surgical outcome, 3 of them had surgery at a level inconsistent with SNI findings. Positive predictive value (PPV) and Negative predictive value (NPV) for SNI were significantly greater than 0 (91.2, P<0.001 and 40.0, P<0.01, respectively). The PPV of the MRI was significantly greater than 0 (88.4, P<0.001). SNI is not better at predicting the level of "offending" herniation, but when MRI results are inconclusive, SNI is better at determining the absence of a symptomatic lesion.]**

Saunders HD. Use of spinal traction in the treatment of neck and back conditions. Clin Orthop Rel Res 1983;179:31-7.

Scham SM, Taylor TFK. Tension signs in lumbar disc prolapse. Clin Orthop 1971;75:195-204. **[Narrative review. The articles used were published between 1881 and 1969. Nerve tension tests, specifically the cross straight leg raise, apply longitudinal and angular tension to extradural nerve root. The cross straight leg raise, when positive, is strong evidence of a significantly-sized disc protrusion.]**

Schaufele M, Hatch L. Interlaminar versus transforaminal epidural injections in the treatment of symptomatic lumbar intervertebral disc herniations. (Poster 96) Arch Phys Med Rehabil 2002;83(11):1661. **[Case control study. The study included 20 consecutive patients who received transforaminal epidural steroid injections and 20 consecutive patients who received interlaminar injections at a large academic spine center between the fall of 2000 and spring of 2002. The inclusion criteria were LBP and radicular leg pain caused by a lumbar disc herniation, a positive MRI confirming a herniation at the suspected level, and failure to respond to more conservative treatment. Patients were excluded if they had any contraindications to steroid injections, previous lumbar epidural steroid injections, previous lumbar spine surgery, progressive neurological deficits and/or cauda equina syndrome, and any active workers compensation or personal injury claims. The verbal numerical rating scale (VNRS) from 0-10 was used as an outcome measure. This was taken by a nurse less than one hour before the injection, less than one hour after the injection, and at an average of two or three weeks after the injection. The transforaminal group had statistically significant improvement in VNRS scores from pre-injection (VNRS mean 5.9) to <1 hour post-injection (mean 2.9, p<0.01, 95% CI 1.63-4.42) and at follow up (mean 3.2, p<0.01, 95% CI 1.53-3.84). The mean follow-up was 18.7 days. Nine of the transforaminal injection patients required one or two repeat injections and two opted for surgery. The VNRS scores for the interlaminar injection subjects (mean 7.3) improved significantly at <1 hour post-injection (mean 3.1, p<0.01, 95% CI 2.80-5.50) and at follow up (mean 5.9, p<0.01, 95% CI 0.52-2.26). The mean follow-up was at 15.6 days. Eight of the 20 interlaminar patients needed additional injections, and 5 of them underwent surgery. The only statistical significance between the two groups was at follow-up. The transforaminal group had improved more than the interlaminar group (mean change of 2.7 vs 1.4, p<0.01, 95% CI 1.08-4.21). The weaknesses of this trial were a short follow-up period, small sample size, lack of randomization, and the injections were all administered by the same practitioner. In conclusion, the patients in this study who received interlaminar epidural steroid injections had better short-term improvement and surgery rates than those in the transforaminal group.]**

Schenk RJ, MacDiarmid A, Rousselle J. The effects of muscle energy technique on lumbar range of motion. J Man Manipul Ther 1997;5(4):172-83.

Schmid G, Vetter S, Gottman D, Strecker EP. CT-guided epidural/perineural injections in painful disorders of the lumbar spine: Short- and extended-term results. Cardiovasc Intervent Radiol 1999;22(6):493-8. **[This is a prospective therapeutic study including 32 patients, 14 female and 18 male, with a mean age of 55 years. All subjects had experienced lumbar spine pain and/or sciatica for at least 6 weeks. Five of the patients only had back pain, and the other 27 had sciatica with back pain. A total of 140 periradicular/epidural injections were performed on 32 subjects, averaging 4.4 treatments per subject. Additionally, 14 facet joint denervations were performed on 9 patients. The denervations were performed in both facet joints at each level treated. Physical examinations were performed at baseline and follow up. Visual analog scale (VAS) scores were taken at intake, end of treatment, and final follow up (mean 9.6 months follow up). More than 50% improvement was scored as a good result, 20%-50% was moderate, and less than 20% was graded as no improvement. In the short term 72% had a good result, 19% were moderate, and 9% had no improvement. At long term follow up (mean of 9.9 months, range 1-18 months) 47% had a good outcome, 9% moderate, and 38% had no improvement. Two patients were lost to long term follow up. When the subgroup with facet joint denervation was removed, 100% had good or moderate improvement in the**

