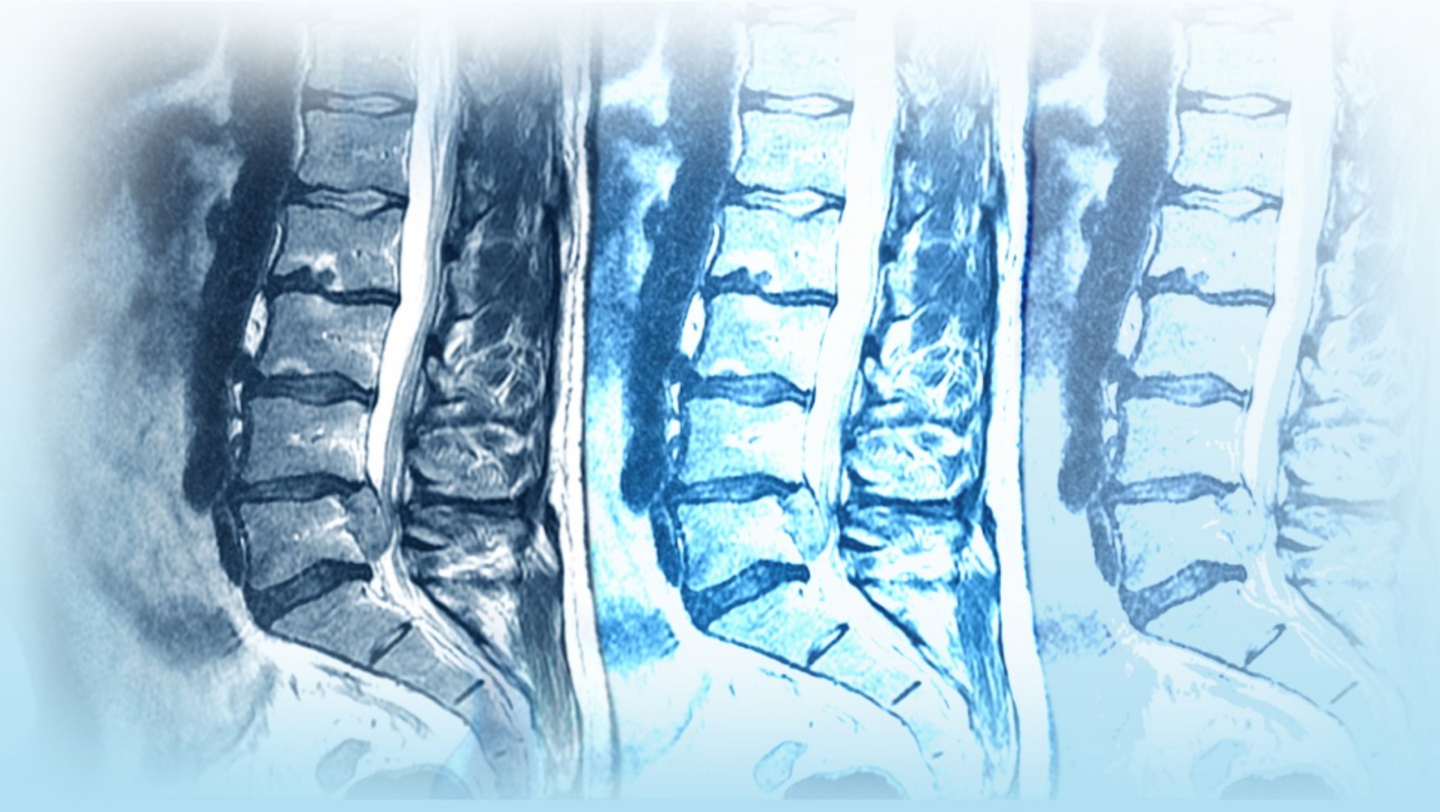
WILLIAM E. MORGAN

Lecture Manual for the Course:

CHIROPRACTIC MANAGEMENT OF LUMBAR DISC DERANGEMENTS



"He who studies medicine without books sails an uncharted sea, but he who studies medicine without patients does not go to sea at all."

William Osler, Canadian Physician, 1849-1919

These notes were written in 2013 and the updated studies which have been published since this document was created and are pertinent to this topic are found on pages 362-390.

Chiropractic Management of Lumbar Disc Derangements

Lecture notes

William E. Morgan, DC, DAAPM, FICC, LLD (hc), FIM

PARKER™
UNIVERSITY

PARKER™
UNIVERSITY

Copyright © 2013 Bethesda Spine Institute
Text by William E. Morgan, DC
All rights reserved. No part of this book may be reproduced in any form or by any electronic, mechanical, or other means without prior permission in writing from the publisher.

Editor: Clare P. Morgan, DC

Disclaimer

The views expressed in this book are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of the Army, Department of Defense, nor the U.S. Government.

Nothing in the presentation implies any Federal/DOD/DON endorsement.

The information within this guide represents the views of the author at the date of publication. Due to the rapid increase in knowledge, the author reserves the right to update and modernize his views as science uncovers more information. While every attempt has been made to verify the information, the author cannot accept responsibility for inaccuracies or oversights. Any perceived disrespect against organizations or individual persons is unintentional. The author makes no guarantee or warranty pertaining to the success of the reader using this material.

The Cost of Piracy

The ability to rapidly share information is part of what makes living in the twenty-first century so extraordinary. So extraordinary that many people forget that much of what is passed from person to person is protected by copyright. Reproducing copyright protected electronic literature is illegal and is, in a word, stealing. Reproducing copyright protected material is morally wrong and illegal.

But more disturbing than the legality of piracy is the fact that doctors and students continue to steal the intellectual property of others. When a doctor or student bootlegs intellectual property, it costs them. It costs them their integrity; it costs them their self-respect; it costs them their honor. Our patients deserve to be treated by doctors who have retained their integrity.

WM

Contents

Chapter	Page
1 Expectations and Way Finding	1
2 The Natural Course of a Disc Herniation	9
3 Outcome Measures	14
4 When to Refer	23
5 The Lumbar Spine	28
6 Disc Herniation	45
7 Clinical Presentation of Lumbar Disc Derangements	50
8 Differential Diagnosis	54
9 Principles of Orthopedic Neurology	68
10 Orthopedic Neurology: The Examination	79
11 The Examination: Practical Application	86
12 The Role of Advanced Imagery in Evaluating Lumbar Disc Lesions	89
13 Introduction to the Systematic Interpretation of the Lumbar MRI	94
14 Anatomical Atlas of the Lumbar Spine on MRI	108
15 The Lumbar Disc on MRI	124
16 Classification of Annular Tears	157
17 Inflammation and Disc Injuries	166
18 Creep	171
19 Lifting and Load Bearing	175
20 Activities of Daily Living	183
21 Physiological Factors in the Management of Disc Derangements	198
22 Extension Exercises	218
23 Exercises to Avoid To Protect Your Disc	234
24 Strengthening the Core	243
25 Nutritional Considerations	259
26 Chiropractic Management of Herniated Discs	268
The Appendices	292
Appendix 1: Piriformis Syndrome	293
Appendix 2: Sciatic Nerve “Flossing”	299
Appendix 3: Glossary	302
Appendix 4: Centralization and Peripheralization	306
Appendix 5: Gallery of Lumbar Disc Derangements	308

To return to this page from any chapter in this book click this icon:

Expectations and Way Finding

1

What are Realistic Expectations?

No book, course, or instruction is able to fully impart all the information to make the reader an expert. This book was created to provide clear, pragmatic information and instruction, offering realistic goals that can be imparted through this particular medium.

The goals of this course are:

- Understand the anatomy and function of the disc, the types of disc derangements, and the lexicon for describing disc lesions
- Identify probable disc derangements through history, observation/examination, and imagery
- Determine the safest course of management
- Understand the concept of evidence-based practice
- Learn the mechanism of injury for disc herniations
- Learn to perform an efficient and meaningful orthopedic/neurologic exam
- Learn to identify disc lesions
- Learn how to conservatively manage a disc derangement
- Learn when to refer

Fine Wine or Sour Milk

The passage of time is both friend and foe. Time allows grape juice to mature into wine, but it can also turn milk sour and cause bread to become stale. Time can create master clinicians or in the case of chiropractors who do not remain current in their knowledge, out-of-date chiropractors. Time can make us wise or just make us older.

There is a general belief that physicians become better with time and experience. Most of us have believed that physicians accumulate knowledge and skill with the passing of years and become better doctors. However, research does not support this belief. Surprisingly, a recent systematic review of 62 studies revealed that in 70% of the studies there was a negative association between length in practice and several measures of quality care. Doctors who have been in practice longer are at risk of providing lower quality care and should be targeted for performance improvement interventions. (Of course this meta-analysis evaluated trends in medical doctors and not chiropractors, but the possibility that this trend could apply to chiropractors should cause chiropractors to take note.)

Unless you deliberately commit yourself to remain current in scientific trends and modern standards of practice, you will most certainly be left behind. If you do not continually seek to improve the quality of the care that you provide, then it may be indicative of the low value that you place on your patients. It takes effort to remain current and relevant, and unfortunately most of us are resistant to change. It is easier to reject guidelines and outcome measures than to take the time to understand why we need them and how they are created.

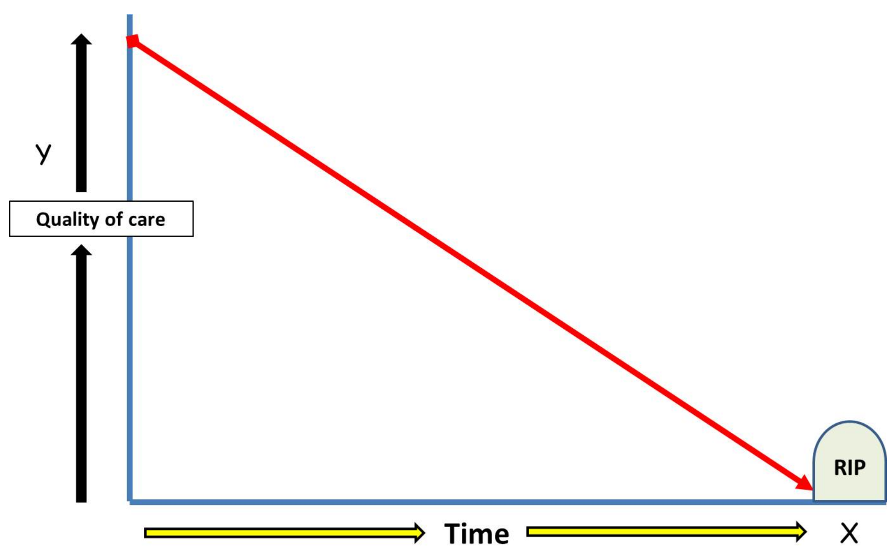


Figure 1:1. While it is a common belief that physicians become better with time, there is compelling evidence that as years pass, physicians actually provide lower quality care.

Choudhry NK, et al. Systematic review: the relationship between clinical experience and quality of health care. Annals of Internal Medicine 2005; 142: 260–273.

Where do you stand?

Are you maturing into a fine wine, or are you becoming sour milk? Are you using clinical guidelines, outcome measures, informed consents, and the safest methods available? Are you evaluating general health indicators, promoting prevention and public health, and limiting your patient's exposure to radiation? Are you well-versed in risk management? How do you measure up?

How can we improve with time?

Seek knowledge. Reject passivity. If you are interested in improving your practice quality with each passing year, then you need to have a purposeful plan. This plan must be flexible and allow for changes in universal practice standards. Start by learning what the current standards of care are in the various aspects of practice, (patient safety, outcome measures, chiropractic practice, risk management…) and then critically evaluate your practice, identify shortcomings, and then make a plan to align your practice with modern standards.

Life-Long Learning

If this is the first time that you have heard the phrase Life-Long Learning, let me assure you that it will not be the last. The vast volumes of new information that is becoming available makes a doctor's formal schooling obsolete in just a few years. The education of everyone in healthcare is destined to be a lifelong pursuit and gone are the days (if those days ever really existed) when a doctor could master a topic and then rest on his or her laurels. Several state boards have already identified the concept of Life-Long Learning and are seeking to expand the hours required for re-licensure and are dictating required topics such as risk management, x-ray, chiropractic technique and public health. We all need to work hard to keep up with the ever-expanding body of knowledge and ever-changing standards of care if we desire to remain relevant.

> Experience does not make you a better clinician. It just makes you older…..unless…you make a concerted effort to stay abreast of current evidence and trends.

Dr. David Eddy, the man who coined the phrase "evidence-based," was interviewed for an article in BusinessWeek (May 29, 2006). Dr. Eddy is a heart surgeon turned mathematician/medical economist. He is known for helping to light the fire of scientific accountability in medicine. He stated that, "The practice of medicine is more guesswork than science." He commonly cites a figure that only 15 percent of what [medical] physicians do is backed by hard evidence.

In spite of all of the ink used to elevate the use of evidence-based health care, we see that much of patient care is still based on anecdotal evidence and health care providers' personal preferences.

Unfortunately, even those who parade under the banner of evidence-based health care fall short of its ideals in their practices. We realize that evidenced-based care is not a destination, but a journey. We take the limited scientific information available and apply it to each patient in the most applicable manner. There are times when there is limited scientific information on a topic, so we must move forward with the best information available.

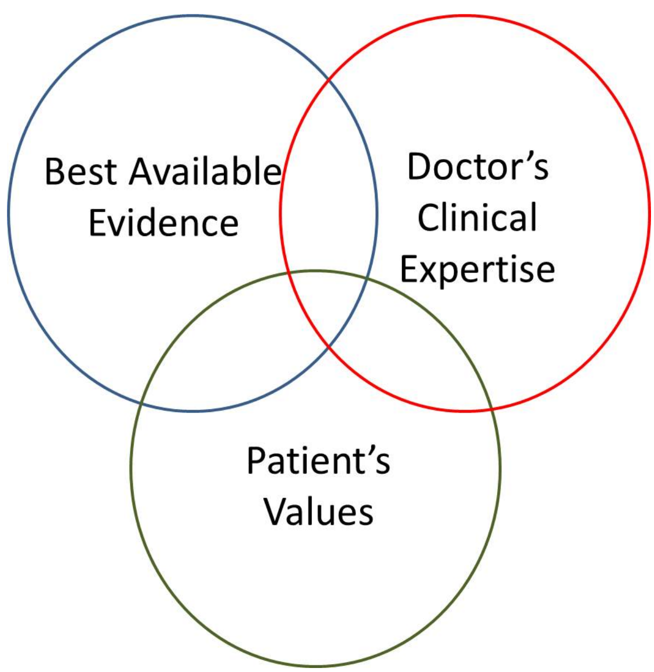


Figure 1:2. Evidence –based care combines the best available evidence, the doctors clinical expertise and experience, with the patient's preferences and values.

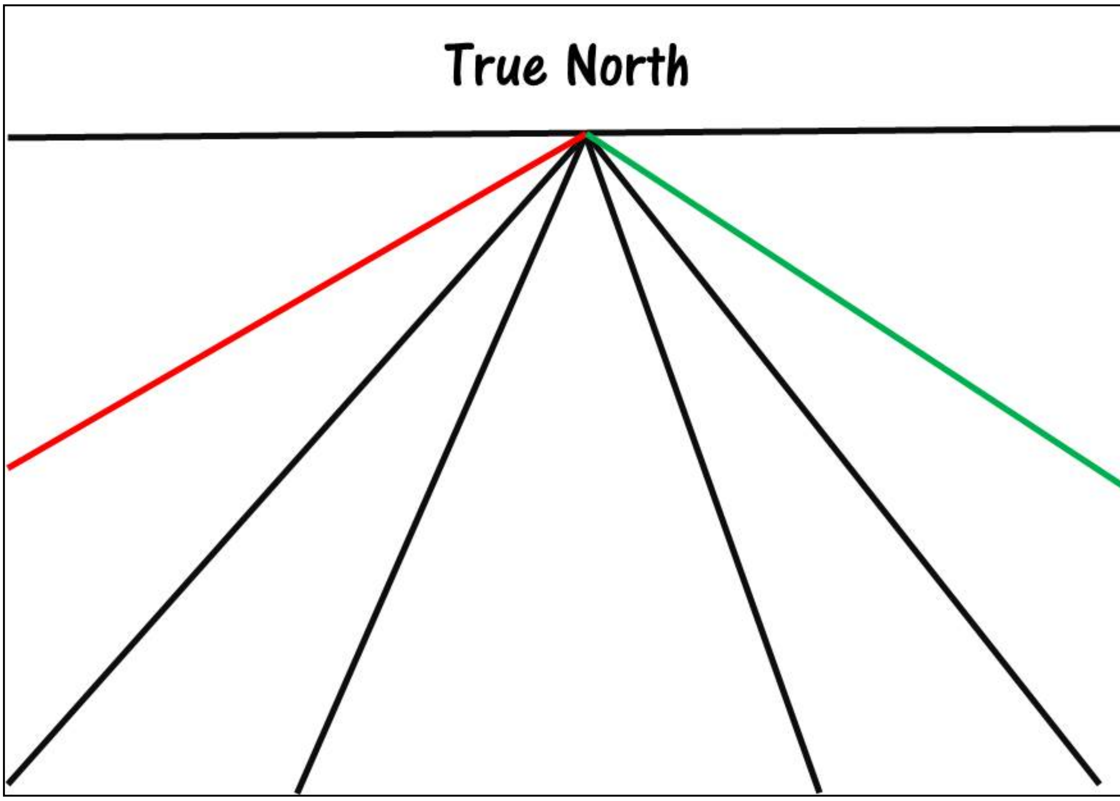


Figure 1:3. The convergence of truth-seekers. If individuals and groups with various viewpoints are really seeking the truth and following the evidence, then they will eventually converge at "Truth North."

Evidence-Based Care is a Moving Target

- This course is an interpretation of the best available evidence at this point in time.
- Invariably there are different interpretations of this evidence.
- In time this interpretation may become obsolete as new discoveries emerge.

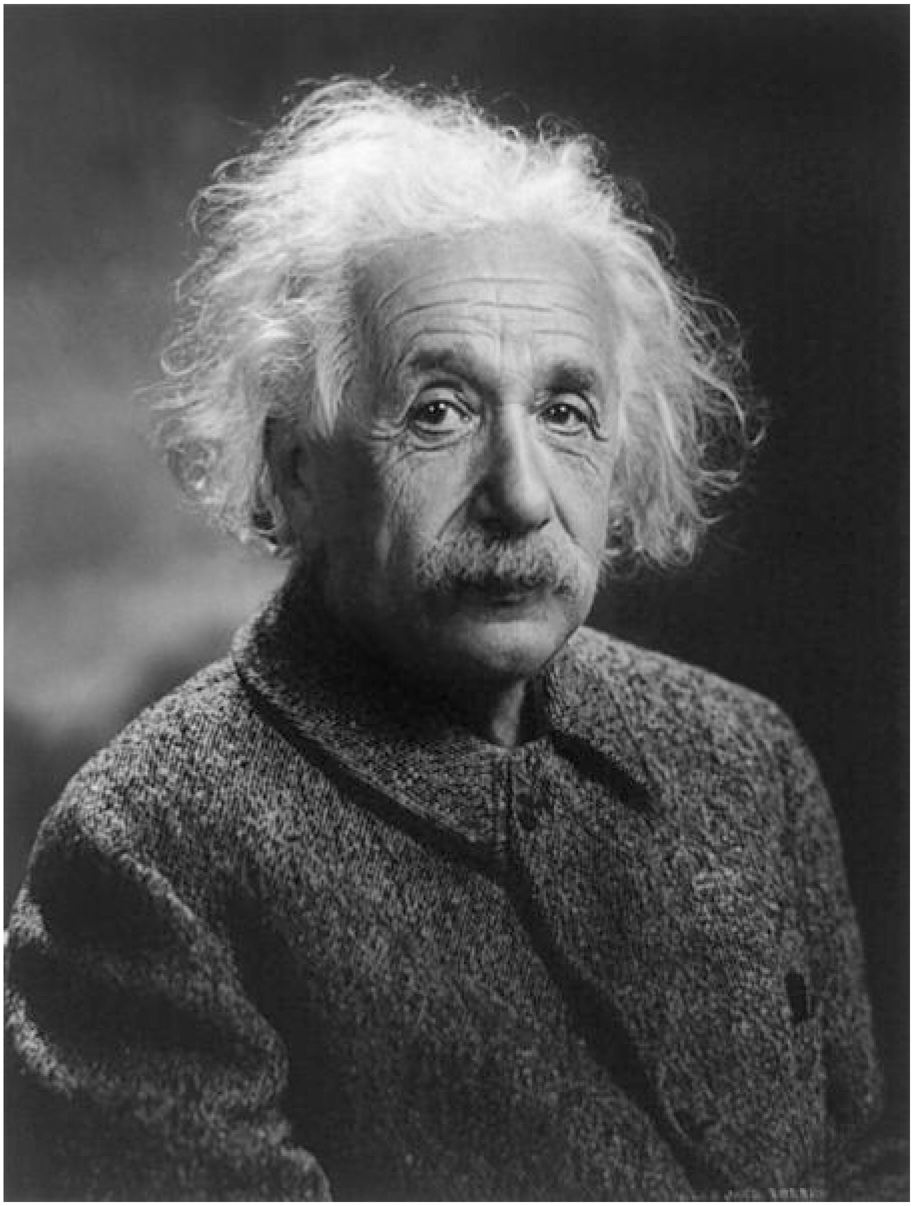


Figure 1:4. Albert Einstein

"A man should look for what is, and not for what he thinks should be."
Albert Einstein

References

Choudhry NK, et al. Systematic review: the relationship between clinical experience and quality of health care. Annals of Internal Medicine. 2005; 142: 260–273.

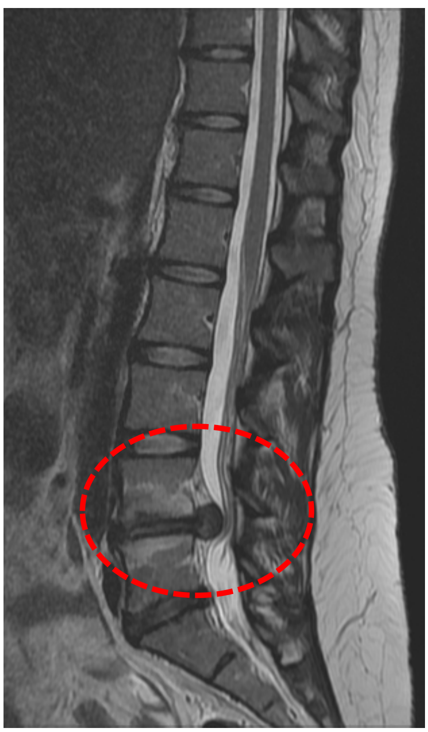
2

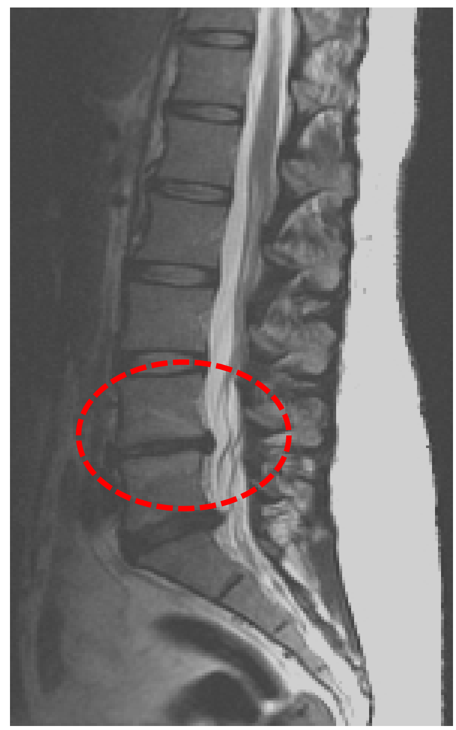
The Natural Course of a Disc Herniation

The Natural Course of a Disc Extrusion

Lumbar disc extrusions have a natural course of progression. This natural progression is characterized by these traits:

- Discs regress with conservative care
- Not just the symptoms, the herniated disc's volume actually regresses
- The larger the herniation, the greater likelihood that it will regress

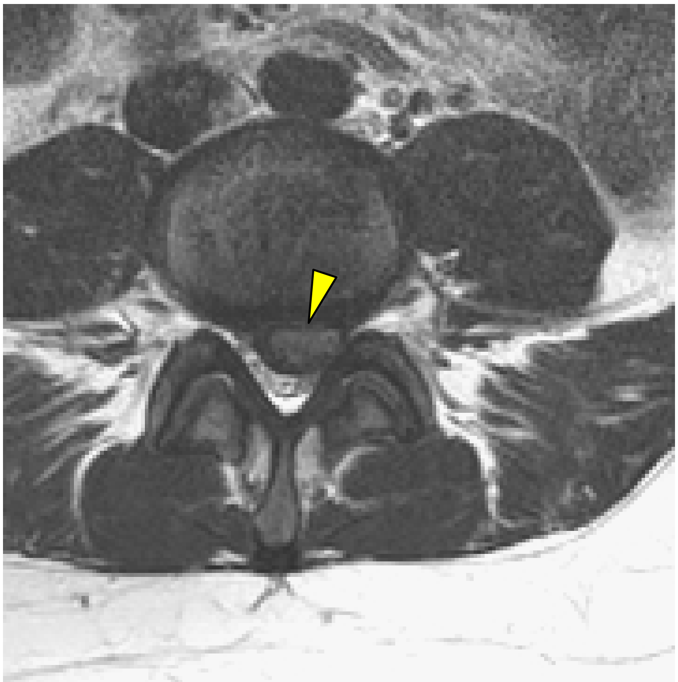




These sagittal T2 weighted MR images demonstrate the regression of a large disc herniation over a five month period.

Benson RT, Tavares SP, Robertson SC, Sharp R, Marshall RW. Conservatively treated massive prolapsed discs: a 7-year follow-up. Ann R Coll Surg Engl. 2010;92:147–53.

http://www.ncbi.nlm.nih.gov/pubmed/15130462



These axial T2 weighted MR images of the same patient from the previous page demonstrate the regression of a large disc herniation over a five month period.

Since the natural response to a disc extrusion is to regress, the vendors of various treatment modalities try to take credit for this regression. The old cowboy proverb, “Timing has an awful lot to do with the outcome of a rain dance” is apropos in describing the timing of any proprietor of a treatment that would take credit for this regression, be it traction, manipulation, flexion-distraction, or exercise.

> “Timing has an awful lot to do with the outcome of a rain dance.”
>
> Old Cowboy proverb

References

Ahn SH, Ahn MW, Byun WM. Effect of the transligamentous extension of lumbar disc herniations on their regression and the clinical outcome of sciatica. Spine. 2000;25:475–80.

Autio RA, Karppinen J, Niinima¨ki J, Ojala R, Kurunlahti M, et al. Determinants of Spontaneous Resorption of
Intervertebral Disc Herniations SPINE Volume 31, Number 11, pp 1247–1252

BenEliyahu DJ. MRI and clinical followup study of 27 patients receiving chiropractic care for cervical and lumbar disc herniation. *JMPT* 1996;19(9):597-606.

Bozzao A, Gallucci M, Masciocchi C, Aprile I, Barile A, Passariello R. Lumbar disk herniation: MR imaging assessment of natural history in patients treated without surgery. Radiology. 1992;185:135–41.

Cherkin DC, Deyo RA, Loeser JD, Bush T, Waddell G. An international comparison of back surgery rates. Spine. 1994;19:1201–6.

Choudhry NK, et al. Systematic review: the relationship between clinical experience and quality of health care. Annals of Internal Medicine 2005; 142: 260–273.

Cribb GL, Jaffray DC, Cassar-Pullicino VN. Observations on the natural history of massive lumbar disc herniation. J Bone Joint Surg Br. 2007;89:782–4.

Delauche-Cavallier MC, Budet C, Laredo JD, Debie B, Wybier M, et al. Lumbar disc herniation. Computed tomography scan changes after conservative treatment of nerve root compression. Spine. 1992;17:927–33.

Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, Von Korff M, Waddell G. Outcome measures for low back pain research. A proposal for standardized use. Spine (Phila Pa 1976). 1998 Sep 15;23(18):2003-13.

Komori H, Shinomiya K, Nakai O, Yamaura I, Takeda S, Furuya K. The natural history of herniated nucleus pulposus with radiculopathy. Spine. 1996;21:225–9.

References

Matsubara Y. Serial changes on MRI in lumbar disc herniations. *Neuroradiology* 1995;37:378-383.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. JMPT 2001; 24: 596-602.

Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). Spine 1995; 20: 2513-21.

Matsubara Y, Kato F, Mimatsu K, Kajino G, Nakamura S, Nitta H. Serial changes on MRI in lumbar disc herniations treated conservatively. Neuroradiology. 1995;37:378–83.

McKenzie RA. The Lumbar Spine. Mechanical diagnosis and therapy. Waikanae: Spinal Publications; 1981.

Modic MT, Ross JS, Obuchowski NA, Browning KH, Cianflocco AJ, Mazanec DJ. Contrast-enhanced MR imaging in acute lumbar radiculopathy: a pilot study of the natural history. Radiology. 1995;195:429–35.

McMorland G, Suter E, Casha S, du Plessis SJ, MD, Hurlbert RJ, MD. Manipulation or Microdiskectomy for Sciatica?
A Prospective Randomized Clinical Study J Manipulative Physiol Ther. 2010 Oct;33(8):576-84.

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine (Phila Pa 1976). 1990 Jul;15(7):683-6

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 Journal.* Mar-Apr 2006;6(2):131-137.

3

Outcome Measures

Outcome Measures

Every patient is unique and will respond differently to treatment. It is important that the provider is diligently observant to progression or regression of signs and symptoms. To this end the provider must understand and implement the use of metrics in treating disc patients.

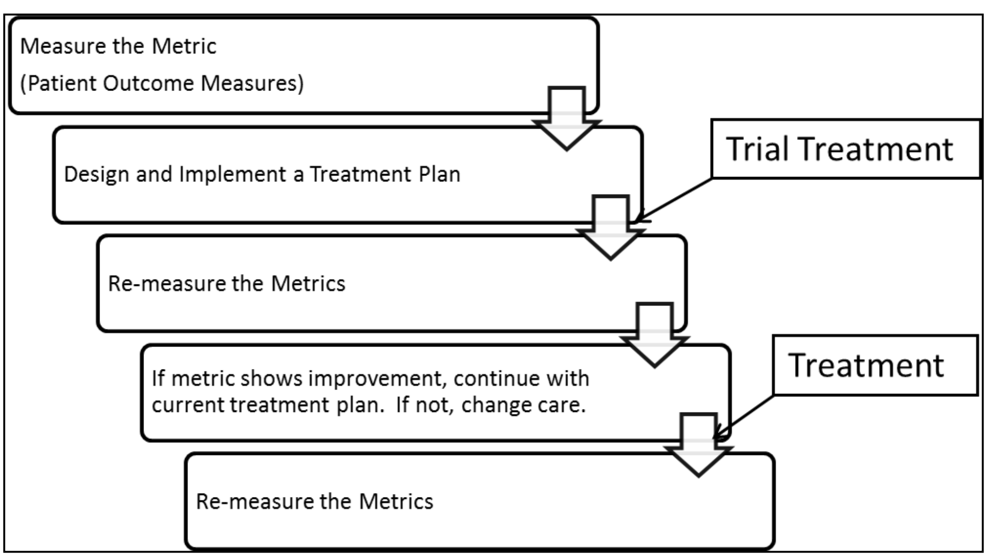
Characteristics of Outcome Measures

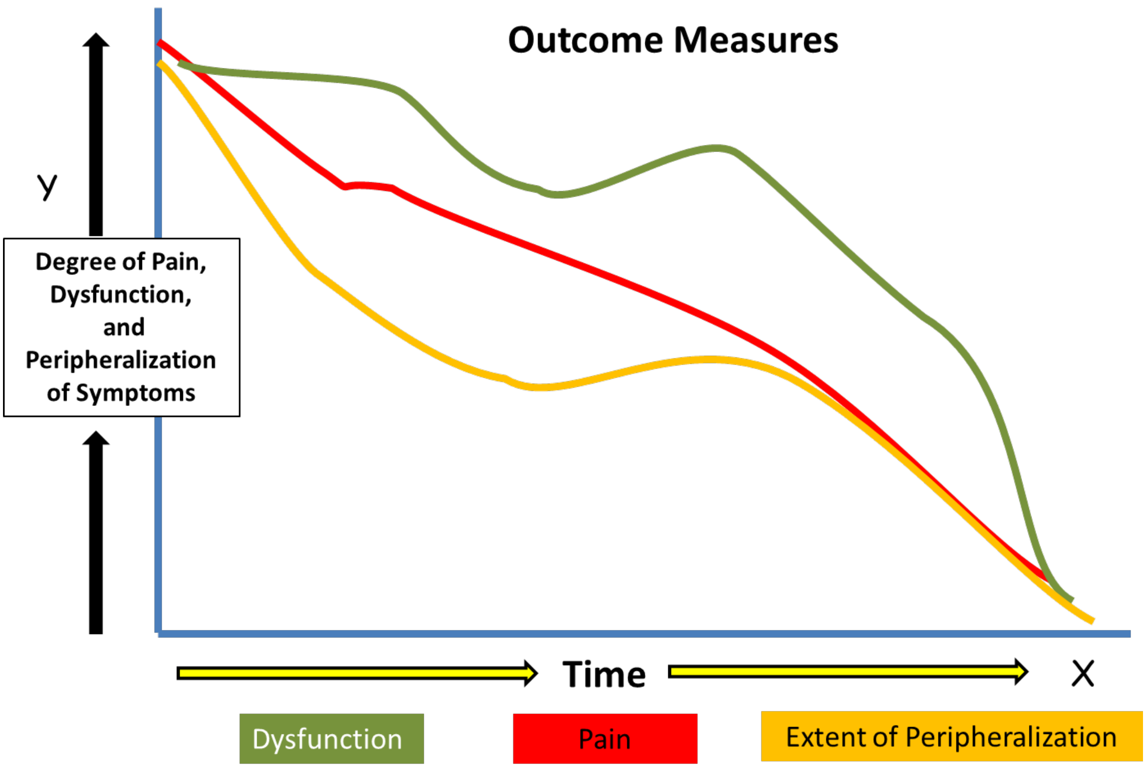
- Relevant
- Have an ability to improve with time
- Measurable

Outcome Measure Metrics

There is a systematic method for implementing outcome measures:

- Select a metric.
- Measure the metric.
- Implement a corrective measure.
- Re-measure the metric.
- If the metric improves, continue with that course, periodically re-measuring the metric.
- If the metric worsens, change the direction of treatment until the metric improves.
- If the patient continues to decline, discontinue treatment and refer.





A successful treatment plan will improve the three metrics of function, pain, and peripheralization over time and can be graphed. Outcome measures will expose unsuccessful treatment programs and will redirect the practitioner toward other more appropriate treatment plans.

What Metrics are Used in Managing Disc Derangements?

What Metrics are Used in Managing Disc Derangements?

- Neurological integrity
- Function (Oswestry, Roland-Morris, …)
- General Health Assessments (SF 36)
- Pain
- Distribution of (radicular) symptoms

Neurologic integrity is the most important metric used in outcome measurements. It matters little if the patient is feeling better but has lost the use of a body part or bodily function.

- Neurological integrity — Doctor Determined
- Function (Oswestry, Roland-Morris, …)
- General Health Assessments (SF 36)
- Pain
- Distribution of (radicular) symptoms

Patient Reported

Neurologic integrity is doctor determined, whereas the other outcome measures are patient reported.

Neurologic Integrity

- The provider will perform a baseline neurological examination and periodically re-examine the patient.
- Treatment will be determined by the neurological integrity of the patient.
- If the exam improves with treatment, the treatment may continue.
- If the results of the exam worsen with treatment, it must be discontinued or modified.

Function: Which Patient Outcome Questionnaire Should be Used?

Which outcome measure should you use? The one that you will use. That means that you need to select a metric that suits the needs of the patient and the doctor and is also easy enough to implement that it does not burden the doctor, staff, or patients. Here are some examples of outcome measurement questionnaires that are available:

- Condition-Specific Outcome Measures:
  - Oswestry Disability Index (ODI)
  - Roland Morris
- General Health Questionnaires
  - Medical Outcomes Study Short Form (SF-36)

http://www.pittsburgh.va.gov/rehab/docs/PainQuestionaires.pdfhttp://www.rmdq.org/

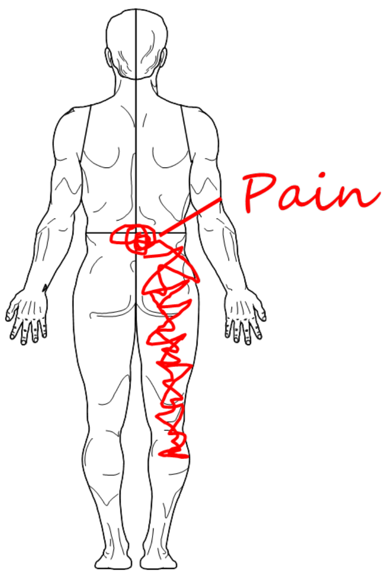
Pain Scales

Recording pain levels is one of the easiest measurements to acquire and track in a flowchart. Here are two popular pain scale measurement tools:

- Visual Analog Scale (VAS) 0-10
- Quadruple Visual Analog Pain Scale
  1. Pain level right now
  2. Pain level at its worst pain level
  3. Pain level at its best pain level
  4. Average or typical level of pain

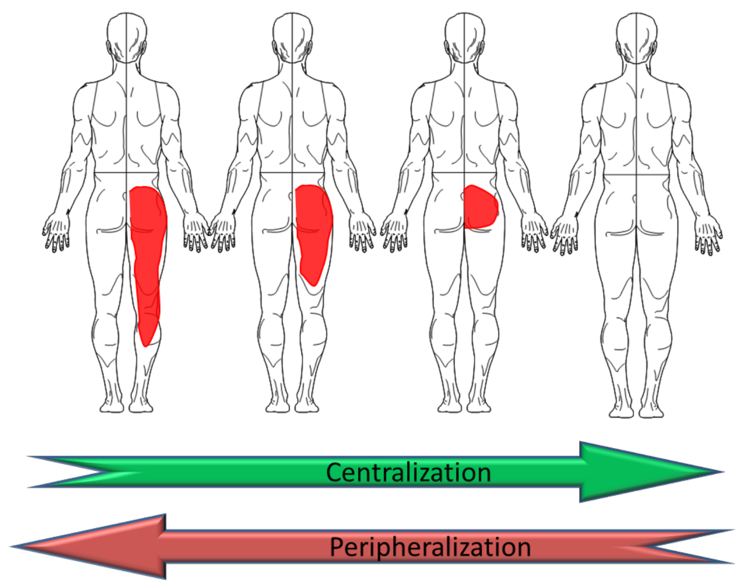
Pain Mapping

Pain mapping allows the patient to document the extent of their referred or radicular pain.



- Patients draw the extent of their pain or other symptoms.
- They label the perceptions (pain, tingling, numbness…).
- Patients sign and date the form.

A successful treatment will cause the patient's symptoms to centralize (move more central). An unintended outcome of treatment would be to have the symptoms progress further down the leg or to peripheralize.



Case Completion is the Goal

Many in chiropractic have selected the wrong measure of a healthy successful practice: total patient visits, patient visit average, or the number of new patients. A better measure of long-term success is your number of *completed cases*. This is especially true if you have an integrated practice that welcomes medical referrals.

What is a *completed case*? As the name implies, it is a clinic case that you have brought to conclusion. Not all completed cases are cured cases or even successful cases. Even with patients that you are not able to help, you owe it them to professionally and ethically see their case through a logical conclusion and ensure that they are referred to someone who may be better able to help them. A completed case does not require that you permanently release these patients from your care. You may complete a case when a condition plateaus, but recommend that the patient return on a regular basis for palliative or continuance care. If you feel that a patient has reached a maximum benefit from care, but periodic additional chiropractic care will prevent relapses, complete the case and return the patient to the referring doctor with your recommendations.

If you are successfully completing cases, your patients will refer, and the medical doctors who refer to you will gladly keep sending patients your way. I have found that chiropractors who do not pursue case completion are more likely to resort to desperate means of maintaining a flow of new patients, such as giving free spinal examinations or the using telemarketing schemes.

On the first visit I describe my goals to the patient in simple terms. I explain that I will treat them until one of three outcomes occurs: They are made well; they get better to a point, then plateau off and become permanent and stationary; or I treat them and they do not get better…or they get worse. Every patient I have explained these definitions of case completion to has accepted it. I then ask their goals and try to align them with my assessment of their condition. I try to persuade the patient to give me a practical measurement that would define success for them. "I would like to pick up my grandson without pain." Or "I would consider this treatment successful if I was able to work with pain that is 2/10 [on an analog scale]."

A physical therapist in our spine clinic likes to have his patients write their goals down, date them, and sign them. He keeps them in the patient's record. When those goals are reached, either the case is completed, or new goals are set.

In addition to personal goals to measure case completion, I like to use outcome measurement tools such as the Roland-Morris questionnaire, pain maps and analog pain scales.

You should have a well-defined plan of treatment, evaluation, re-evaluation and conclusion to all of your cases. Your patient, the referring doctor and any third-party payer should all know your specific definition for case completion.
If you do not use well-defined case completion goals and treatment plans, the patient will feel, possibly justifiably, that you don't know what you are doing or that you are just stringing them along for pecuniary gain.

References

Ahn SH, Ahn MW, Byun WM. Effect of the transligamentous extension of lumbar disc herniations on their regression and the clinical outcome of sciatica. Spine. 2000;25:475–80.

Autio RA, Karppinen J, Niinima¨ki J, Ojala R, Kurunlahti M, et al. Determinants of Spontaneous Resorption of
Intervertebral Disc Herniations SPINE Volume 31, Number 11, pp 1247–1252

BenEliyahu DJ. MRI and clinical followup study of 27 patients receiving chiropractic care for cervical and lumbar disc herniation. *JMPT* 1996;19(9):597-606.

Bozzao A, Gallucci M, Masciocchi C, Aprile I, Barile A, Passariello R. Lumbar disk herniation: MR imaging assessment of natural history in patients treated without surgery. Radiology. 1992;185:135–41.

Cherkin DC, Deyo RA, Loeser JD, Bush T, Waddell G. An international comparison of back surgery rates. Spine. 1994;19:1201–6.

Choudhry NK, et al. Systematic review: the relationship between clinical experience and quality of health care. Annals of Internal Medicine 2005; 142: 260–273.

Cribb GL, Jaffray DC, Cassar-Pullicino VN. Observations on the natural history of massive lumbar disc herniation. J Bone Joint Surg Br. 2007;89:782–4.

Delauche-Cavallier MC, Budet C, Laredo JD, Debie B, Wybier M, et al. Lumbar disc herniation. Computed tomography scan changes after conservative treatment of nerve root compression. Spine. 1992;17:927–33.

Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, Von Korff M, Waddell G. Outcome measures for low back pain research. A proposal for standardized use. Spine (Phila Pa 1976). 1998 Sep 15;23(18):2003-13.

Komori H, Shinomiya K, Nakai O, Yamaura I, Takeda S, Furuya K. The natural history of herniated nucleus pulposus with radiculopathy. Spine. 1996;21:225–9.