short term and 65% had good or moderate improvement in the long term follow up. From the 20 patients with disc herniation, 95% and 65% had good or moderate improvement in the short and long term follow ups, respectively. Out of 7 patients with spinal canal stenosis, 72% and 28% had successful outcomes in the short and long term, respectively. The disc herniation patients had a significantly better outcome than the stenosis patients (p=0.067). No severe complications were reported. The authors conclude that epidural/perineural injections along with facet joint denervation are effective in the treatment of chronic lumbar spine pain. They are slightly more effective at treating lumbar disc herniations than spinal stenosis.]

Schneider-Helmert D, Spinweber CL. Evaluation of L-tryptophan for treatment of insomnia: A review. Psycho-pharmacology (Berlin) 1986;89:1-7.

Senstad O, Leboeuf-Yde C, et al. Frequency and characteristics of side effects of spinal manipulative therapy. Spine 1997;22(4):435-41.

Sheng B, Yi-Kai L, Wei-dong Z. Effect of simulating lumbar manipulations on lumbar nucleus pulposus pressures. JMPT 2002;25:e5. Online: doi:10.1067/mmt.2002.123168. **[Experimental Study. Seven male lumbar spines were used in this study. They were collected from cadavers who were between the age of 24-34 years and were ambulatory without any disease that would affect the properties of skeletal tissue at the time of death. The specimens were loaded into a Material Test System and intradiscal pressure was recorded from the nucleus pulposus at L3-4, L4-5 and L5-S1 while the spines were rotated, rotated and compressed, and rotated and tractioned simultaneously. The pressure in the nucleus pulposus increased in both rotation, and rotation combined with compression. When rotated and tractioned, the pressure either decreased or changed little. The pressure changes in all three "states" at L3-4 had a P-value of <0.01; at L4-5 the P-value was <0.05; and at L5-S1 the P-value was <0.01. The author concluded that rotation combined with traction may be the safest way for the lumbar spine to be manipulated.]**

Sherry E, Kitchener P, Smart R. A prospective randomized controlled study of VAX-D and TENS for the treatment of chronic low back pain. Neurol Res 2001;23(21):780-4. **[This is a randomized controlled trial. Inclusion criteria were: 18-65 years of age, minimum visual analog scale (VAS) score of 2, and the patient had to live within 45 minutes of the clinic. The exclusion criteria were: stenosis, spinal instability, spinal surgical implants, shoulder problems, tumor, infection, inflammatory disease, pregnancy, and previous VAX-D treatment. Patients in the treatment group received 5 VAX-D decompression table treatments per week for 4 weeks, then 1 treatment a week for 4 more weeks, according to the VAX-D protocol. Each session consisted of 15 decompression cycles in 30 minutes in the range of 50-95 pounds each. The control group received TENS therapy for 30 minutes daily for 20 days, then once a week for 4 weeks. The outcomes assessed were the VAS score and a disability questionnaire in which the patient rated their ability to perform 4 different activities on a scale from 1 (cannot perform) to 4 (can do without limitation). A successful outcome was a 50% improvement in VAS score and any improvement in disability rating. Patients with successful outcomes at the end of treatment were followed up with 6 months after the trial. A total of 44 patients were included in the trial, with 22 in each of the groups. Due to drop-outs, there were 40 "efficacy-evaluable" subjects, with 19 in the VAX-D group and 21 in the TENS group. In this group, 13 of 19 (68.4%) of the VAX-D group had a successful outcome, as opposed to 0 of 21 TENS patients (p<0.001). At six months post-treatment, 7 of the 13 successful VAX-D patients showed sustained success by still meeting the criteria for a successful treatment. The authors cited the lack of blinding to be a potential weakness of this study, but also stated that the high success rate clearly outweighs the potential placebo effect. They conclude that patients treated by VAX-D decompression can achieve significant improvement in pain and disability.]**

Simmons E. Contemporary concepts in spine care radiographic assessment with low back pain. Spine 1995;20:32-44.