References

Matsubara Y. Serial changes on MRI in lumbar disc herniations. *Neuroradiology* 1995;37:378-383.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. JMPT 2001; 24: 596-602.

Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). Spine 1995; 20: 2513-21.

Matsubara Y, Kato F, Mimatsu K, Kajino G, Nakamura S, Nitta H. Serial changes on MRI in lumbar disc herniations treated conservatively. Neuroradiology. 1995;37:378–83.

McKenzie RA. The Lumbar Spine. Mechanical diagnosis and therapy. Waikanae: Spinal Publications; 1981.

Modic MT, Ross JS, Obuchowski NA, Browning KH, Cianflocco AJ, Mazanec DJ. Contrast-enhanced MR imaging in acute lumbar radiculopathy: a pilot study of the natural history. Radiology. 1995;195:429–35.

McMorland G, Suter E, Casha S, du Plessis SJ, MD, Hurlbert RJ, MD. Manipulation or Microdiskectomy for Sciatica?
A Prospective Randomized Clinical Study J Manipulative Physiol Ther. 2010 Oct;33(8):576-84.

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine (Phila Pa 1976). 1990 Jul;15(7):683-6

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 Journal.* Mar-Apr 2006;6(2):131-137.

WHEN TO REFER

4

Most Disc Herniations Resolve Without Surgery

Most disc herniations resolve without the need for surgery. It is the rule, not the exception.* However, the damage caused by a disc herniation may require that the disc be treated aggressively to avoid long-term neurological damage. This manual is intended to shepherd the patient with disc herniations through the recovery process. Unfortunately, not all patients will be able to wait long enough to allow their disc to regress naturally, and they will need surgery to prevent permanent nerve damage. A complete neurological examination by a competent doctor will help to determine if nerve damage is occurring.

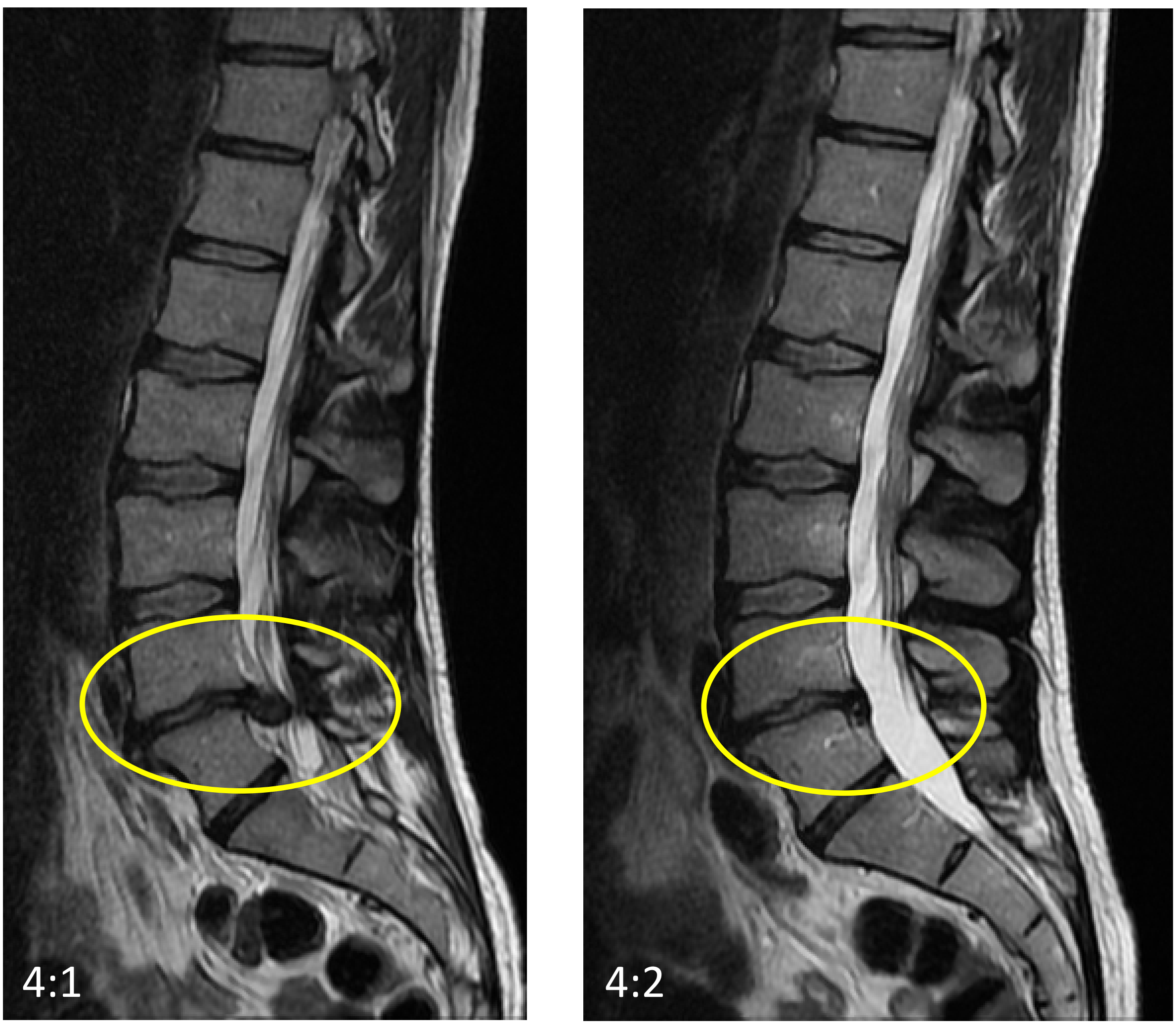


Figure 4:1 and 4:2. Figure 4:1 reveals the MRI of a large herniation of a patient. Figure 4:2 shows the same patient five months later with the disc herniation totally resolved. This patient was treated by a chiropractor using the principles found in this book.

* http://www.med.nyu.edu/pmr/residency/resources/general%20MSK%20and%20Pain/determinants%20of%20HNP%20resorption_Spine.pdf

When to Seek Medical Care

Avoiding *unnecessary* spinal surgery is the intent of this course, but unfortunately not all spine surgery is avoidable, and not every reader will avoid surgery. Some disc injuries require surgery or at least a consultation with a spine surgeon. Before reading the rest of this book you are urged to carefully review the next pages to determine if you need a surgical consultation. There are varying degrees of urgency in seeking a surgical consultation. On one end of the spectrum is a medical emergency which requires immediate surgical intervention to avoid or minimize a permanent impairment. On the other end of the continuum is the elective surgical consultation. An elective surgical consultation occurs when a patient elects to be seen for a surgical consultation due to a chronic progressive condition that, while not emergent, constitutes a sustained and unresolved spinal condition which may be addressed with surgery.

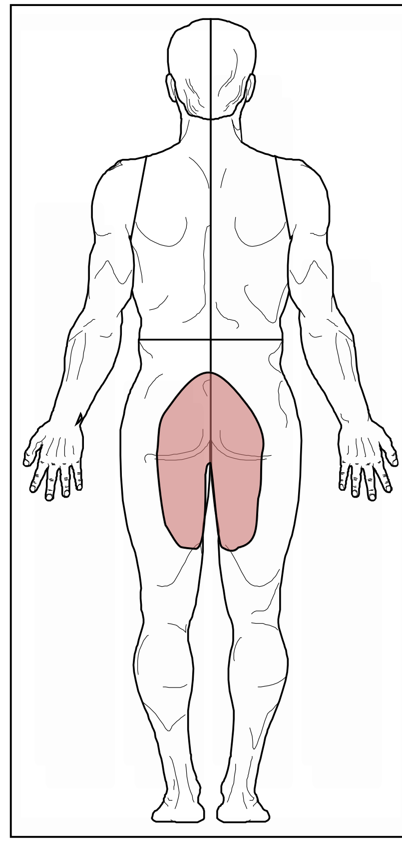


Figure 4:3. Saddle distribution numbness may indicate a medical emergency.

Medical Emergencies

Certain spinal symptoms require an immediate surgical consultation: Loss of bowel or bladder control, urinary retention, neurological sexual dysfunction, muscle weakness or flaccidity, neurological deficit, numbness of the genitalia, or numbness in the distribution of a saddle.

Less urgent symptoms that may need a surgical consultation include severe and disabling back pain or shooting pain into the legs that is refractory (does not respond) to other treatments and lasts more than four to eight weeks.

When to Seek Medical Care

Red Flags for Potentially Dangerous Conditions These conditions need immediate medical attention	
Conditions	**Red Flags**
Spinal Fractures	• Trauma (falling, car accident…) • Osteoporosis: Even minor trauma can cause fractures in people who have osteoporosis. Risk for osteoporosis increases with age or with the use of steroids or transplant immune-suppressing drugs.
Infection or Tumor	• Pain that is worse at night • The use of corticosteroids or HIV or immune-suppressive drugs (drugs that reduce symptoms that help fight disease) • Unexplained weight loss • Night sweats, chills, fever • History of cancer • Recent infection
Severe Neurological Conditions	• Bladder or bowel dysfunction • Numbness of the anus or genitals • Weakness of the legs • Numbness in the distribution of [both] your inner thighs

Figure 4:4. Aside from disc herniations, there are several other conditions and symptoms that require immediate medical attention. Fractures, infections, cancer, tumors, and progressive neurological disease can all mimic the signs of a herniated lumbar disc. This chart highlights some of the symptoms that are considered *Red Flags*. Red Flags require immediate medical consultation.

When to Seek Medical Care

When is elective surgery appropriate?

For the majority of patients with a disc injury, surgery is not required.
Spinal surgery may be an option if….

1. An MRI, CT, or other advanced imagery confirms that a herniated disc is compressing nerves, and there are significant correlated symptoms or findings that match the radiographic findings.
2. The patient has unrelenting pain that extends past the knee.
3. Foot weakness or tingling is present and persistent.
4. Six weeks of conservative treatment such as physical therapy or chiropractic has failed to alleviate the condition.

Surgery carries significant risk. Patients should partner with their primary care physician, surgeon, and conservative spine care specialist (chiropractor) to determine if the potential benefits of surgery justify the risks.

The Lumbar Spine

5

The Lumbar Spine

To fully understand spinal injuries, it is important to have an understanding of the anatomy of the spine. The lumbar spine is composed of five bones called vertebrae. These bones are stacked on top of each other and are a bridge between the pelvis and the thoracic spine. The thoracic spine includes the vertebrae which have ribs attached.

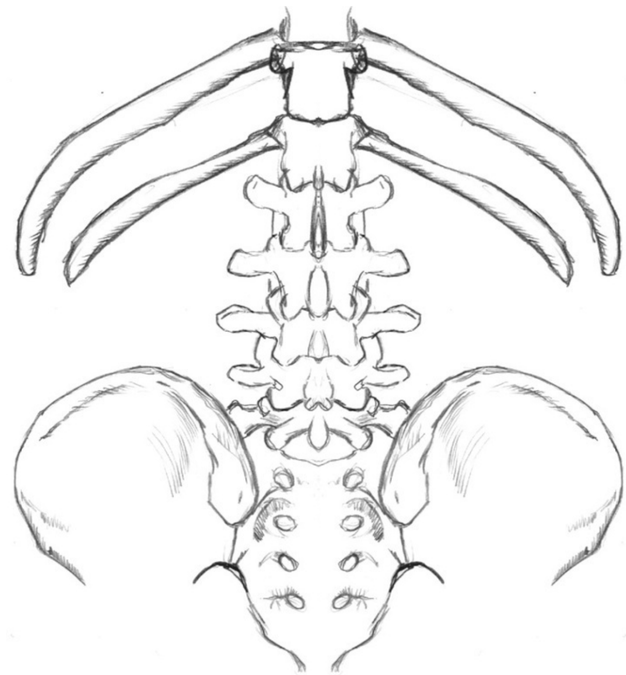


Figure 5:1 The lumbar spine.

A significant amount of motion occurs in the lumbar spine since it lacks bony support as found from the ribs above or from the pelvic bones below. This increased mobility allows for greater stress to be placed upon these segments, particularly on the lumbar discs. Most disc herniations occur in the lumbar spine, the majority occurring at the L5-S1 level (the disc between the lowest lumbar vertebra and the sacrum). The sacrum serves as the base of the spine.

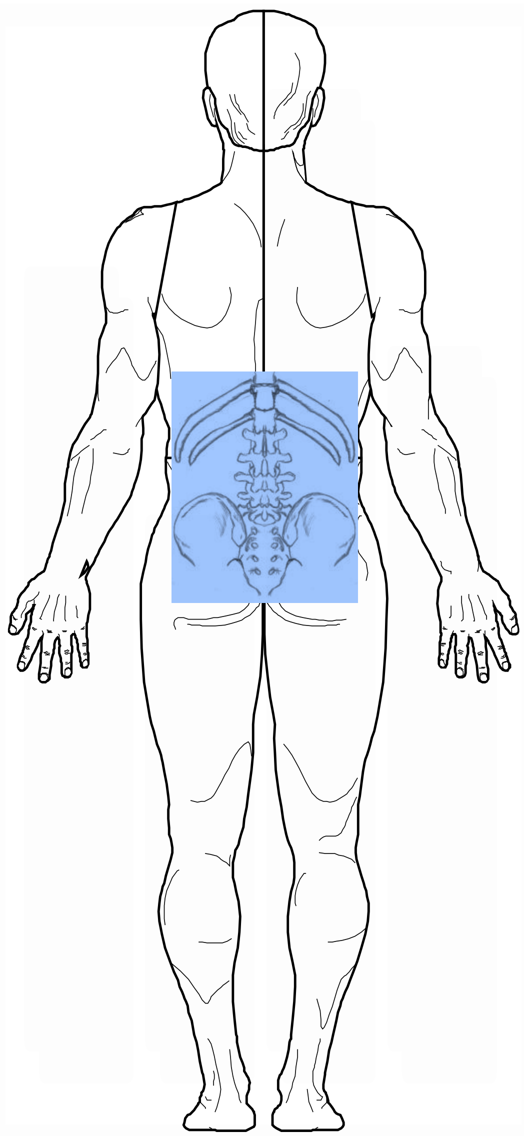


Figure 5:2 The lumbar spine.

The Intervertebral Disc

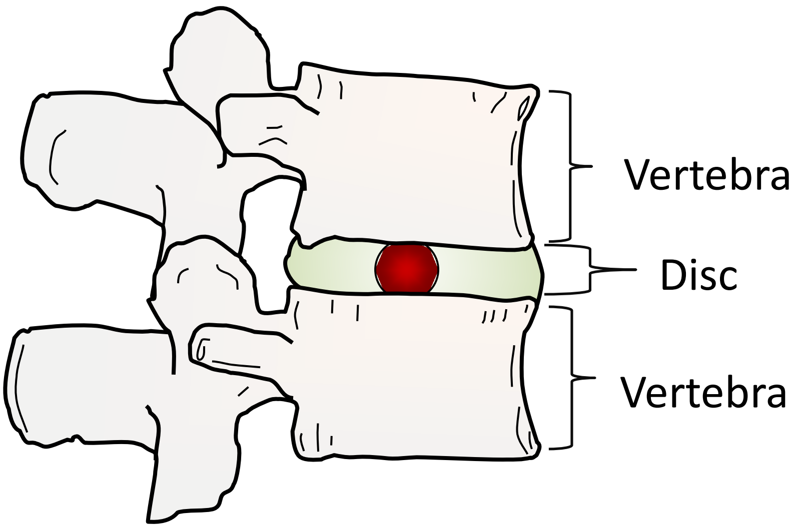


Figure 5:3 Adjoining spinal segments.

What is the Intervertebral Disc?

The bones of the spine are called vertebrae, and each individual bone is called a vertebra. Between the vertebrae are pads called intervertebral discs. These pads are composed of bands of connective tissue called fibrocartilage. The consistency of fibrocartilage is flexible like your nose or ear. In the center of the bands of fibrocartilage is an encapsulated gel-filled nucleus. The disc acts as a shock absorber, a pivot, and a spacer. These properties allow humans to have spinal mobility and support our upright postures.

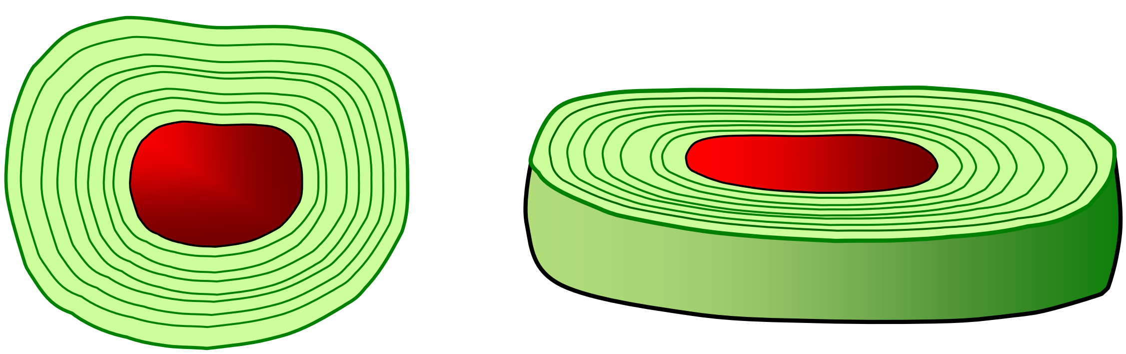


Figure 5:4. The disc is composed of concentric bands of fibrocartilage, the same material that provides the flexible structure of your ears and nose. In a cross-section the bands of fibrocartilage resemble an onion sliced in half. These bands are called the annulus.

The Intervertebral Disc

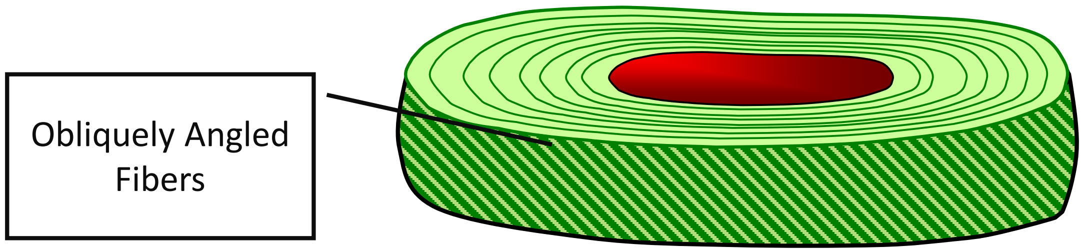


Figure 5:5. The rings of the disc have fibers that angle obliquely. Each layer of fibrocartilage has a different fiber orientation.

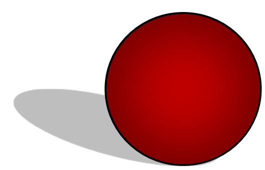


Figure 5:6. In the center of the fibrocartilage bands is an encapsulated gel-filled nucleus. The thick gel has the consistency of cold syrup. This gel is given shape and structure through the tissue which surrounds it, like a water balloon. For illustrative purposes the schematic shows the nucleus as being round. In reality a disc may be rounded, but not symmetrically spherical.

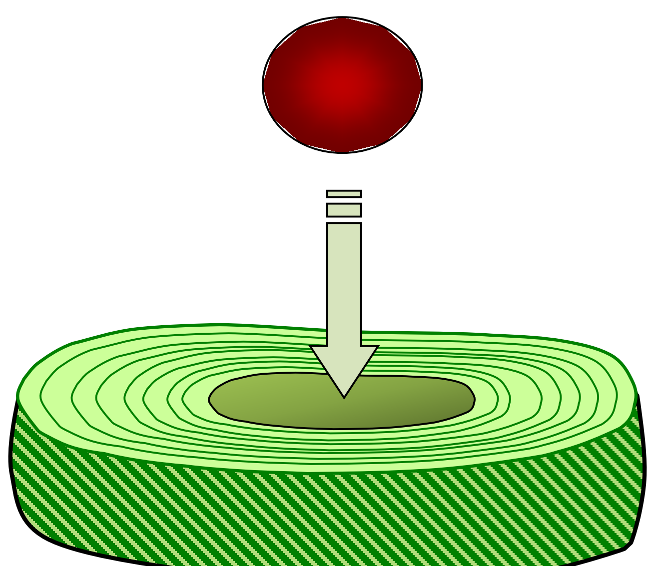


Figure 5:7. The nucleus is encompassed within the cartilage rings of the disc.

The Intervertebral Disc

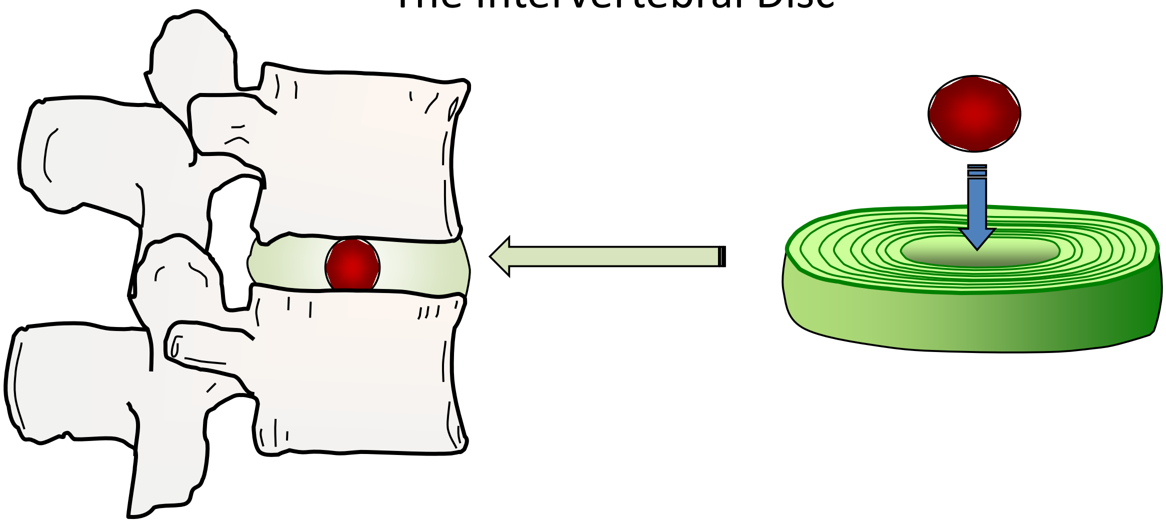


Figure 5:8. Each disc is sandwiched between two vertebrae.

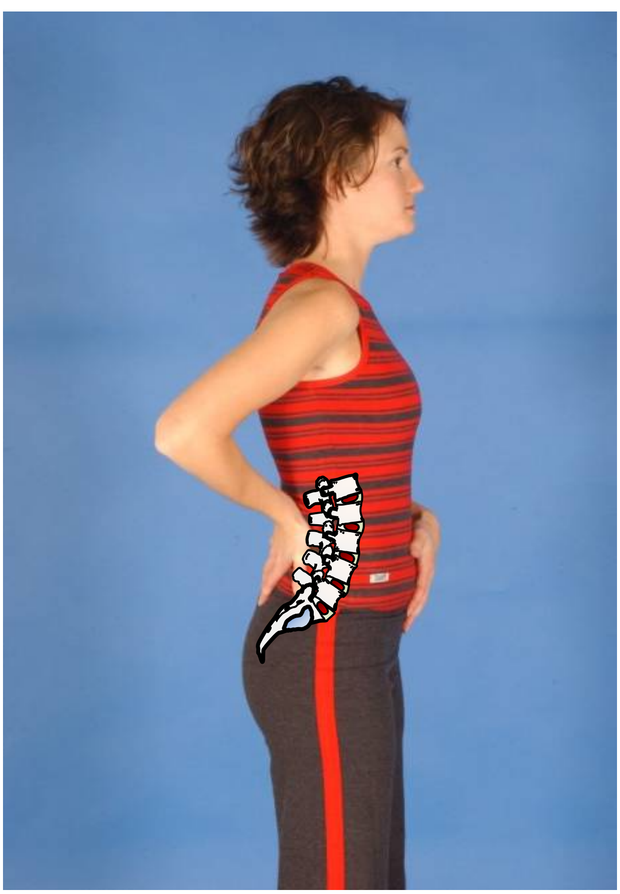


Figure 5:9. Twenty-four vertebrae make up the spine. The bottom five are called the lumbar vertebrae or the lumbar spine.

The Intervertebral Disc

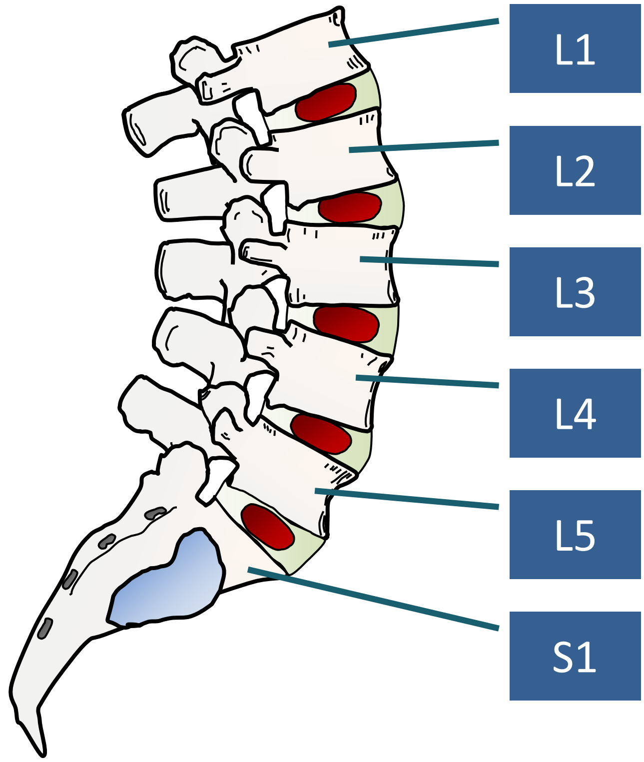


Figure 5:10. The lumbar vertebrae are numbered 1 through 5. The top lumbar vertebra is referred to as L1. The bottom lumbar vertebra is L5. The base (bottom) of the spine is the sacrum. The top of the sacrum is called S1. The discs are identified by which vertebrae they are between. The most common site for herniation is the L5-S1 disc.

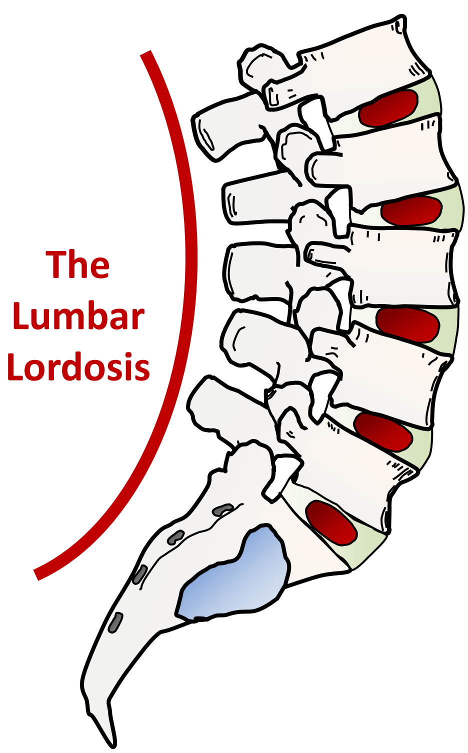


Figure 5:11. A normal lumbar spine has an arch called a "lordosis." Maintaining a lumbar lordosis is important in protecting the lumbar discs.

The Intervertebral Disc

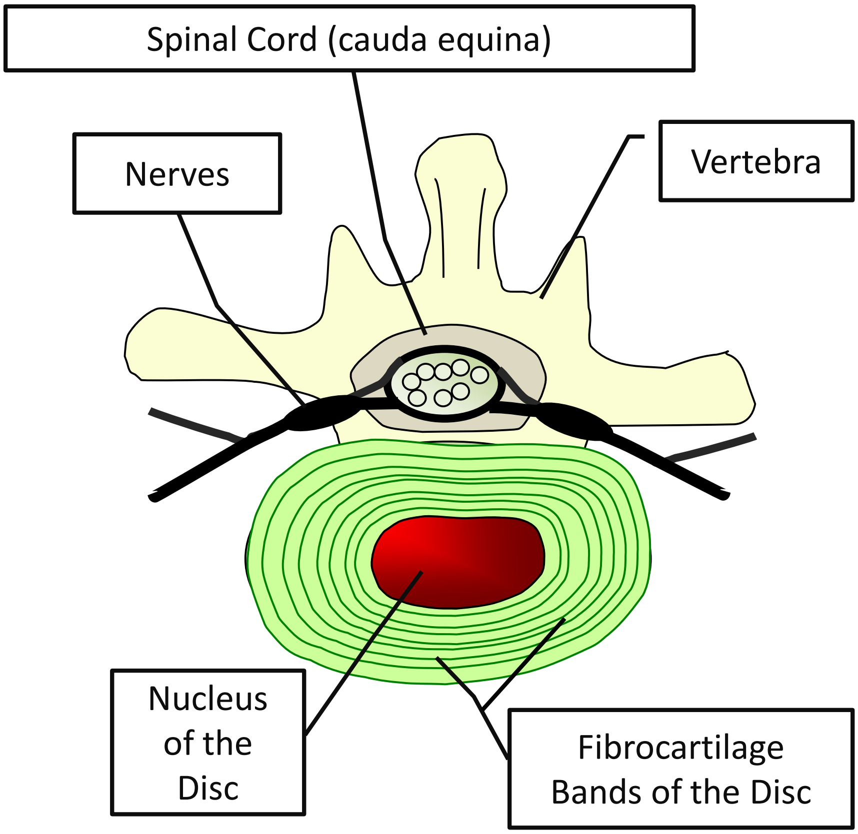


Figure 5:12. Cross section of a vertebral segment

The spinal cord and nerves are protected within the spine from the skull to the pelvis by a bony ring within the vertebrae. This cross-sectional view shows the relationship between the disc and the spinal nerves.

The Intervertebral Disc

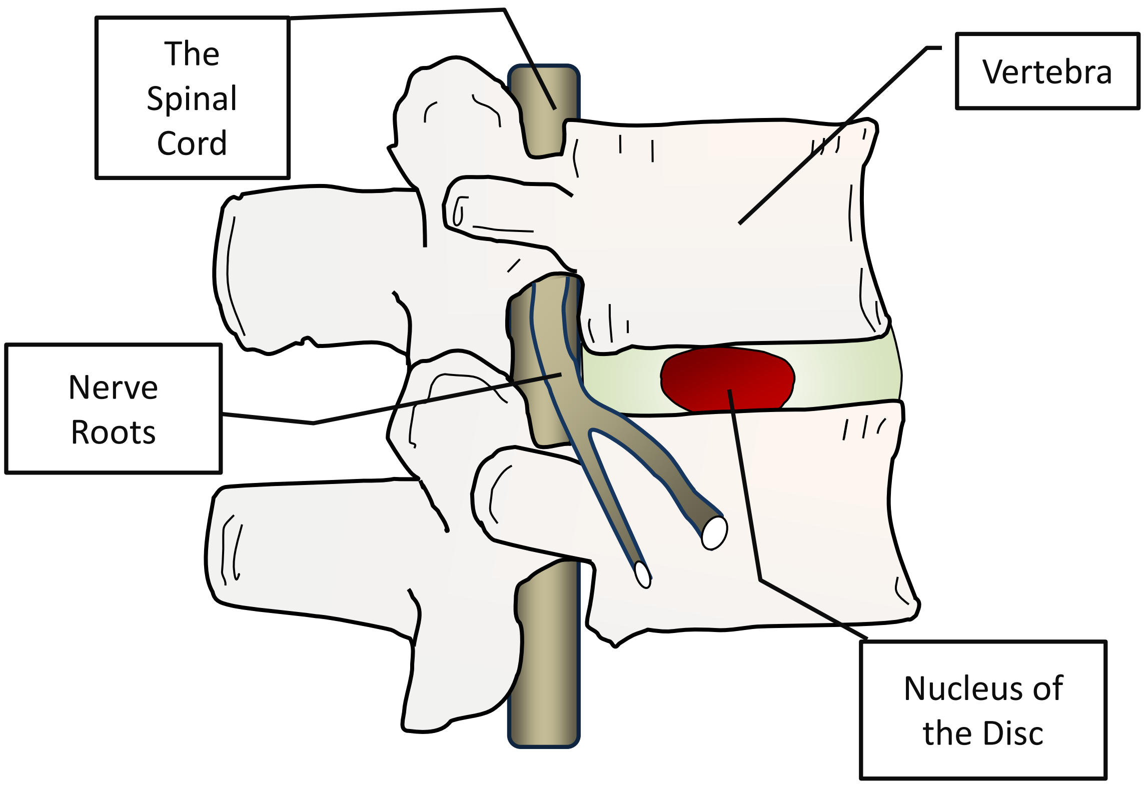


Figure 5:13. Side view of a vertebral segment.

This side-view schematic shows the relationship between the disc and the spinal nerves. The nerves leave the spine and travel to the various parts of the body.

The Intervertebral Disc as a Fulcrum

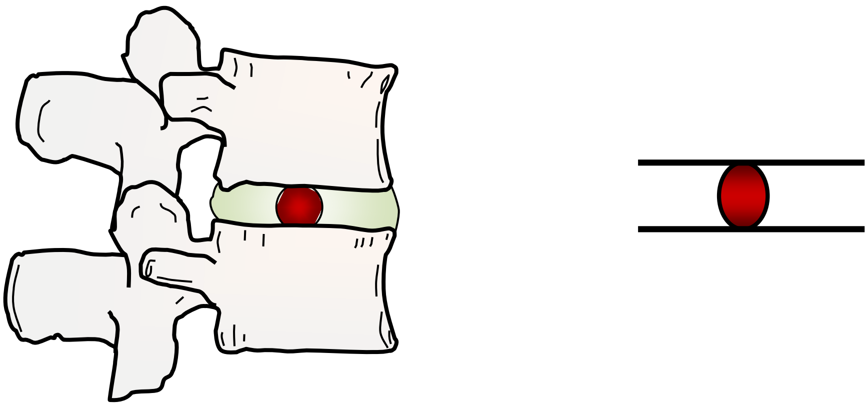


Figure 5:14. The gel-filled nucleus of the intervertebral disc is contained in a capsule that acts as a fulcrum on which the vertebrae pivot.

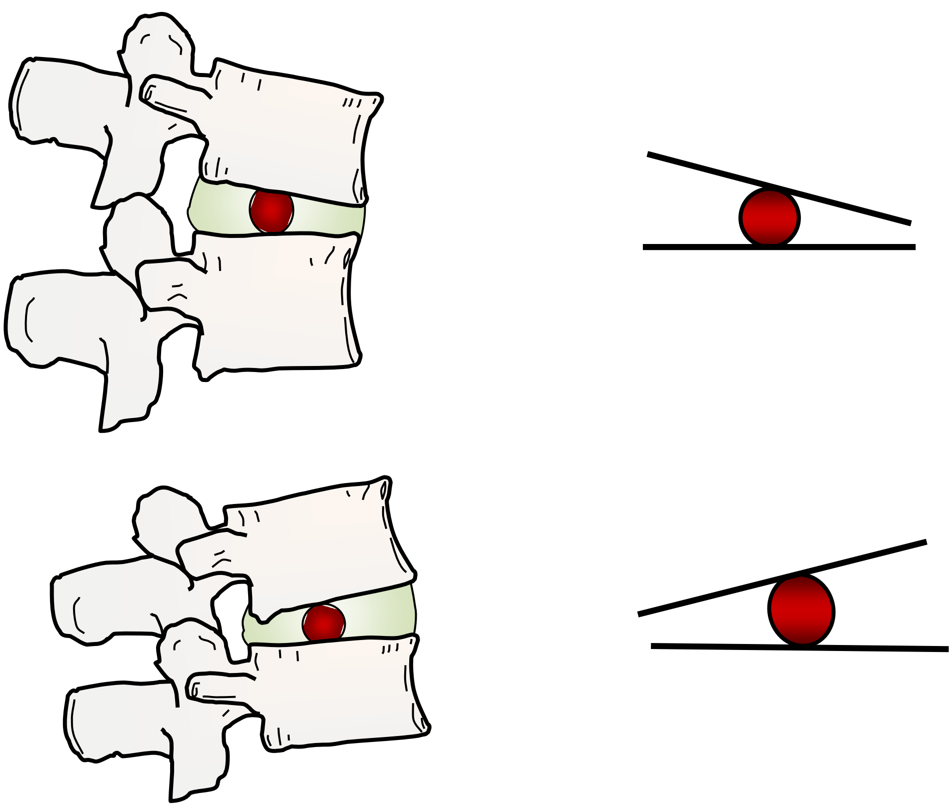


Figure 5:15. Flexion and extension (bending forward and backward) are possible due to this unique biomechanical function.

The Intervertebral Disc as a Fulcrum

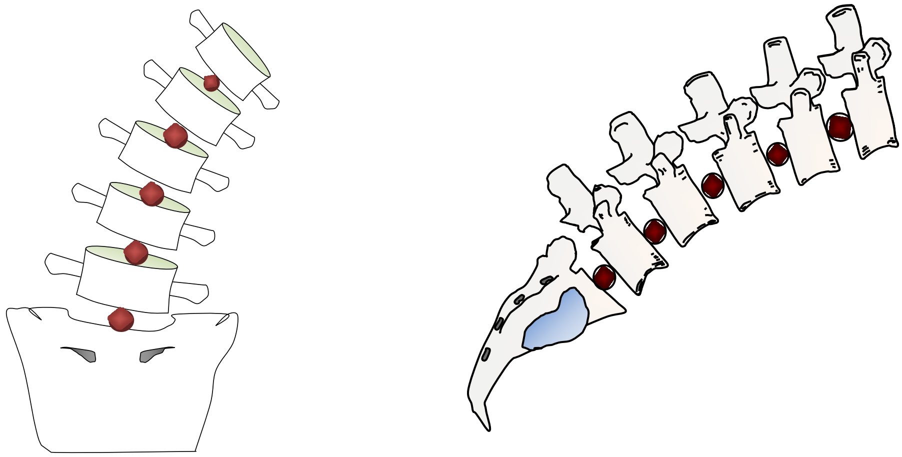


Figure 5:16. Since each vertebra has its own pivot point, there is a wide range of motion available.

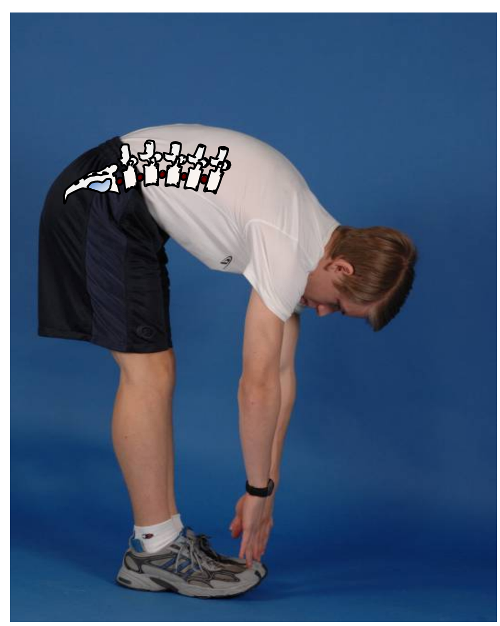


Figure 5:17 and 5:18. The disc-vertebrae mechanism allows spinal motion and flexibility.

Migration of the Nucleus with Spinal Flexion

Excessive or repetitive bending can cause the nucleus to migrate backward toward the spinal nerves. In time, this may lead to the nucleus bursting through the annulus. This is called a herniated disc. Bending forward is called *flexion*.

Figure 5:19. Forward bending.

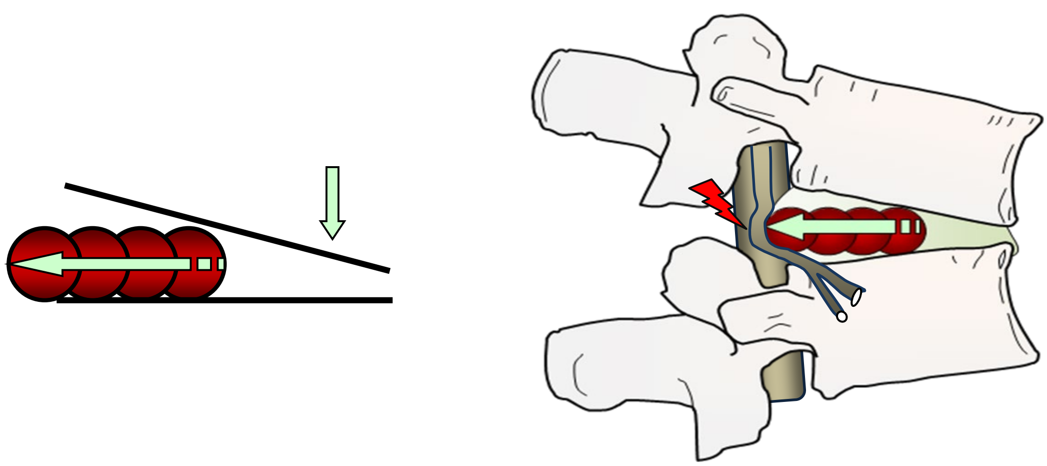


Figure 5:20. Forward bending promoting migration of the disc toward the cord.

Migration of the Nucleus with Spinal Extension

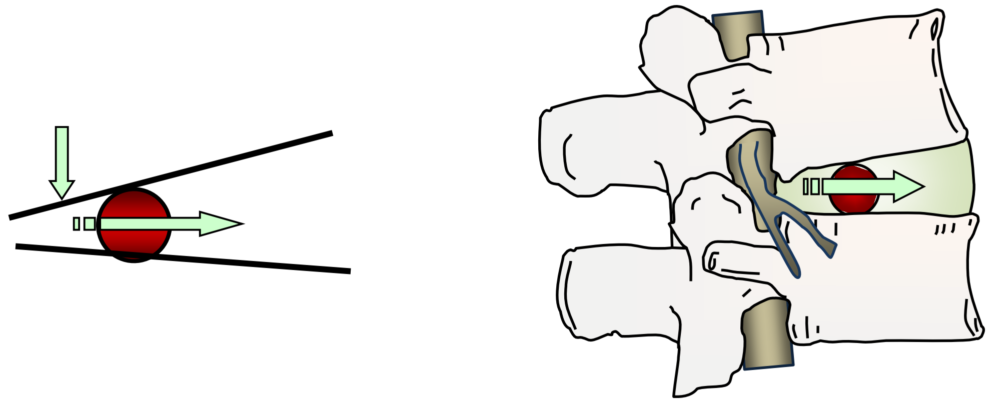


Figure 5:21. In a normal healthy spine, extension exercises help to manipulate the nucleus forward, away from the nerves.