Simmons ED, Guyer RD, Graham-Smith A, Herzog R. Radiograph assessment for patients with low back pain. Spine J 2003;3(Suppl):3S-5S. **[Narrative review of 4 studies spanning 1981-1990 illustrating the idea that radiographic imaging should be utilized less frequently in the management of LBP. The authors conclude that, in the absence of an abnormal history or physical exam, imaging is not indicated for a first episode LBP patient with pain present for <7 weeks who is improving or has not been treated, or for a chronic LBP patient if imaging has been done within the last 2 years. In addition, views should be kept to a minimum, namely weight bearing AP and lateral unless otherwise indicated.]**

Smeal WL, Tyburski M, Alleva J. Discogenic/radicular pain. Disease-A-Month 2004;50(12):636-69.

Song XJ, Gan Q, Cao JL, et al. Spinal manipulation reduces pain and hyperalgesia after lumbar intervertebral foramen inflammation in the rat. JMPT 2006;29(1):5-13. **[In vivo study on the effect of the activator assisted spinal manipulative therapy (ASMT) for acute intervertebral foramen inflammation in the adult Sprague-Dawley rat. Inflammation was induced in the IVF followed by resultant thermal hyperalgesia and mechanical allodynia. Rats were divided into 3 groups, a group which received IVF inflammation only (n=6), a group which received inflammation and ASMT (n=6), and a surgical control group (n=6). ASMT was then applied to L4, L5, S1 for a series of 10 adjustments 24 hours following surgery, with subsequent application for 7 consecutive days, and then every other day for another 7 days. Electrophysiological recordings were obtained in vitro 15-28 days post surgery for evaluation of DRG excitability. Rats were also observed for postoperative behavioral changes, along with excision and observation of the DRG. This study was conducted at a chiropractic research institution. The authors concluded that ASMT significantly reduced severity and duration of pain and hyperalgesia caused by lumbar IVF inflammation.]**

Soulairac A, Lambinet H. Etudes cliniques de líaction du precurseur de la serotonine le L-5-hydroxy-tryptophane, sur les troubles du sommeil. Schweiz Bundschau Med (PRAXIS) 1998;77(34a):19-23.

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Splendiani A, Puglielli E, De Amicis R, et al. Spontaneous resolution of lumbar disk herniation: Predictive signs for prognostic evaluation. Neuroradiology 2004;46(11):916-22. **[Diagnostic Neuroradiology]**

Staiger TO, Paauw DS, Deyo RA, Jarvik JG. Imaging studies for acute low back pain. When and when not to order them. Postgrad Med 1999;105(4):161-72.

Stanley D, Stockley I, Davies GK, Getty CJ. A prospective study of diagnostic epidural blockade in the assessment of chronic back and leg pain. J Spinal Disord 1993;6(3):208-11. **[A prospective consecutive series of 100 patients with back and leg pain, to evaluate epidural blockade as a diagnostic tool for differentiation between organic and non-organic origin. The series included 75 men and 25 women (mean age 45.5) referred to a hospital back clinic. All patients had either chief complaint**

leg or back pain, as well as clinical assessment that included the identification of inappropriate physical signs. Patients underwent a CT and radiculography, which was correlated with the symptomatic presentation of the patient after injection of saline, followed by anesthetic. Subjects were separated into 2 categories, those who had undergone previous spinal surgery and those who had not. Of the spinal surgery patients, 16 had a positive (>60% improvement in pain score) response to anesthetic, 8 had a negative response, and 1 responded to the placebo. Of the non-surgery patients, 35 had a positive response, 22 a negative response, and 18 a placebo response. Interpretation of these results indicates that no correlation can be made between positive epidural blockade, the number of inappropriate physical signs on exam, and abnormal anatomy evidenced by radiculography and CT.]