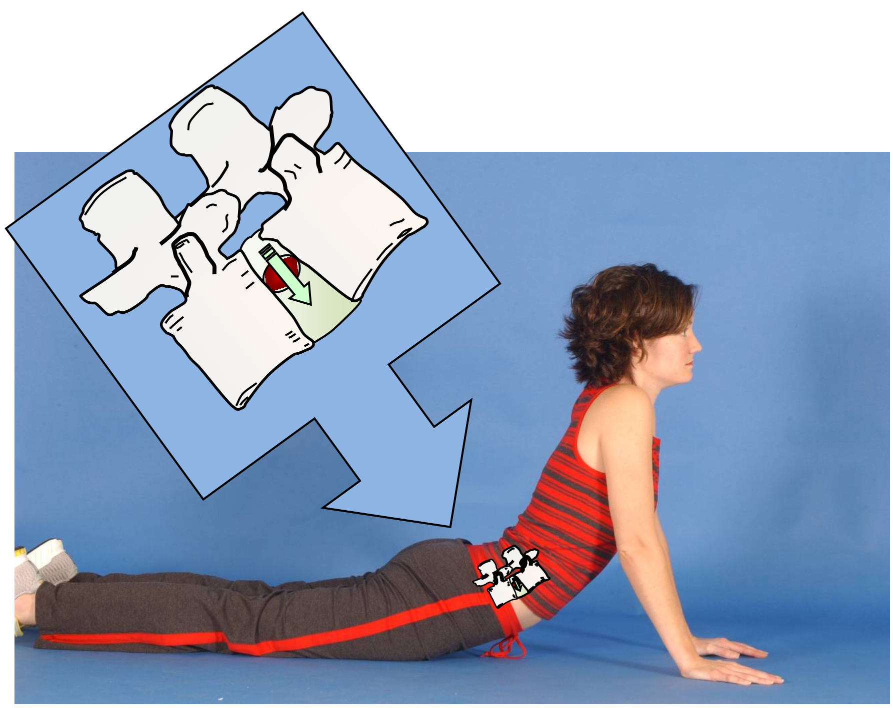


Figure 5:22. Extension exercises are commonly prescribed to disc patients in an attempt to manipulate the nucleus of the disc away from the spinal nerves.

The Disc as a Shock Absorber

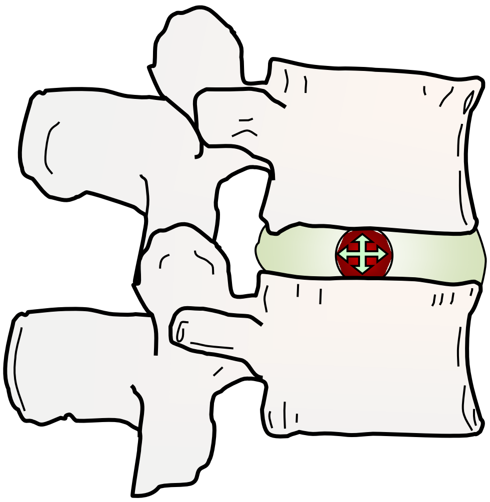


Figure 5:23. The vertebrae float on the discs. The hydrodynamics of the gel-filled nucleus and the elasticity of the annular rings combine to create a natural shock absorber.

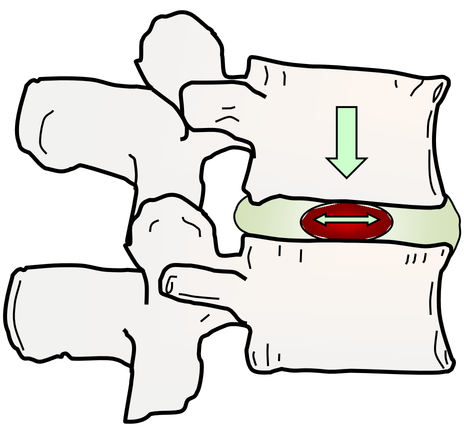


Figure 5:24. The disc distorts to absorb pressure.

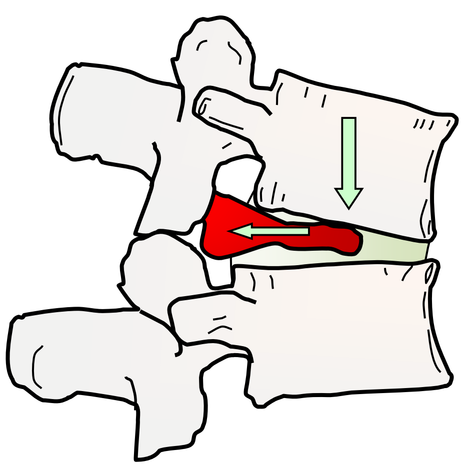


Figure 5:25. When the disc is over-burdened, either by repetitive bending, twisting, lifting, or excessive pressure, it fails. This results in disc injury and often disc herniation.

The Disc as a Shock Absorber

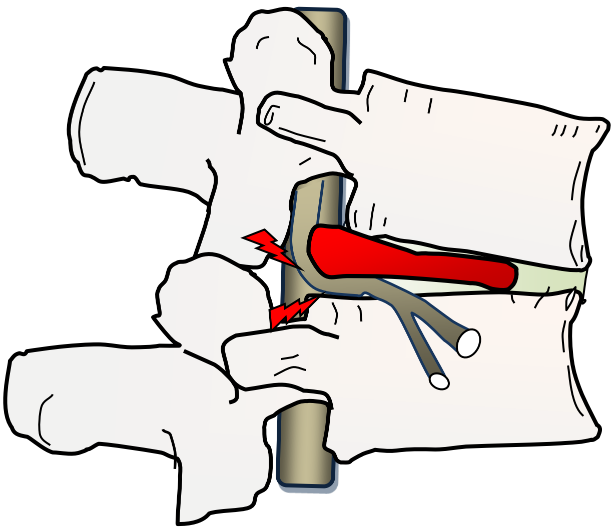


Figure 5:26. Disc derangements can compress the spinal nerves or even the spinal cord.

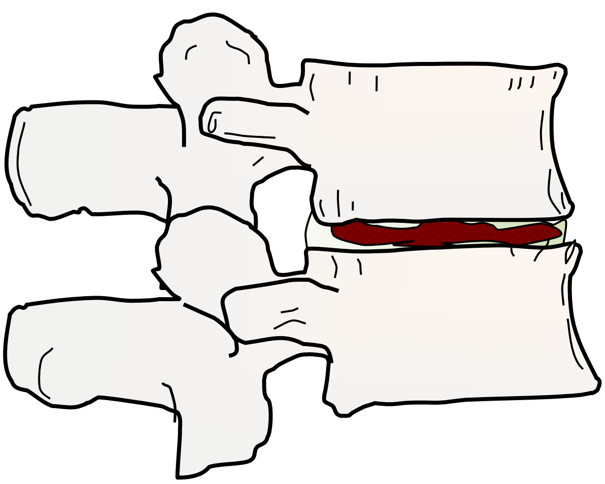


Figure 5:27. Disc degeneration.

Degenerative Discs

With age and injury the discs loose their shock absorption properties as they degenerate. Through this process there is less water retained in the disc. The discs thin and harden. This explains some of the height loss associated with aging and why older people have fewer herniations than middle-aged people. One study (Miller, et al.) found that by age fifty, 90% of all lumbar discs had a least some evidence of degeneration. Disc degeneration is not a indicator for pain or infirmity.

Miller JA, Schmatz C, Schultz AB: Lumbar disc degeneration: correlation with age, sex, and spine level in 600 autopsy specimens. Spine 13:173-178, 1988

The Intervertebral Disc

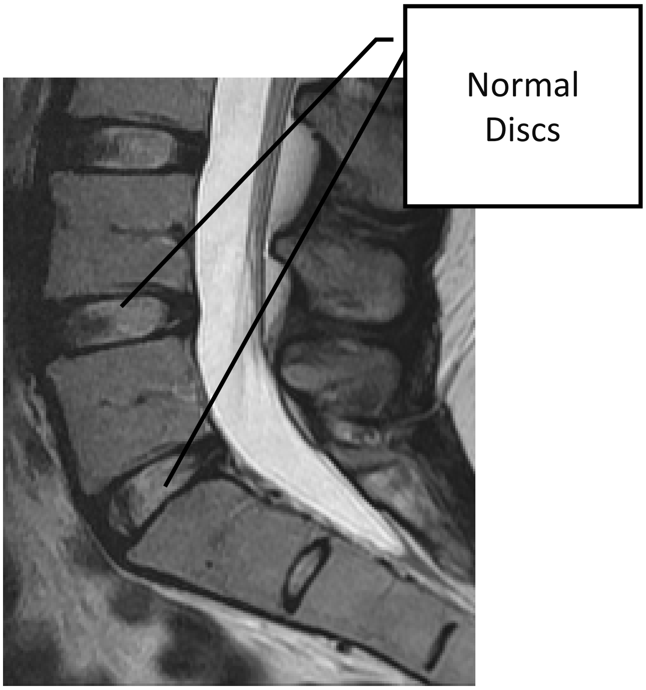


Figure 5:28. Healthy discs as viewed on an MRI. These discs appear somewhat white, indicating good water content.

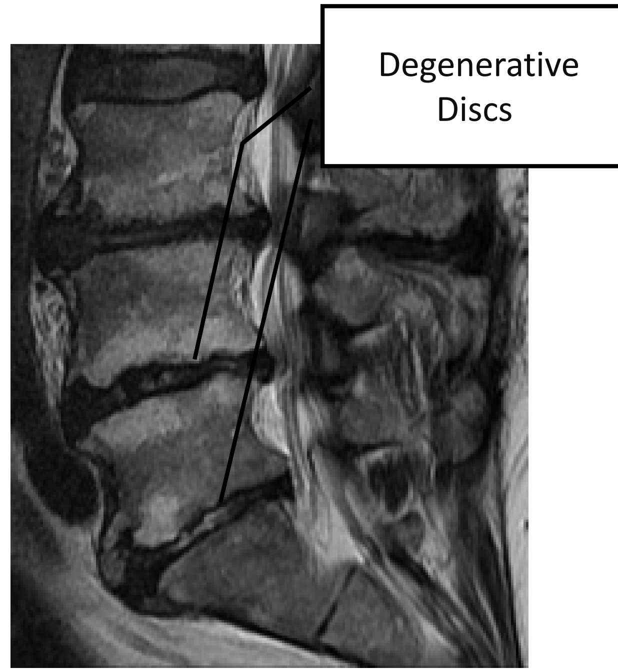


Figure 5:29. Degenerative discs as viewed on an MRI. These discs are black, indicative of chronic dehydration.

There is no direct blood supply to the discs. The discs receive nutrients and hydration from the vertebrae. Motion of the discs contributes to this nutrient and fluid exchange. As we age, the vertebral endplates thicken, allowing less fluid and nutrients to reach the discs. This is one reason that our discs dehydrate with age. This contributes to the loss of height that accompanies advancing age.

If there is not enough motion between the vertebrae, degeneration occurs. If there is too much motion between the vertebrae, degeneration also occurs.

By age 30 most discs have begun to show signs of deterioration. They begin to dry out, become brittle, and show signs of deterioration. There may be symptoms and pain before the actual herniation occurs.

Herniation occurs most frequently in people in their 30s through their 50s. Middle-aged men are who are physically active are especially at risk.

Herniations occur primarily in the lumbar spine, most frequently in the lowest segments (L5 – S1) of the lumbar spine.

Fluid Dynamics of the Intervertebral Disc

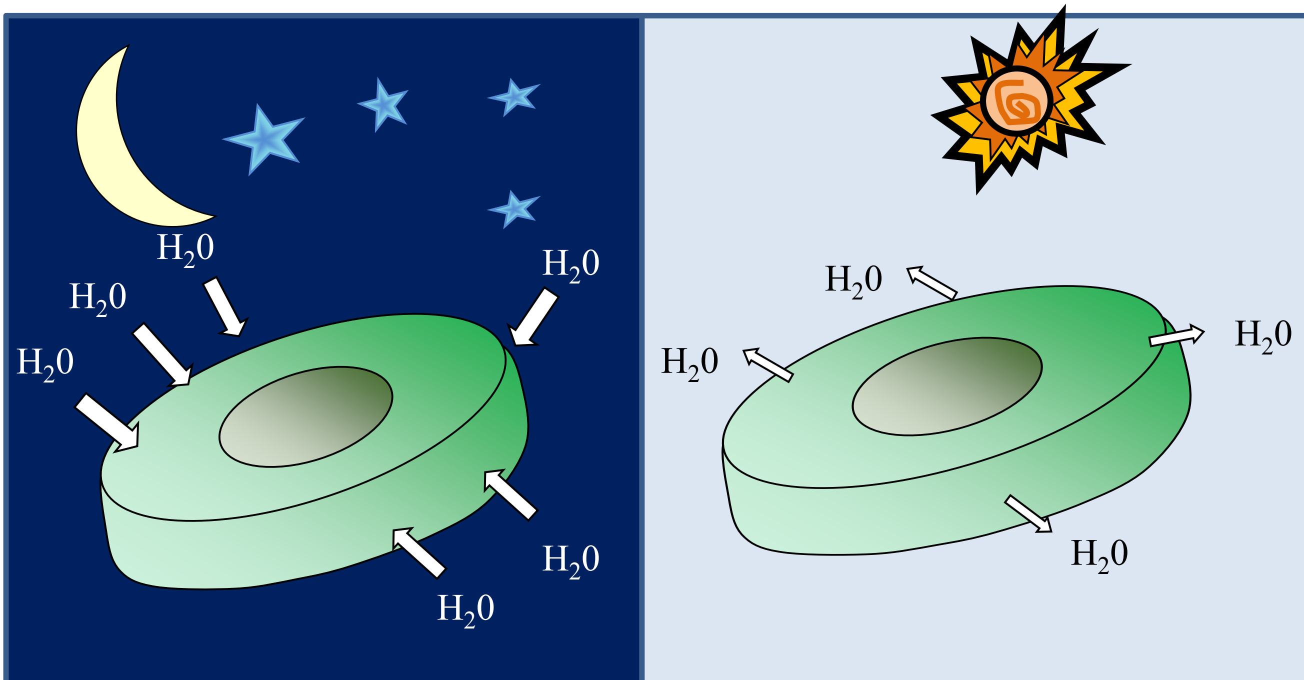


Figure 5:30: The water content of the disc increases when we lie down. As the water content increases, the disc increases in size. **Figure 5:31**: Conversely, as we are upright throughout the day, the disc loses hydration. As the discs lose hydration, they become smaller. This explains why we are taller in the morning and shorter at the end of the day. It also explains why many disc conditions are more painful in the morning than at night.

Since the intervertebral discs are more hydrated and full in the morning than at night, they are more susceptible to pain and injury in the morning. For this reason it is recommended that we limit bending at the waist and strenuous exertion for the first 1 ½ hours in the morning. It also explains why many disc herniations are more symptomatic in the morning.

The first 1 ½ hours in the morning are the most hazardous for the lumbar disc. Be especially restrictive of spinal flexion and twisting after rising:

- Modify personal hygiene habits (brushing teeth, shaving, sitting on the commode) to limit flexion.
- Limit exertion and provocative activities during the first couple hours in the morning. Do not perform sit-ups, toe touches, or any flexed-posture exercise early in the morning. Avoid exercises that compress the spine, like weighted squats.

Disc Pressures in Various Postures

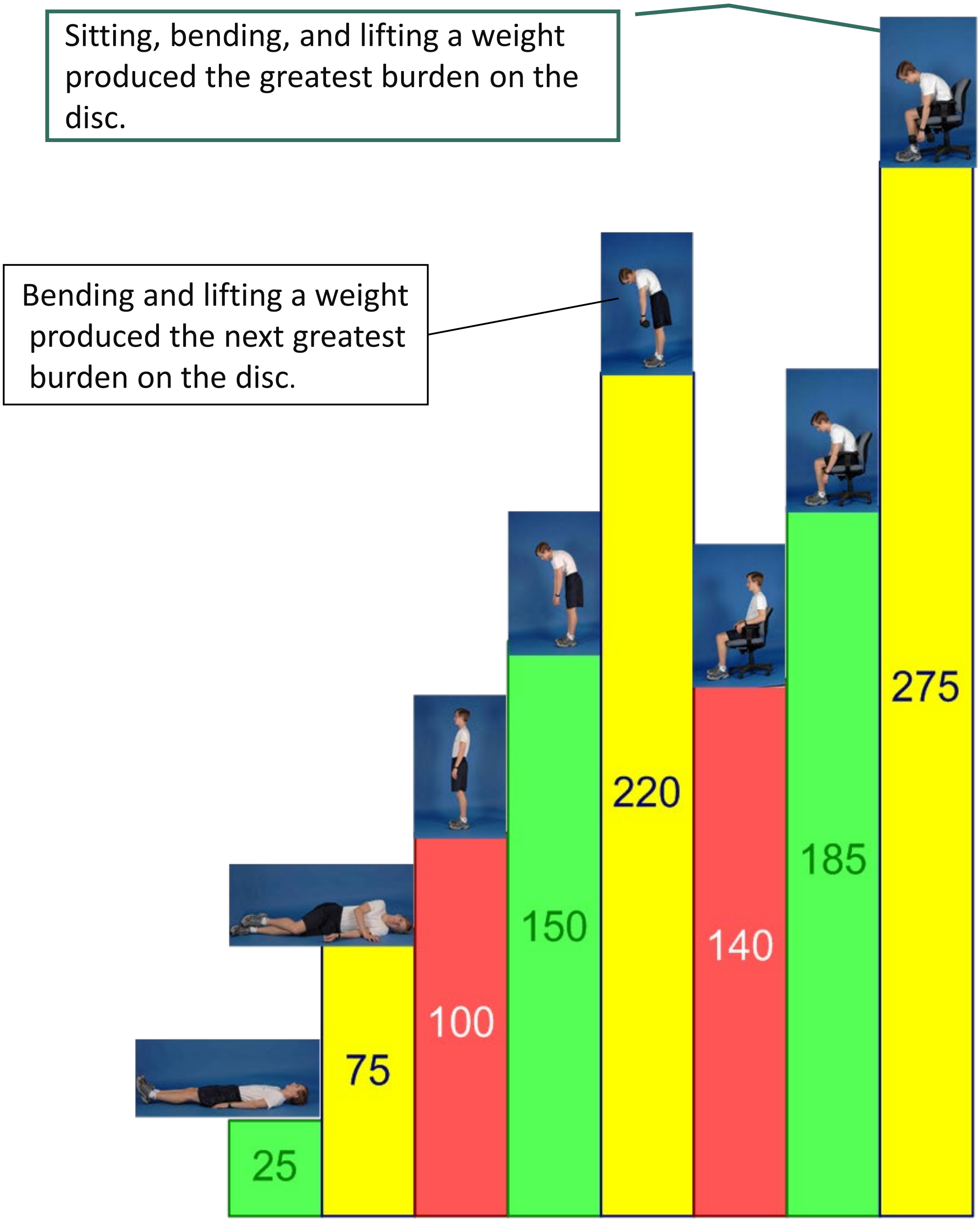


Figure 5:32. The famous spinal researcher Alf Nachemsom, MD, PhD, measured the pressure of discs in various positions. He found that lying down produced the lowest pressure in the lumbar discs. Bending, twisting, and lifting produced greater amounts of pressure in the lumbar discs. The relative increases in disc pressures are measured in kg.

Nachemson AL. In vivo discometry in lumbar discs with irregular nucleograms. *Acta Orthop Scand*, 1965;36;426.

Disc Herniation

6

Disc Herniation

What is a Disc Herniation?

A disc herniation occurs when the nucleus of the disc migrates from its normal position and ruptures through the disc. A torn disc or a herniated disc may be painful on its own, but more severe symptoms occur when the disc contacts the spinal nerves.

While there are many people walking around with disc herniations who do not have symptoms, some are in severe pain and even disabled. When a disc is herniated, it has the potential to compress nerves exiting from the spine or even the spinal cord itself. This can cause pain, muscle weakness, shooting pain, sensory impairment, and in severe cases, bladder and bowel dysfunction, or paralysis.

Even if the disc does not compress a nerve, it can produce symptoms from the inflammatory response it creates.

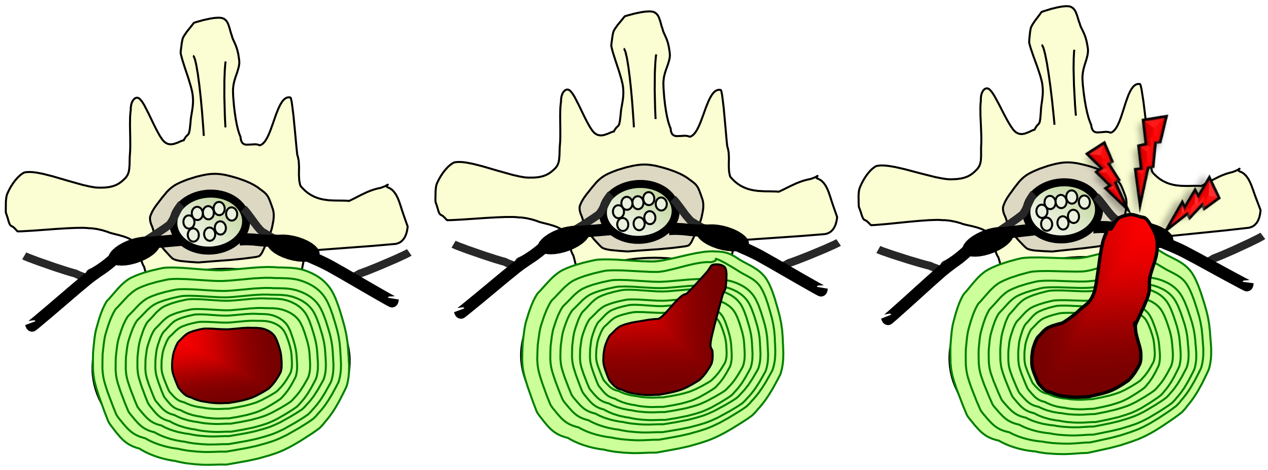


Figure 6:1. A disc herniation occurs when the nucleus of the disc migrates from its normal position and ruptures through the disc.