Sterling M, Jull G, Wright A. Cervical mobilization: concurrent effects on pain, sympathetic nervous system activity and motor activity. Man Ther 2001;6(2):72-81.

Stern PJ, Cote P, et al. A series of consecutive cases of low back pain with radiating leg pain treated by chiropractors. JMPT 1995;18(6):335-42.

Stitz MY, Sommer HM. Accuracy of blind versus fluoroscopically guided caudal epidural injection. Spine 1999;24(13):1371-6.

Stonebrink R. Evaluation and Manipulative Management of Common Musculoskeletal Disorders, 2nd ed. Portland, OR: Western States Chiropractic College; 1996. **[Expert opinion, textbook.]**

Suk KS, Lee HM, Moon SH, Kim MH. Lumbosacral scoliotic list by lumbar disc herniation. Spine 2001;26(6):667-71. **[Clinical Case Studies (The Lumbar Disc)]**

Supik LF. Sciatic tension signs and lumbar disc herniation. Spine 1994;19(9):1066-9.

Tachihara H, Kibuchi S, Konno S, Sekiguchi M. Does facet joint inflammation induce radiculopathy? Spine 2007;32:406-12. **[Animal study, including a total of 130 adult female rats, 60 of which were in the arthritis group, 60 in the control group, and 10 in a sham group. For the arthritis group, a 1mm sponge was soaked in a solution that induces humoral and cellular immunity and inserted into an incision in the L5-L6 facet joint capsule, which was then closed along with incisions in the fascia and skin. The control group received the same operation except that the sponge was soaked in a physiologic saline solution, and the sham group received only an incision in the facet joint capsule with nothing placed inside. At 1, 3, 5, 7, 14, 21, and 28 days after surgery, 10 rats from each of the 3 groups were tested for allodynia using a series of 8 von Frey hairs, each having a different weight. The hairs were applied to the lateral plantar surface of the left hind paw, which is innervated by the L5 nerve root. A 50% withdrawal threshold (the force necessary to elicit a pain response 50% of the time) was determined with the hairs. Histologic analysis was done at 3, 7, 14, 21, and 28 days on 5 rats from each of the control and arthritis groups. The rats were fixated with paraformaldehyde and L5 and L6 vertebral bodies were removed, decalcified, then prepared into cross-sections for analysis by a physician blinded to the rats' group assignments. Tumor Necrosis Factor (TNF) was evaluated by immunohistochemical analysis at 1, 3, 7, 14, 21, and 28 days on 5 rats from each of the control and arthritis groups. The rats were sacrificed, fixated, and 4 random cross sections of the left L5 dorsal root ganglion were prepared to evaluate the presence of TNF-α-positive neurons. A reduced mechanical threshold was displayed by the arthritis rats at days 3, 5, and 7 compared to the control and sham groups ($P<0.05$). At days 3 and 7, there were significantly more leukocytes in the epidural space of the arthritis group compared to the control group ($P<0.05$). Mankin's score (to measure cartilage degeneration) was significantly higher in the arthritis group compared with the control group throughout the entire study ($P<0.05$). At days 1 and 3, the number of TNF-α-positive neurons was significantly higher in the arthritis group than the control group ($P<0.01$). The results of this study demonstrate that inflammation in the facet joint can cause both the spread of TNF-α from the synovium to the epidural space and the up-regulation of TNF-α by the neurons in the dorsal root ganglion. The timing of the infiltration is associated with the duration of allodynia in the L5 dermatome of the rats in this study. These results suggest that inflammation in the facet joint can possibly cause radiculopathy.]**

Taimela S, Kujala UM, Salminen JJ, Viljanen T. The prevalence of low back pain among children and adolescents. A nationwide, cohort-based questionnaire survey in Finland. Spine 1997;22(10):1132-6.

Takahashi K, Shima I, Porter RW. Nerve root pressure in lumbar disc herniation. Spine 1999;24(19):2003-6. **[Clinical Study]**

Takui I, Takano Y, Yuasa N. Types of lumbar herniated disc and clinical course. Spine 2001;26(6):648-51. **[A retrospective study, consisting of 2 study groups, which investigated different types of herniated discs and duration of symptoms in patients with lumbar disc herniation. Study 1 included chart reviews of 156 patients, ages 13-81 years (avg. 43.2 years), who had surgical repair of disc herniation between Oct 1991 and March 1998 at the author's institution. Initially, all patients were treated conservatively, and surgical treatment was indicated when patients had cauda equina syndrome, progressive motor weakness, or intolerable symptoms. During surgery, it was found that 108 of the herniations were contained and 64 were non-contained. As the preoperative course became longer, the rate of contained herniations found became higher, e.g. 65.5% (36 of 65) of all surgeries were for non-contained herniations within the first month, while only 7.7% (1 of 13) was found to be non-contained after 4 months, and none were non-contained in those having surgery after 8 months. Study 2: Between April 1998 and March 2000, 390 patients were diagnosed with lumbar disc herniation in the author's clinic. 69 patients required hospitalization because of severe sciatica, while all others responded to conservative care, including bed rest for a few days, medication (NSAIDs), and sacral epidural block. Chart reviews were conducted for all patients with hospitalization, and these patients were interviewed and evaluated using the assessment scale of the Japanese Orthopedic Association (JOA). Of the 69 patients who were hospitalized, 34 were treated without surgery. 34 herniotomies were performed an analyzed for this study on patients ranging in age from 17-64 years (avg. 38.2). Of these, 3 were found to have non-contained herniations, all of which were operated on within 2 months of onset. The remaining 31 were contained, 9 of which were operated on within 2 months of onset, and the remaining 22 of which were operated on 4 or more months after onset.]**

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Taylor BA, Casas-Ganem J, Vaccaro A, et al. Differences in the work-up and treatment of conditions associated with low back pain by patient gender and ethnic background. Spine 2005;30(3):359-64. **[Health Services Research]**

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Tsao B. The electrodiagnosis of cervical and lumbosacral radiculopathy. Neurologic Clin 2007;25:473-94. **[Clinical review. Seventy-four studies were referenced in this article, ranging in date from 1892-2006. In summary, electrodiagnosis (EDX) of cervical and lumbar radiculopathy should include Needle Electrode Examination and Nerve Conduction Studies. It can be done to identify and measure the extent of axon loss radiculopathy, specify which nerve root is affected, and rule out other neuromuscular disorders. EDX should not include thermography, Sensory Evoked Potentials, or Motor Evoked Potential, as they offer little additional benefit to an EDX exam.]**

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Urban LM. The straight-leg raising test: A review. J Orthop Sports Phys Ther 1981;2:117-33.

Vad VB, Bhat AL, Lutz GE, Cammisa F. Transforaminal epidural steroid injections in lumbosacral radiculopathy: A prospective randomized study. Spine 2002;27(1):11-16. **[A prospective randomized study (by patient choice) of 48 patients with diagnosed lumbosacral radiculopathy secondary to herniated nucleus pulposis (HNP), to compare treatments of epidural steroid injections (TFESI) (n=25) with saline trigger point injections (TPI) (n=23). Patients with complaints of leg pain greater than low back pain of at least 6 weeks duration, and documented via MR imaging, or manifested clinical signs such as radicular pain and sensory of fixed motor deficits consistent with lumbar radiculopathy at the MRI-documented nerve root level, were included in the study. Exclusion criteria included prior lumbar surgery, large HNP with central or foraminal stenosis on MRI, or progressive neurological deficits. Patients were referred by primary care providers to the private practice of one physician affiliated with a major teaching hospital. Both treatment groups received a basic self-directed home lumbar stabilization program. Based on pre- and post-treatment outcome measurements of Roland-Morris low back questionnaire scores, visual numeric pain scale, finger to floor distance (cm), and patient satisfaction score, 84% of the TFESI patients showed improvements and 48% of the TPI patients responded to treatment. Neither group reported complications such as dural puncture, excessive bleeding, headache, or infection.]**

Van den Hoogen HJM, et al. The interobserver reproducibility of Lasegue's sign in patients with low back pain in general practice. B J Gen Prac 1996;46:727-30.