Disc Herniation

Cross Section Comparison of Healthy versus Herniated Discs

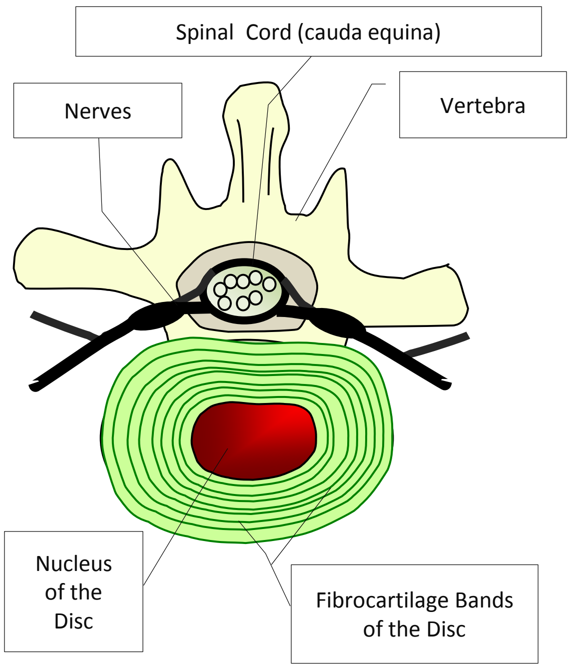


Figure 6:2. A normal spinal segment.

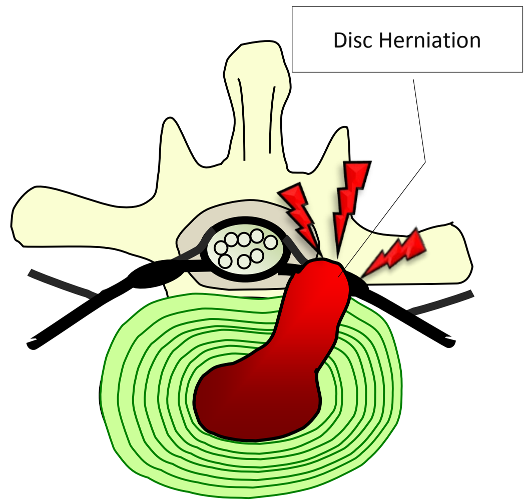


Figure 6:3. A disc putting pressure on a spinal nerve.

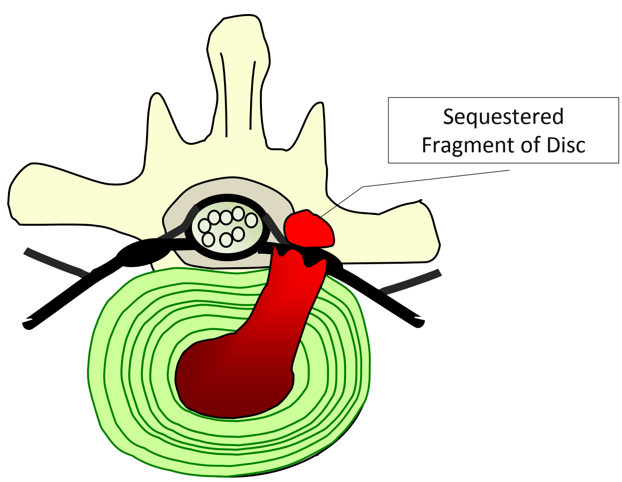


Figure 6:4. A sequestered (separated) fragment of disc occurs when a portion of disc separates from the main body of the disc.

Disc Herniation

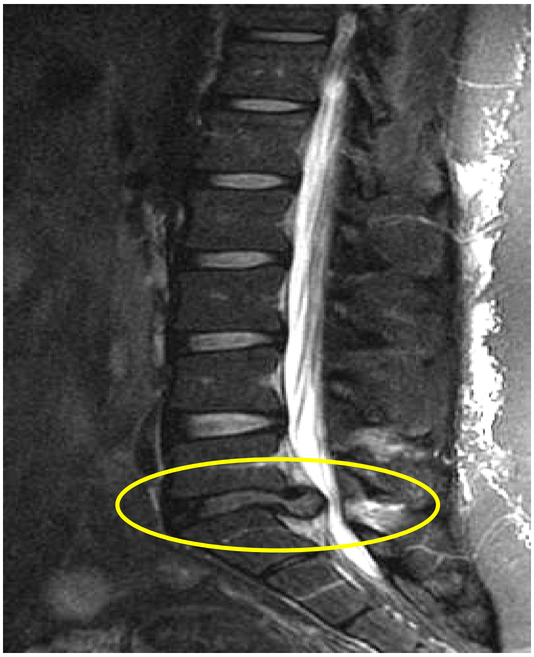


Figure 6:5. Herniation of the L5-S1 disc on MRI.

Figure 6:6. Bending forward at the waist is a common cause of disc injuries.

What causes disc herniations?

Bending, lifting, and twisting are the most common contributors to disc herniations. Prolonged sitting also contributes to disc injuries. Heavy lifting or repeated or prolonged bending or twisting can cause damage to the cartilage rings of the disc. This is called annular tearing.

Annular tears may precede disc herniations. Bending forward at the waist increases the pressure of the disc, especially when lifting. This pressure pushes the nucleus back toward the spinal nerves. Over time, repetitive bending, especially with the combination of bending, lifting, and twisting, can cause disc tearing and disruption.

The nucleus will begin to migrate to the rear (posterior) from its ideal position in the center of the disc. This migration can continue until ultimately the nucleus erupts from the disc and puts pressure on the spinal nerves.

Sciatica

What is Sciatica?

Sciatica refers to inflammation of the sciatic nerve which travels from the spine down the back of the leg. The pain may be shooting, sharp, dull, or burning. It normally affects only one side of the body. Sciatica is caused by irritation of the sciatic nerve, usually as a result of a herniated disc, degenerative disc, or stenosis (narrowing of the nerve passages of the spine). There are other causes of leg pain that are not true sciatica.

Frequently sciatica is mistaken for a tight hamstring. This mistake may lead to the person attempting to stretch the hamstring muscle. This can lead to further damage and irritation of the sciatic nerve.

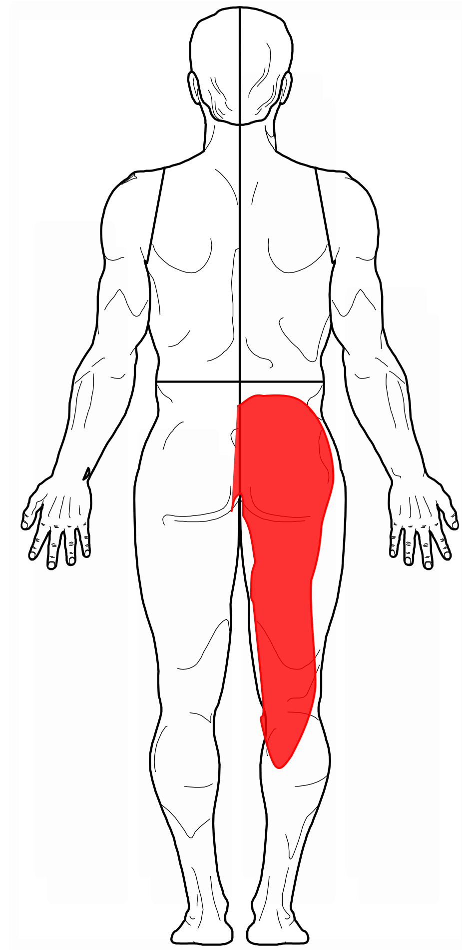


Figure 6:7. Sciatica is nerve pain or neuralgia that extends down the back of the leg.

7

Clinical Presentation of Lumbar Disc Derangements

Disc Herniation Symptoms

Symptoms of a Herniated Lumbar Disc	
Severity	**Symptoms**
Mild	• Manageable back pain • Pain referred to the buttocks
Moderate	• Back pain with referred pain or altered sensation to the thigh • Muscle spasms • Significant level of back and leg pain • Tingling sensation in the legs • Abnormal stance or posture
Moderately Severe	• Severe pain • Unrelenting spasms • Pain, tingling, or altered sensation that extends below the knee • True numbness (no perception of pain or touch) of part of an extremity • Twisted or leaning posture • Worse with coughing, sneezing, or straining at stool
Severe Neurological Conditions (Needs immediate surgical care)	• Bladder or bowel dysfunction • Numbness of the anus or genitals • Progressive weakness of the legs • Numbness in the distribution of [both] your inner thighs (saddle distribution numbness)

Figure 7:1. Degrees of symptom severity in herniated discs.

Characteristics of a Disc Herniation

- Back or leg pain that is worse with truncal flexion
- Commonly (but not always) improved with extension
- Worse in morning
- Mildly better in the evening
- Worse with sitting
- Better with short-term standing or walking
- Radicular symptoms
- Spasms and antalgia

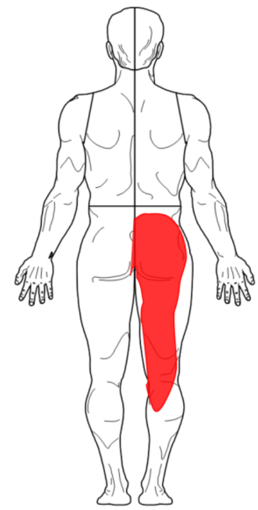


Figure 7:2.

The Perception of "Tight Hamstrings"

- Disc patients frequently mistake nerve tension with tight hamstrings.
- Ironically, this perception provokes the patients to further damage their discs and nerves in attempting to stretch out the perceived tightness.

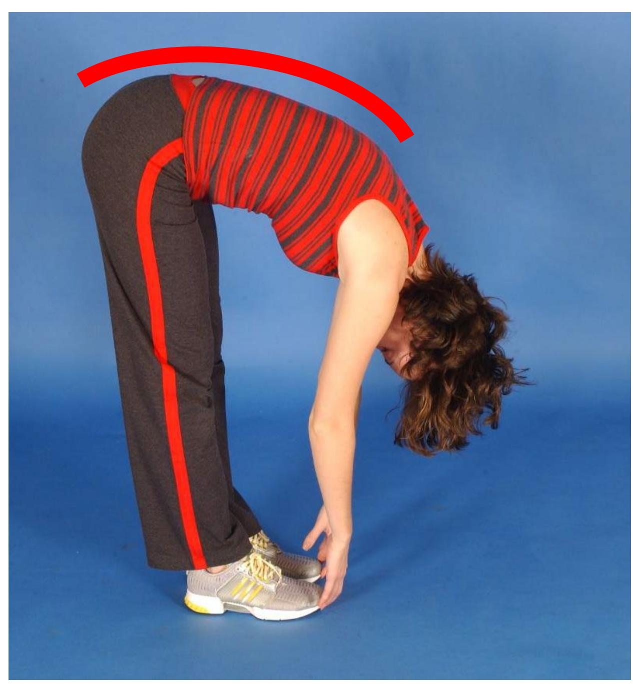


Figure 7:3.

Attention

Stretching the hamstrings can tug on an irritated sciatic nerve. Many people mistake sciatic nerve tension, caused by a herniated lumbar disc, with tight hamstrings. Trying to stretch the hamstrings can be provocative to an irritated nerve. It is unwise to "stretch out" leg tension in a patient suffering from an acutely herniated disc.

Figure 7:4.

8

Differential Diagnosis

Differential Diagnosis

There are characteristics found in lumbar disc lesions that are common with other conditions. Since the proper management of each condition requires an accurate diagnosis, this section will introduce some of the diagnoses that could be mistaken for a herniated disc.

Partial List of Differentials

- Tethered Cord
- Spinal Cord Tumor
- Central Canal Stenosis
- Spinal Epidural Lipomatosis
- Foraminal Stenosis
- Synovial Cysts
- Gynecological Conditions
- Piriformis syndrome
- Meralgia Paresthetica
- Herpes Zoster: "Shingles"
- Upper Motor Lesions
- Hamstring Injury

Figure 8:1.

Tethered Cord

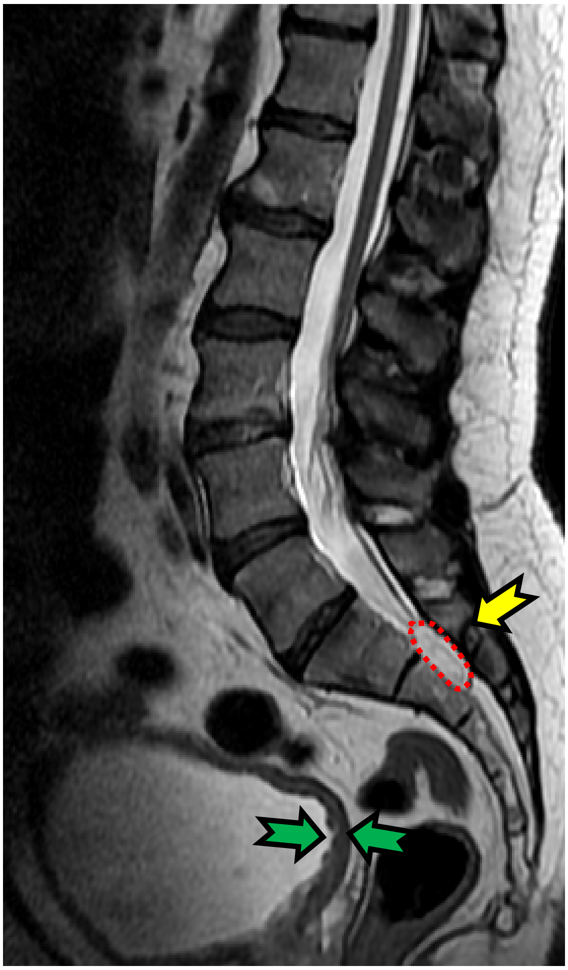


Figure 8:2.

Figure 8:3.

Tethering of the cord can produce significant neurological symptoms and can mimic some of the findings found in lumbar disc herniation. These T2 weighted sagittal images show a lipoma of the filum terminale anchoring the cord (yellow arrow) and resulting in a neurogenic bladder (detrusor muscle) hypertrophy seen between green arrows) and Chiari (red arrows).

Spinal Cord Tumor

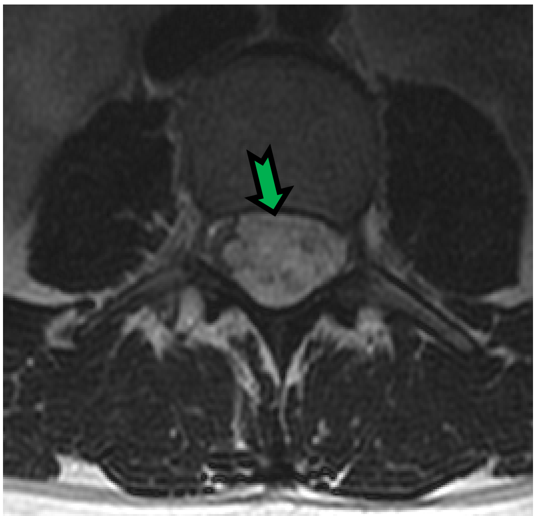


Figure 8:4.

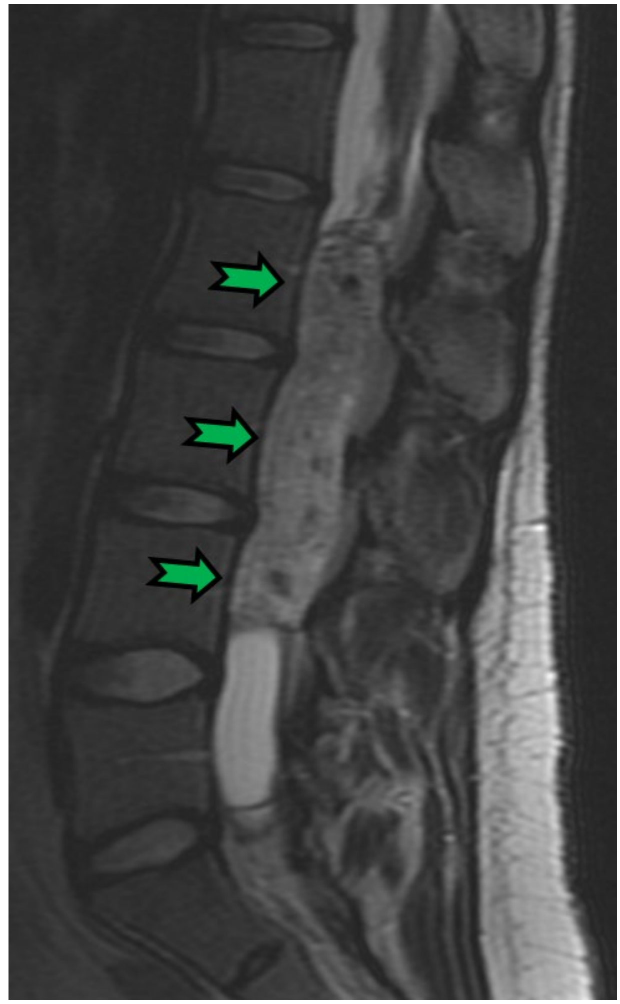


Figure 8:5.

Spinal cord tumors can mimic the signs seen in lumbar disc herniations.

Central Canal Stenosis

Figure 8:6.

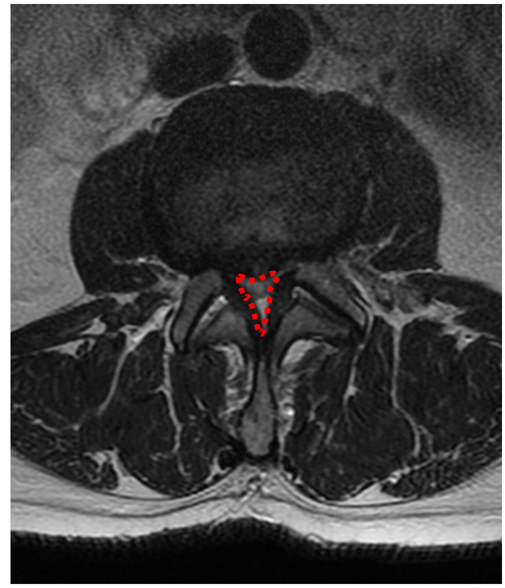


Figure 8:7.

Central canal stenosis is commonly mistaken for lumbar disc derangements. Central canal stenosis can result from congenital factors or any combination of these factors:

- Ligamentum flavum hypertrophy or enfolding
- Facetal hypertrophy
- Disc bulging
- Spondylosis

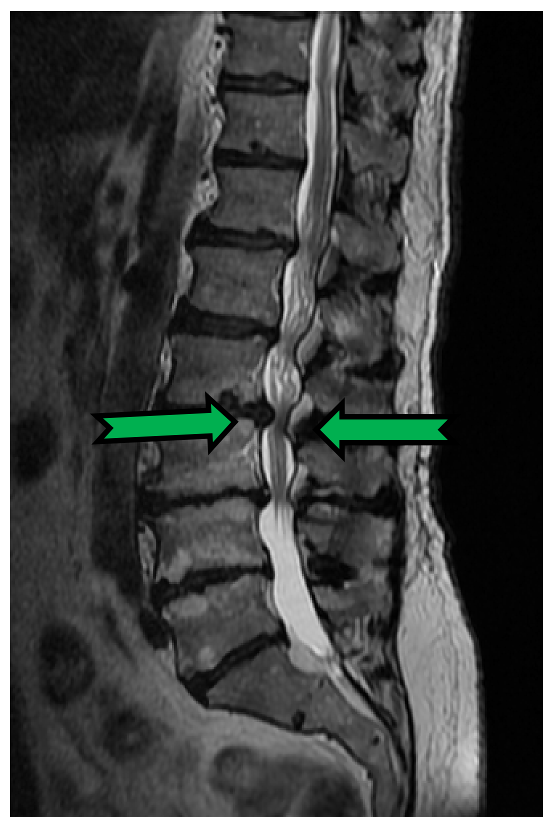


Figure 8:8.

Spinal Epidural Lipomatosis

Figure 8:9.

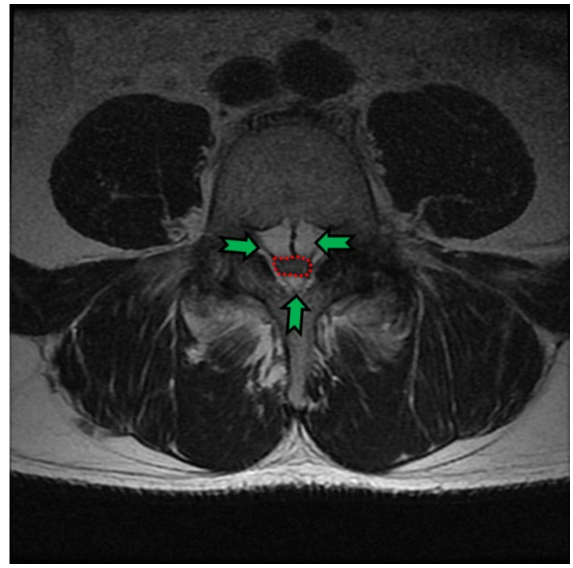


Figure 8:10.

Spinal epidural lipomatosis (SEL), the excessive fat deposition in the spinal canal, is responsible for compression of neural tissues (nerve roots or cord) that can cause nerve root symptoms and myelopathy. SEL is commonly seen in patients with endocrinopathy, obesity, or those receiving protracted steroid therapy. Idiopathic SEL is rare, but has also been documented. SEL can cause back pain, nerve root impingement, and cord compression. Slowly progressive myelopathy is the normal presentation of a patient with SEL.

The MRI images demonstrate excessive fat deposition posterior to the vertebral bodies and anterior to the spinal canal. Epidural lipomatosis has been attributed to various compression findings on MRI .