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Vroomen PC, de Krom MC, Wilmink JT, Kester AD, Knottnerus JA. Diagnostic value of history and physical examination in patients suspected of lumbosacral nerve root compression. J Neurol Neurosurg Psychiatry 2002;72(5):630-4. **[A prospective study of 274 primary care patients referred to a hospital neurology department with a new episode of pain radiating into the leg below the gluteal fold that was sufficiently severe to justify further action. MRI of the lumbar spine was used as the gold standard to demonstrate presence or absence of nerve root compression. Nerve root compression was founds on 56% of the MR images. Patient characteristics, history, and physical exam findings were analyzed to determine if there was an association between clinical findings and diagnosis of nerve root compression on MRI. Positive MRI was associated with 3 patient characteristics (age, sex, and having a job with predominance of standing, walking or lifting activities), 3 symptoms (typical dermatomal pain, coldness in the leg, and increased pain on coughing, sneezing or straining), and 4 physical findings (paresis, a finger-floor distance of >25cm, absence of knee or ankle tendon reflex, and a +SLR).]**

Vroomen$_a$ PC, de Krom MC, Knottnerus JA. Diagnostic value of history and physical examination in patients suspected of sciatica due to disc herniation: A systematic review. J Neurol 1999;246(10):899-906. **[Systematic Review]**

Vroomen$_b$ PC, de Krom MC, Wilmink JT, Kester AD, Knottnerus JA. Lack of effectiveness of bed rest for sciatica. NEJM 1999;340(6):418-23. **[A randomized, controlled, blinded trial of 167 primary care patients with LBP that radiated into one leg below the gluteal fold and was of sufficient severity to justify 2 weeks of bed rest, in order to determine the efficacy of two weeks bed rest for the treatment of sciatica, compared to watchful waiting and palliative treatments including acetaminophen, supplemented by codeine or naproxen, and/or Temazepam for insomnia. Primary outcome measures were the patients' and a single investigator's perception of whether there was improvement since the intake history and physical exam at 2 and 12 weeks. Secondary outcome measures were changes in functional status and in VAS pain scores (after 2, 3 and 12 weeks), absenteeism from work, and the need for surgical intervention. After 2 and 12 weeks, there were no significant differences between the groups in primary or secondary outcome measures.]**

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Vucetic N, Maattanen H, Svensson O. Pain and pathology in lumbar disc hernia. Clin Orthop Related Research 1995;320:65-72. **[A prospective study of 245 patients undergoing surgery for suspected lumbar disc herniation and spinal stenosis to determine if correlation exists between preoperative pain drawings and confirmed disc pathology/level at surgery. Pathology was identified by the surgeons on a scale ranging from sequestered hernia (with free fragment of disc in spinal canal), extruded hernia with intact posterior ligament, protruded hernia – all with nerve root involvement; or normal disc (perhaps slightly bulging but without root involvement). Patients with L4/L5 lesions drew a different pain pattern than those with L5/S1 herniations. The 2 variables with the highest discriminative power for level were anterolateral leg pain (L4/L5) and sciatica to the foot (L5/S1). The degree of hernias also yielded different patterns; the most discriminative variables were bilateral back pain, suggesting protrusion, and sciatica to the foot, suggesting sequestered herniation.]**