Increased obesity in the developed world may contribute to a rise in the occurrence of this condition, but the increase in the prevalence of MRIs has also been cited as a cause for more frequent diagnosis of this condition.

SEL cannot be diagnosed on plain film radiography or on physical examination. Prior to the advent of MRI, lipomatosis was identified serendipitously during spinal surgery.

Conservative care of SEL includes stopping steroid therapy and losing weight (in obese patients). However, in severe or refractory cases, a consultation to a spine surgeon may be appropriate.

With increasing rates of obesity in the western world, we may be begin to see a surge in the number of obesity-related cases of spinal epidural lipomatosis.

Obstetric and Gynecological Conditions

Figure 8:11.

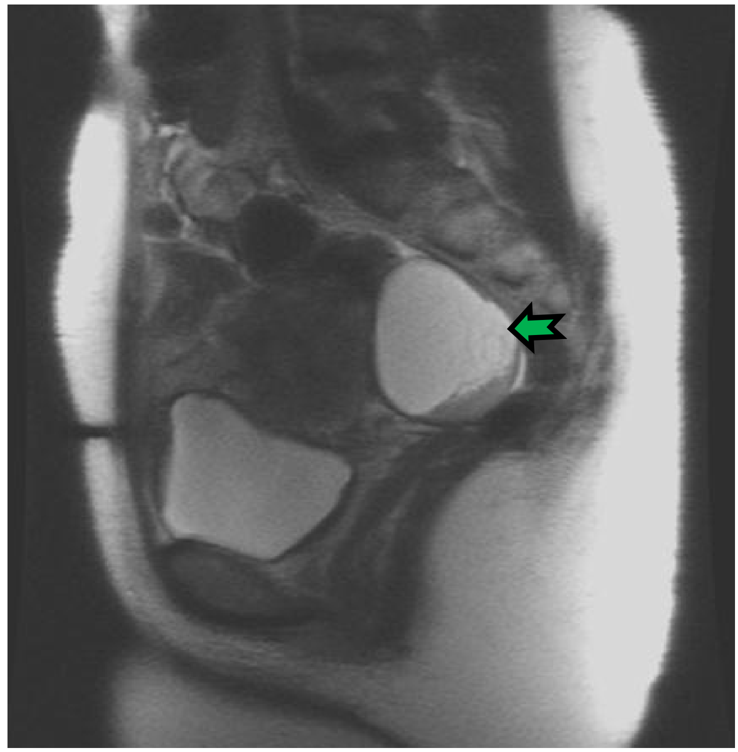


Figure 8:12.

Gynecological and obstetric conditions can cause back pain and sciatic neuralgia. These T2 weighted sagittal MR images reveal hemorrhagic ovarian cysts.

Yoshimoto M, Kawaguchi S, Takebayashi T, et al. Diagnostic features of sciatica without lumbar nerve root compression. *J Spinal Disord Tech*. Jul 2009;22(5):328-33.

Foraminal Stenosis

Figure 8:13.

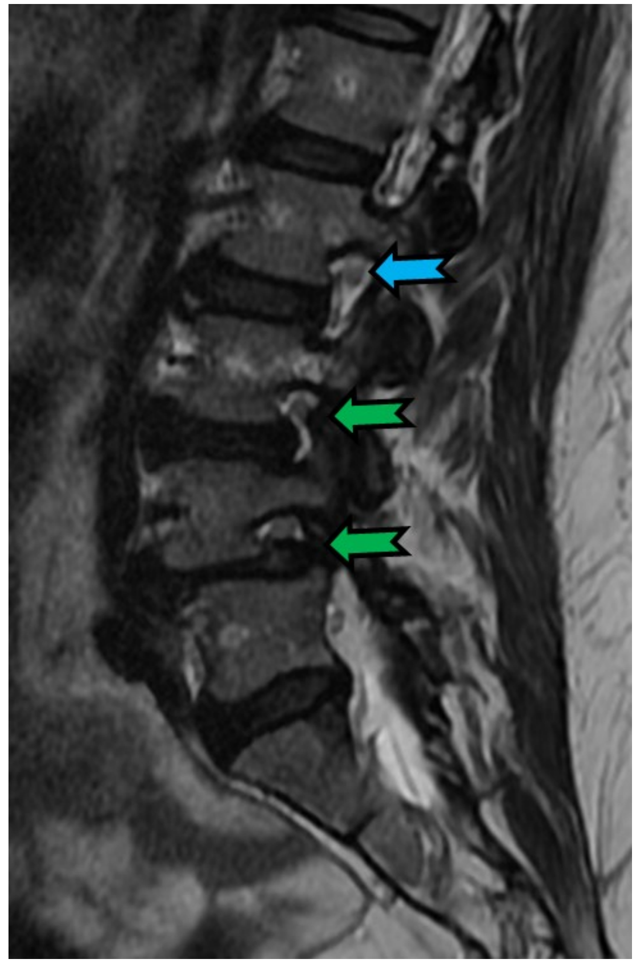


Figure 8:14.

Spondylosis, facet hypertrophy, and spondylolisthesis can all cause foraminal stenosis. Foraminal stenosis may mimic or contribute to the effects of a lumbar disc derangement.

The blue arrow points to a normal, patent intervertebral foramina (IVF). The green arrows point to stenotic IVF.

Synovial Cysts

Figure 8:15.

Figure 8:16.

When a synovial cyst occupies space with in the central canal, it may produce findings akin to those seen in lumbar disc derangements. The red circle denotes a synovial cyst.

Piriformis Syndrome

Figures 8:16 and 17.

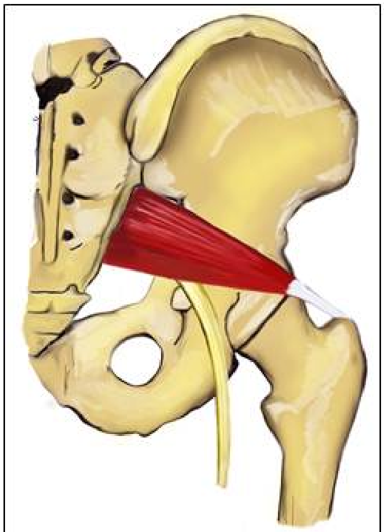


Figure 1. The sciatic nerve typically passes between the piriformis and the ilium and has been identified as a potential site for nerve entrapment.

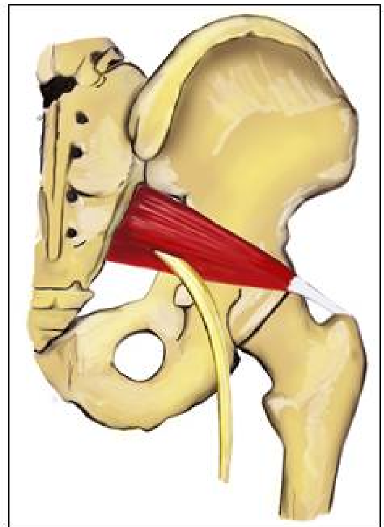


Figure 2. Variations in the anatomy are not uncommon. This image depicts the sciatic nerve traveling through the piriformis muscle.

The piriformis is a flat, pear-shaped (literal translation from Latin: piri-pear, formis-shape) muscle that originates on the anterior sacrum and the sacrotuberous ligament. From its origin on the pelvis, it passes through the sciatic notch and inserts into the greater trochanter of the femur. The sciatic nerve passes between the piriformis and the ilium (figure 1). The purposed theory is that a taut or anomalous piriformis (figure 2) will compress the sciatic nerve and cause sciatic neuralgia that may mimic disc-related sciatica. Myofascial manipulation, therapeutic modalities, ergonomic modification, and stretching (figure 3) have been recommended by a host of lecturers, authors, and clinicians as the treatment of this spectral diagnosis.

Occurrence
Even if we disregard the controversy over the existence of piriformis syndrome and the lack of a firm diagnostic test, studies place the probable occurrence of PS from rare (4) to about 6% (5) of the sciatica cases. Other studies show that patients who meet their definition of PS to be higher. (6) Surprisingly a more common source of non-nerve root compression sciatica is gynecological conditions such as ovarian cysts, pregnancy, and endometriosis. (5)
Variations in the anatomy of the sciatic nerve and piriformis exist (7), but are not necessarily related to being symptomatic.

Diagnosis
There are no practical laboratory, radiographic, or electrodiagnostic tests recommended for PS at this time. Therefore diagnosis is based on clinical observations and history. The diagnosis of PS should be made after excluding other sources of sciatic pain. First, look to the spine for causation of sciatica, then to non-nerve root compression causes. Differential diagnosis for non-nerve root compression sciatica should also include gynecological disorders, space-occupying lesions, and myofascial entrapments (such as PS).

Meralgia Paresthetica

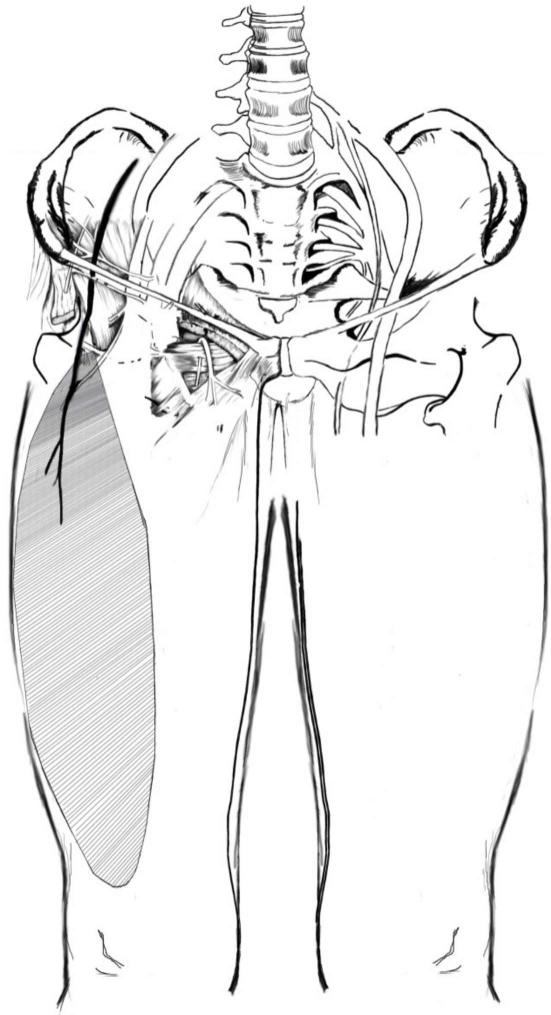


Figure 8:18.

Entrapment of the lateral femoral cutaneous nerve causes a condition known as meralgia paresthetica. The entrapment normally occurs as the nerve travels under the lateral portion of the inguinal ligament. Meralgia paresthetica produces superficial pain, burning, and/or paresthesia of the lateral thigh. Risk factors for meralgia paresthetica include abdominal surgery, obesity, pregnancy, wearing load bearing belts, and prolonged sitting.

Herpes Zoster
"Shingles"

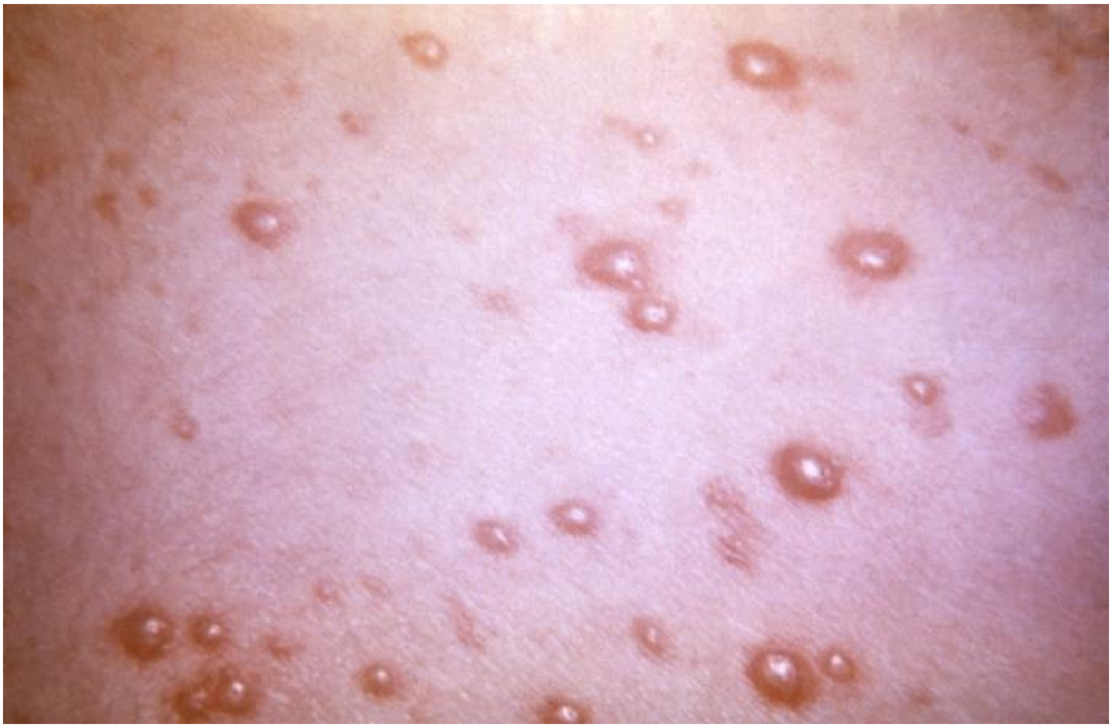


Figure 8:19. Blebs characteristic of H. Zoster

"Shingles, also known as herpes zoster, is a disease that affects an estimated one million people in the United States each year.

Although it is most common in people over age 50, if you have had chickenpox, you are at risk for developing shingles. Shingles is also more common in people with weakened immune systems from HIV infection, chemotherapy or radiation treatment, transplant operations, and stress."

The pain and characteristic blebs of H. zoster follow nerve root dermatomes. Since the pain may precede the formation of blebs, zoster has been mistaken for lumbar disc herniations in the past.

http://www.niaid.nih.gov/topics/shingles/Pages/Default.aspx

This image was made available through the CDC and Dr. K.L. Hermann
http://phil.cdc.gov/phil/details.asp

Upper Motor Lesions

Upper motor neuron lesions can be mistaken for lumbar disc lesions, especially if a lumbar MRI reveals a coincidental finding of a lumbar disc derangement.

Some of the findings of an upper motor lesion include the following:

- Bowel and bladder dysfunction
- Paresthesia and other sensory findings
- Weakness
- Slowness of motion
- Reduced coordination

Hamstring or Leg Injury

While sciatica is frequently mistaken for hamstring strains, it is possible for the opposite to also occur. A hamstring injury may mimic a disc lesion.

References

Anderson BC. Office Orthopedics for Primary Care: Diagnosis and Treatment, 3rd Edition, Elsevier Company, Philadelphia 2005.

Beges C, Rousselin B, Chevrot A, et al. Epidural lipomatosis. Interest of magnetic resonance imaging in a weight-reduction treated case. Spine 19:251– 254, 1994.

Bergman RA, Afifi AK, Miyauchi R. Variations in relation of sciatic nerve to m. piriformis. Illustrated encyclopedia of human anatomic variation: opus III: Nervous system http://www.anatomyatlases.org

Bernard TN, Kirkaldy-Willis WH. Recognizing specific characteristics of nonspecific low back pain. Clin Orthop. 1987;217:266–280

Bogduk N. clinical anatomy of the lumbar spine and sacrum, 3rd edition. Churchill Livingstone, Edinburgh, 2001.

Fassett DR, Schmidt MH. Spinal Epidural Lipomatosis: A Review of Its Causes and Recommendations for Treatment. Neurosurg Focus. 2004 Apr 15;16(4):E11.

Fessler RG, Johnson DL, Brown FD, et al. Epidural lipomatosis in steroid-treated patients. *Spine* 17:183–188, 1992

Fishman LM, Dombi GW, Michaelsen C, et al: Piriformis syndrome. diagnosis, treatment, and outcome: a 10-year study. *Arch Phys Med Rehabil* 2002; 83:295-301.

Ivins GK. Meralgia paresthetica, the elusive diagnosis. Ann Surg. 2000 August; 232(2): 281–286.

Kim KT, Park SW, Kim, YB.Disc Height and Segmental Motion as Risk Factors for Recurrent Lumbar Disc Herniation.Spine:15 November 2009 - Volume 34 - Issue 24 - pp 2674-2678

Kuhn MJ, Yussef HT, Swan TL, Swenson LC. Lumbar epidural lipomatosis: the "Y" sign of thecal sac compression *Comput Med Imaging Graph*. 1994 Sep-Oct;18(5):367-72.

Payer M, Van Schaeybroeck P, Reverdin A, et al. Idiopathic symptomatic epidural lipomatosis of the lumbar spine. *Acta Neurochir* 145:315–321, 2003.

Robertson SC, Traynelis VC, Follett KA, et al. Idiopathic spinal epidural lipomatosis. *Neurosurgery* 41:68–75, 1997

Stewart JD. The piriformis syndrome is overdiagnosed Muscle Nerve. 2003 Nov; 28(5):644-6.

Silver JK, Leadbetter WB. Piriformis syndrome: assessment of current practice and literature review. Orthopedics. 1998;21:1133–1135

Yeoman W. The relation of arthritis of the sacroiliac joint to sciatica. Lancet. 1928;ii:1119-22.

Yoshimoto M, Kawaguchi S, Takebayashi T, et al. Diagnostic features of sciatica without lumbar nerve root compression. *J Spinal Disord Tech*. Jul 2009;22(5):328-33.

9

Principles of Orthopedic Neurology

Orthopedic Neurology

The goal of orthopedic neurology is to integrate the complete clinical presentation of a patient to accurately ascertain the type, level, and severity of an orthopedic-neurological insult.

A doctor should use the concepts of orthopedic neurology to consider the patient's clinical presentation, physical findings, and imagery to reach a conclusion. As the case progresses, it may evolve to either confirm or alter the doctor's conclusion. Being able to perform a competent and timely neurological examination is a basic skill for managing a patient's care.

Repeated orthopedic/neurological evaluation of patients throughout their care will ensure that their care is appropriate and effective. If a patient's condition tracks the wrong direction, a skilled doctor will be able to tease this out quickly.

Identifying red flags early is important to ensuring that the patient does not suffer irreparable harm. The major orthopedic/neurological red flags that need urgent care are:

- Bladder or bowel dysfunction
- Numbness of the anus or genitals
- Weakness of the legs, especially progressive weakness of the legs
- Saddle distribution numbness which can include numbness of both inner thighs, inner buttocks, and anus

Note that subtle signs of a serious neurological insult could include fecal or urinary leakage that the patient attributes to age or another health condition.

Severe Neurological Conditions	• Bladder or bowel dysfunction • Numbness of the anus or genitals • Weakness of the legs • Numbness in the distribution of [both] your inner thighs

Neurogenic Bladder

Urinary Retention and the Neurogenic Bladder

The two functions of the bladder are storage and voiding. Either of these can be affected by neurologic compromise. While MSK practitioners frequently think of incontinence in association with neurologic impairment, urinary retention is another condition that can result from spinal cord injuries. Either retention of urine or incontinence of urine can occur depending on the location of the neurological insult.

Urinary incontinence is frequently associated as a red flag in spine injuries, particularly cauda equina syndrome and conus medullaris syndrome. But urinary retention can also be a severe consequence of neurologic insult, though less often screened. Retention can be a less obvious sign than incontinence: wetting one's pants draws more attention than retention, especially in cases where there is no perceived perception of urinary urgency. Acute anuria (inability to urinate) is a medical emergency and will require an emergency visit to a hospital or emergency room.

Neurogenic bladder

Any type of urinary bladder dysfunction caused by irregular neurologic function is referred to as neurogenic bladder. While a lower motor lesion may cause urinary incontinence, upper motor compromise can result in the inability to urinate. A disc lesion that presses upon the spinal cord (vs. the nerve roots) interrupts the complex neurological concert that enables normal urination. Brain lesions, myelopathy, syrinx, tumors, strokes, disc herniations, and tethered cord lesions are all potential causes of urinary dysfunction.

Retention can cause incontinence. The bladder can become so full that there is an involuntary overflow of urine.

Other causes of urinary retention

Neurogenic bladder is not the only cause of urinary retention, but regardless of the cause, total urinary retention is a medical emergency. Urinary retention of any cause can result in urinary retrograde and lead to renal damage.

Obstruction of the urethra may cause urinary retention. For men, prostate enlargement (from prostate hypertrophy or cancer) is the most common cause of urethra blockage. But infection, scarring, medicine-induced retention (particularly cold medications, antihistamines, and some antidepressants), or post-surgical complications can also cause urinary retention.

Neurogenic Bladder

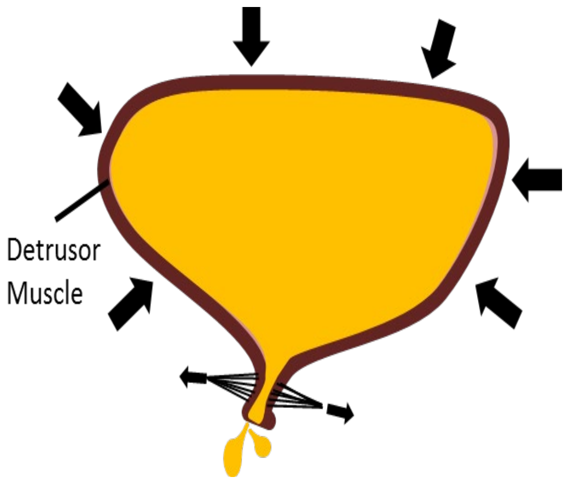


Figure 9:1. Normal urination requires a synchronized contraction of the detrusor muscle and opening of the sphincters that allows normal urination.