Vucetic N, Svensson O. Physical signs in lumbar disc hernia. Clin Orthop Related Research 1996;333:192-201.**[Propsective study of 171 consecutive patients with surgical confirmed lumbar disc hernaitons.]**
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Walsh TL, Hanscom B, Lurie JD, Weinstein JN. Is a condition-specific instrument for patients with low back pain/leg symptoms really necessary? Spine 2003;28(6):607-15. **[Analysis of longitudinal data collected prospectively from 970 patients diagnosed with disc herniation, spinal stenosis, or spondylosis, who were seen for an initial-visit survey and follow-up survey at 3 months, in 1 of 27 National Spine Network member centers across the United States, in order to evaluate the responsiveness of the Oswestry Disability Index, MODEMS scales, and all scales and summary scales of the MOS Short-Form 36 (SF-36) for patients with low back pain and leg symptoms. Pain scales were significantly more responsive, statistically, than function scales, though this difference was small and of questionable clinical significance. There were no significant differences between the condition specific scales and their equivalent general health counterpart.]**
Weber H, Holme I, Amlie E. The natural course of acute sciatica, with nerve root symptoms in a double-blind placebo-controlled trial evaluating the effect of piroxicam (NSAID). Spine 1993;18:1433-8. **[A prospective, multi-centered study of 208 patients with L5, S1 radiculopathy treated with 1 week of bed rest only. 70 % of patients had marked reduction of leg and back pain and improved functional ability within the first month; 60% went back to work; 30% had back problems restricting work or leisure after 1 year. LDH was not differentiated from stenosis.]**
Weber H. Lumbar disc herniation: A controlled, prospective study with ten years of observation. Spine 1983;8(2):131-40.
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Weiner BK, Fraser RD. Foraminal injection for lateral lumbar disc herniations. JBJS (Br) 1997;79B(5):804-7. **[Case series of 30 patients with severe symptoms related to far lateral herniations, most were off work; 27 reported at least moderate relief within 3 weeks, 22 had substantial relief an average of 3.4 years after treatment.]**
Weinstein JN, McLain RF. Primary tumors of the spine. Spine 1987;12(9):843-51.
Weinstein JN, Tosteson TD, Lurie JD, et al. Surgical vs. nonoperative treatment for lumbar disk hernation. JAMA 2006;296(20):2441-50. **[A randomized clinical trial which compared outcomes of surgery (standard open discectomy) to non-operative treatments in 501 surgical candidates, mean age 42 years, for intervertebral disc herniation with radicular leg pain and persistent symptoms of at least 6 weeks duration. The study was conducted at 13 multidisciplinary spine practices in 11 US states between Mar 2000 and Nov 2004. 472 of 501 patients enrolled presented for at least 1 follow-up and were included in the analysis. Primary outcome measures were the Medical Outcomes SF-36 bodily pain and physical functions scales, and the American Academy of Orthopaedic Surgeons MODEMS version of the Oswestry Disability Index (ODI). Patients in both groups improved substantially over the first 2 years. Between-group differences in improvements were consistently in favor of surgery for all outcomes and at all time periods but were small and not statistically significant except for the secondary measures of sciatica and self-rated improvement. Because of the high number of patients who crossed over in both directions, conclusions about the superiority or equivalence of treatments are not warranted based on the intent-to-treat analysis.]**
Weinstein S, Herring S. Lumbar epidural steroid injections. Spine J 2003;3(3 Suppl):37S-44S.
Weise MD, Garfin SR, Gelberman RH, Katz MM, Thorne RP. Lower-extremity sensibility testing in patients with herniated lumbar intervertebral discs. J Bone Joint Surg 1985;67(8):1219-24. **[A prospective study of 25 patients, mean age 42 years, with documented lumbar disc herniation, mean onset 1.2 years, to determine the significance of sensory changes determined by pinprick and light touch in the ankle and foot to determine the location of the disc lesion. The side of the disc lesion was determined correctly with high frequency (90%), while the correct spinal level was identified 50% of the time.]**
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scans of the lumbar spine from a control population with no history of back trouble were mixed randomly with 6 scans from patients with surgically proven spinal disease and interpreted by 3 neuroradiologists. Irrespective of age 35.4% were found to be abnormal, with spinal disease identified (herniated disc in all cases) in an average of 19.5% of the under 40-year-olds. In patients over 40-years, 50% of the scans were read as abnormal, with the most common diagnoses being canal stenosis and facet degeneration. Of the 6 scans of patients with proven disease, all interpretations were found to correlate perfectly with their diagnoses.]

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