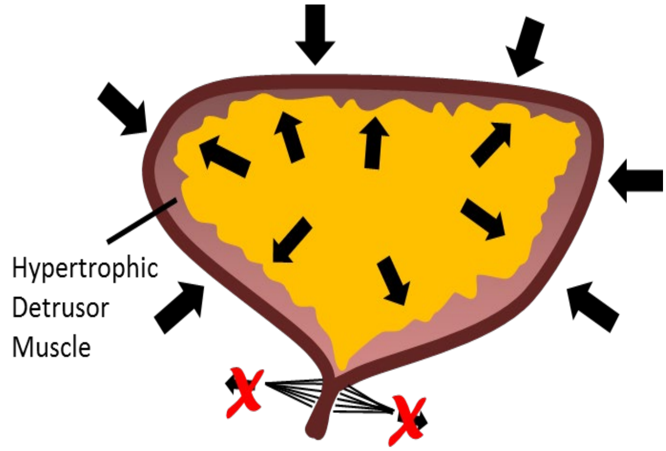


Figure 9:2. Urinary retention in a neurogenic bladder. If the sphincters do not open in concert with the contraction of the detrusor, the detrusors must contract more fully to overcome the resistance of the sphincters. Over time this can lead to detrusor hypertrophy.

Clinical Points

Ask. Address the signs and symptoms of urinary function including urinary retention and incontinence.

Palpate. In some cases the distended bladder will be large enough to be palpated and even distend the abdomen.

Urinary retention is more common in men than women. Urinary retention is not uncommon, and it is frequently managed by physicians on an outpatient basis. Hypertrophy of the prostate is a common cause of urinary retention in men, but prostate cancer is another possible cause.

Anuria (the complete inability to urinate) from any cause is a medical emergency that will require an emergency referral. Initial emergency treatment will probably include catheterization.

> "Acute urinary incontinence or anuria (total inability to urinate) is a medical emergency requiring an immediate emergency referral."

Peripheral Sensitivity

A screening examination is performed with a sharp object such as a disposable pinwheel or safety pin. This will determine if the patient is able to perceive pain. A more detailed version of this examination can be performed with the patient's eyes closed, having them differentiate between light touch, sharp, heat, and cold. But for our screening examination we will stick with pain.

Key points:

Avoid the temptation to record peripheral sensitivity deficits as dermatome deficits. Allow for a non nerve root cause of reduced sensation. Record the location of the deficit, not the dermatome: "Reduced sensitivity to pain on the dorsum of the foot" versus "L5 dermatome hyposensitivity to pain."

Peripheral nerve lesions, diabetes, vascular disease, and other conditions can also affect peripheral sensitivity.

Orthopedic Neurology Table

Disc Level*	Nerve Root	Sensation or Pain	Motor	Reflex
T12-L1	L1	Medial thigh and inguinal region	Hip flexion (L1-2-3)	None
L1-L2	L2	Medial and anterior upper thigh	Slight contributor to quadriceps	Partial patellar
L2-L3	L3	Anterior upper thigh	Main contributor to quadriceps	Supra patellar reflex
L3-L4	L4	Posterolateral thigh and anterior leg	Tibialis anterior	Patellar tendon
L4-L5	L5	Dorsum of the foot	Extensor hallucis longus	none
L5-S1	S1	Lateral aspect of foot	Gastrocnemius, fibularis longus and brevis	Achilles tendon

* For most paracentral herniations

Paracentral Herniations Versus Foraminal Herniations

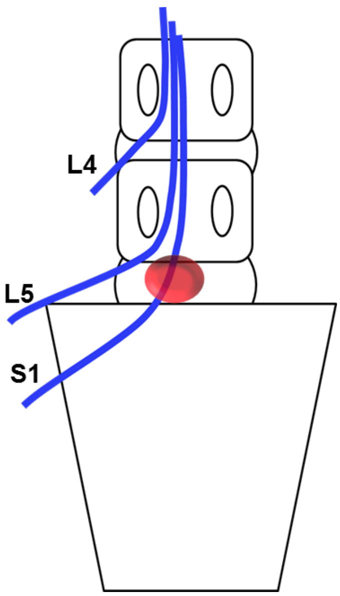


Figure 9:3. Paracentral herniations are more likely to affect the descending nerve root, so an L5-S1 paracentral herniation will most likely affect the S1 nerve root.

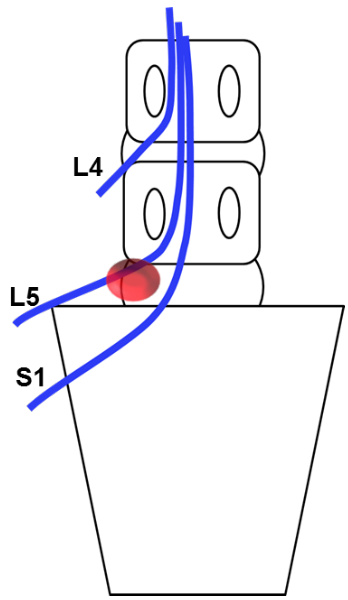


Figure 9:4. Foraminal and lateral herniations occur less frequently and are more likely to affect the exiting nerve root. An L5-S1 foraminal herniation would likely affect the L5 nerve root.

When using the orthopedic neurology table (Figure 3) remember that this chart categorizes most herniations as paracentral herniations. This chart should be accurate for moderate (sized) paracentral herniations, but the astute clinician will realize that foraminal herniations, lateral herniations, very large herniations, and other conditions will also affect the reliably of this chart. It should be used as a tool, not as the diagnostic end-all.

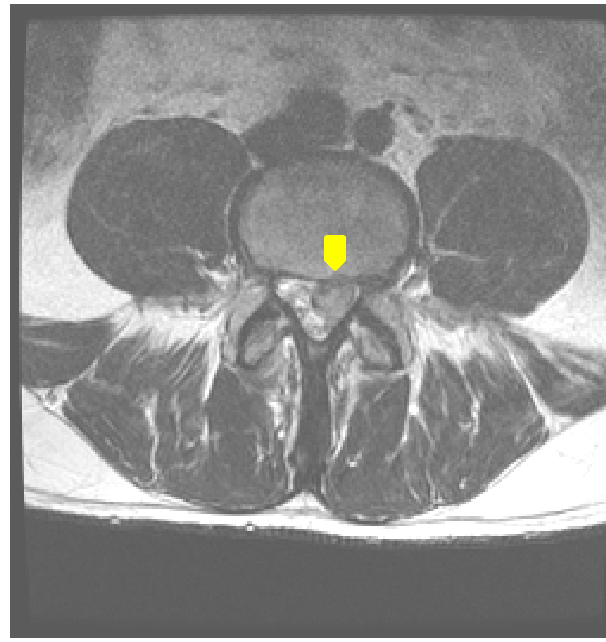
Disc Level*	Nerve Root	Sensation or Pain	Motor	Reflex
T12-L1	L1	Medial thigh and inguinal region	Hip flexion (L1-2-3)	None
L1-L2	L2	Medial and anterior upper thigh	Slight contributor to quadriceps	Partial patellar
L2-L3	L3	Anterior upper thigh	Main contributor to quadriceps	Supra patellar reflex
L3-L4	L4	Posterolateral thigh and anterior leg	Tibialis anterior	Patellar tendon
L4-L5	L5	Dorsum of the foot	Extensor hallucis longus	none
L5-S1	S1	Lateral aspect of foot	Gastrocnemius, fibularis longus and brevis	Achilles tendon

Figure 9:5. Orthopedic neurology table.

Lateral Herniation Occluding the IVF

These images reveal a foraminal herniation at L3-L4. This herniation will adversely affect the exiting L3 nerve root. Foraminal herniations have a unique clinical presentation and may be provoked by truncal extension and relieved by truncal flexion. This is the opposite of most paracentral herniations.

Large Paracentral Herniation



Large herniations may affect multiple levels and multiple nerve roots. This herniation resulted in tibialis anterior weakness and drop foot.

Assessing Motor Integrity

Loss of motor strength is a serious neurological sign and may necessitate the need for a surgical referral or an MRI if one has not yet been taken. Assessing motor integrity entails these three components of the motor exam:

- Look. Is there obvious atrophy?
- Feel the muscles. Note the tone. Is it flaccid?
- Test the strength.

Strength Grade	Strength Descriptor
0	No contraction of the muscle is detected.
1	Evidence of contraction can be visually observed or palpated.
2	The patient can move the body part with gravity eliminated.
3	The patient overcomes gravity, but not against only minimal resistance.
4	The patient can move the muscle with some examiner resistance.
5	**Normal muscle strength. The patient overcomes the resistance provided by the examiner.**

This chart represents the standardized descriptors for assessing motor strength. This grading system is standardized throughout all health care professions.

Clinical Note: Muscle Strength Grading

This grading system is skewed toward grading weakness so (–) and (+) are often employed to denote more subtle changes in strength. A spinal care specialist should be able to discern the difference between a 4+, and a 5-. This may take years to master.

Do not mistake pain inhibition for true weakness. Pain inhibition occurs when the pain of muscle testing affects the patient's ability to perform the muscle test.

Teasing Out the Subtlety of Muscle Testing

- There is no specific muscle test for each individual nerve root from L1-3; muscle testing is sometimes indistinct.
- We try to discern the dominate nerve root, but sometimes we are in error.
- Peripheral nerve entrapments or lesions may be mistaken for nerve root lesions.

Reflexes

Reflexes are used to identify both nerve root lesions and upper motor neuron lesions. The reflex hammer provides a brief stretching of the muscle tendon and the muscle normally responds with a contraction. The response is observed and graded. This chart depicts the standardized descriptors of the reflex portion of the examination.

Reflex Grade	Descriptor
0	No response
1+	A slight but perceptible response
2+	**Brisk response, normal**
3+	Exaggerated, overly brisk response
4+	Continued beats of brisk response
Clonus	With rapid dorsiflexion of the foot and constant sustained pressure on the plantar surface of the forefoot

Clinical Points for Reflexes

- When striking the tendon of the muscle to be examined, make sure the hammer swings freely, and use a whipping wrist motion. Strike the tendon briskly.
- Ensure that you are striking the tendon directly (make sure that you do not miss).
- If you find it difficult to elicit a reflex, you may employ the Jendrassik maneuver. (Have the patient grasp the opposing hands and isometrically pull the hands apart.) The Jendrassik may override a non-nerve root inhibition of the reflex.

10

Orthopedic Neurology: The Examination

Motor Examination

Toe Walking

- The patient walks back and forth across the room on their toes for a screening exam
- Testing of gastrocnemius; S1 nerve root
- For a more focused examination, have the patient perform 10 to 20 single-leg heel raises
- Patients with neuropathic gastrocnemius weakness can overcome an examiner's manual muscle testing

Heel Walking

- The patient walks on their heels with their toes/metatarsals lifted off the ground
- Testing of tibialis anterior; L4 nerve root

Extensor Hallucis Longus

- Isolate the great toe and have the patient hold the toe in extension against the examiner's resistance
- Testing of L5 nerve root innervation

Fibularis longus and brevis

- Test eversion strength of the feet and compare strength from side to side
- S1 nerve root tested
- Muscles formally known as peroneus longus and brevis
- Much easier to manually test than the gastrocnemius muscle
- Peripheral nerve is the superficial fibular nerve (superficial peroneal nerve)

Quadriceps

- Innervated by the femoral nerve (L2, L3, L4)
- Multiple levels of innervation can make this test difficult to isolate a nerve root, but L3 is the dominant nerve

Hip Flexors

- Iliopsoas (T12) L1, L2, L3
- Particularly prone to pain inhibition

Hip Adduction

- L2, L3, L4: Obturator nerve

Hip Abduction

- L4, **L5,** S1 (superficial gluteal nerve)

Orthopedic Tests

Straight Leg Raising

- The patient lies supine as the examiner lifts the straight leg, supporting the heel, while the foot is in neutral position.
- Look for reproduction of back or leg pain.
- Perform on both sides.
- Well leg raising is a test of its own.

Soto-Hall

- The patient lies supine and lifts their head. The doctor stabilizes the patient's sternum and applies a gentle overpressure of cervical flexion.
- This tests for nerve tension.

Femoral Nerve Tension Test

- Patient lies prone.
- The examiner moves the knee into flexion and if tolerated, the hip is moved into extension.
- A positive test is reproduction of pain in front of the thigh.
- This test has been associated with upper lumbar disc lesions.

Yeoman's Test

- Patient lies prone.
- The examiner moves the knee into flexion and if tolerated, the hip is moved into extension.
- A positive test is reproduction of SI pain.
- This test is similar to the femoral nerve stretch test.

Ely's Test

- Patient lies prone while the examiner passively flexes the knee.
- Pain is noted, but a positive finding is pelvis hunching.
- This is indicative of hip flexor tautness.

Nachlas' Test (aka Prone Knee Bending Test)

- With the patient prone, the examiner flexes the knee until the heel approximates the ipsilateral buttocks.
- Pain in SI is indicative of an SI lesion.
- Lumbosacral pain is indicative of a lumbar lesion.
- Anterior pain indicates femoral nerve (L2, L3) lesion.
- Lateral pain may denote a lateral femoral cutaneous nerve lesion.

Orthopedic Tests

Patrick's FABER Test

- FABER is the acronym for Flexion, ABduction, and External Rotation.
- It is performed supine and intended to identify hip dysfunction.

Hibb's Test

- Patient is prone.
- The knee is flexed to 90^{o} and the hip is externally rotated.
- This test can identify hip and SI lesions.

Gait Analysis

- Watch the patient rise from a chair (Minor's Sign positive or negative)
- Observe the patient's gait, looking for abnormalities or weakness.

Neurologic Exam

Romberg

- Stand with feet together, eyes closed
- Visual input removed
- Observe truncal stability
- True Romberg: positive swaying from feet up
- False Romberg: positive swaying from waist up
- Cerebellum tested

Pronator Drift

- Patient stands with arms extended, palms up, and eyes closed for 30 seconds.
- Look for palms to drift into pronation and down.
- Pronation indicates mild hemiparesis.

Rebound Test

- With patient's eyes closed and arms extended tap the arms and observe the rebound.
- Excessive rebound can be indicative of cerebellar disease.

Finger to Nose, Finger to Finger

- With the patient's eyes closed, have the patient touch one index finger to their nose, then repeat with the other finger.
- Next, have the patient touch the index fingers to each other.
- Dysmetria is the inability to coordinate proprioception and intended motion.
- Dysmetria may be indicative of a cerebellar lesion.

Trendelenburg Sign

- Trendelenburg sign is witnessed during gait or by having the patient raise one leg up and observing whether the gluteal muscles are activated.
- If the side with the leg raised drops or sags, it is indicative of gluteal weakness on the opposite side.
- Trendelenburg sign reveals muscular dysfunction (weakness of the gluteus medius or minimus).
- Trendelenburg sign should not be recorded as a test. Trendelenburg test and Trendelenburg sign are distinctly different examinations.

Neurologic Exam

Heel to Shin

- With patient lying supine, ask them to glide their heel along the shin of the opposite leg.
- Repeat with the other leg.
- Inability to smoothly perform this test in a coordinated fashion may be indicative of cerebellar disease.

Heel to Toe Walking

- Patient walks forward and backward in a heel to toe manner.
- May be impeded due to several causes: intoxication, motor weakness, ataxia, hip DJD, or cerebellar lesions.

References

Bickley L. (2002). *Bates guide to physical exam and history taking*. Lippincott Williams & Wilkins.

Carragee EJ, Don AS, Hurwitz EL, Cuellar JM, Carrino JA, Herzog R. 2009 ISSLS Prize Winner: Does discography cause accelerated progression of degeneration changes in the lumbar disc: a ten-year matched cohort study. Spine (Phila Pa 1976). 2010 Jun 15;35(14):1414.

Cook C, Hegedus E. (2013). *Orthopedic Physical Examination Tests: An Evidence-Based Approach.* Pearson Prentice Hall.

Finsterbush A, Frankel U, Arnon R. Quantitative power measurement of extensor hallucis longus. A simple objective test in evaluation of low-back pain with neurological involvement. Spine (Phila Pa 1976). 1983 Mar;8(2):206-10.

Hoppenfeld et al. (1977). *Orthopaedic Neurology: A Diagnostic Guide to Neurologic Levels.* Lippincott Williams & Wilkins.

Humphreys SC, Eck JC Clinical Evaluation and Treatment Options for Herniated Lumbar Disc *Am Fam Physician.* 1999 Feb 1;59(3):575-582.

Morgan WE. Herniated Disc: A Survival Guide. TheLumbarDisc.com

Walker HK, Hall WD, Hurst JW, (Eds.). (1990*). Clinical Methods: The History, Physical, and Laboratory Examinations*. *(*3rd ed.) Boston: Butterworths.

Zehr E, Stein R (1999). Interaction of the Jendrássik maneuver with segmental presynaptic inhibition. *Exp Brain Res* 124 (4): 474–80.

11

The Examination: Practical Application

The Examination

This brief portion of the lecture notes will essentially be a list of the order of the examination. The patient will be examined in a particular order: Standing, walking, sitting, laying supine, and laying prone. If, during the examination, the provider finds compelling reason to modify the examination or to expound on a particular component of the exam, he or she should indeed do so. The provider should practice performing this examination until it is second nature and a rhythm is establishing during all examinations. In time, even a subtle break in the rhythm of the examination will alert the examiner of a subtle finding.

The examiner should strive for competence and confidence in performing this examination. With practice, a skilled practitioner should be able to complete this examination in ten minutes. During the examination, look, feel, smell, and listen all that you are able to observe.

Begin by washing your hands prior to beginning the examination. The examination is performed after a detailed history and vital signs have been be taken, and outcome measures are recorded.

Standing

- Gait analysis
- Minor's Sign
- Heel walking
- Toe walking
- Heel to toe walking forward and back
- Trendelenburg's Sign
- Romberg's Test
- Observer for Pronator Drift
- Rebound Test
- Finger to Nose
- Finger to Finger
- Heel to Shin
- Lumbar ROM
- Observe Muscles: atrophy or hypertrophy?
- Pinwheel: Back of legs and buttocks

Sitting

- Reflexes DTR
- Test for Clonus
- Babinski
- Peripheral sensitivity with pinwheel
- Motor testing (bulk, tone, and strength)
- Seated Leg Raising
- Kemp's Test
- Spinal palpation
- Cervical range of motion
- Cervical (axial) Compression
- Cervical Distraction
- Spurling's Test
- Shoulder Distraction

Supine

- Straight Leg Raising
- Well Leg Raising
- Braggard’s Test(if SLR is positive)
- FABER Test
- Thomas’ Test
- Heel to Shin Test
- Soto-Hall Test

Prone

- Ely’s Sign
- Gillis’ Test
- Yeoman’s Test
- Nachlas Test
- Hibb’s Test
- Femoral Nerve Stretch
- Spinal palpation: (muscle tone, motion, step-off…)
- Hip motion: internal/external rotation and extension

12

The Role of Advanced Imagery in Evaluating Lumbar Disc Lesions

What Makes it into a Radiology Report?

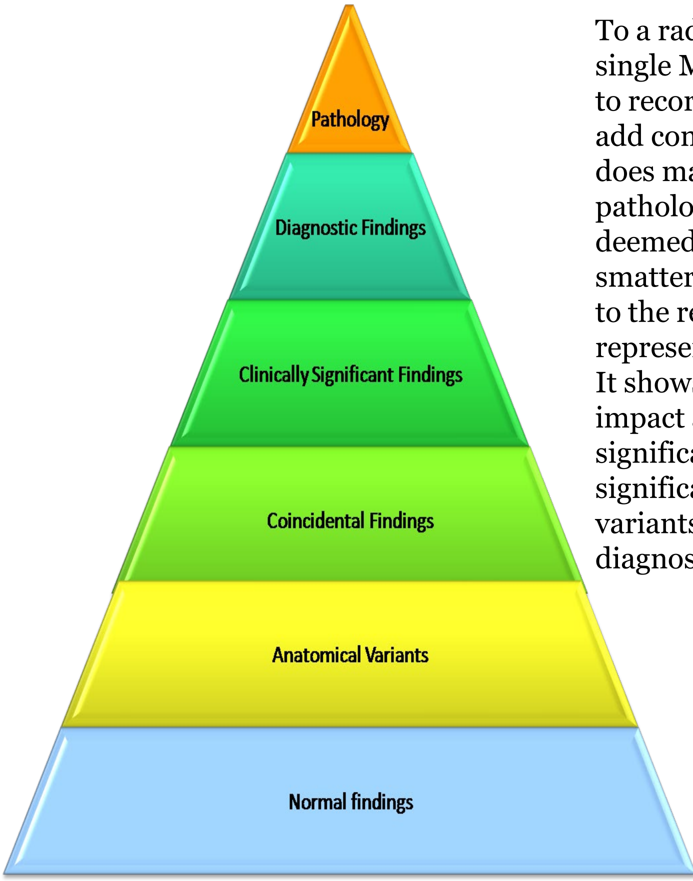


Figure 12.1.

To a radiologist, the amount of information on a single MRI study is vast. So vast, that to attempt to record all findings is not practical and would add confusion to the average practitioner. What does make it onto a radiology report is most pathology, most clinically significant findings, as deemed significant by the radiologist, and a smattering of other details that may be pertinent to the requesting provider. This pyramid represents the findings that are visible on MRI. It shows that findings with less of a clinical impact are more common, and the more significant findings are less common, but more significant: Normal findings and anatomical variants are on the bottom while pathology and diagnostic findings are at the top.

The red inverted triangle represents what is included in radiology reports. Since a report that included everything could consume an hour of dictation and a ream of paper, the radiologist must prioritize and economize what is reported. Of course all pathology and diagnostically significant findings should be included and most are. The radiologist will also include a smattering of other findings that have potential significance: coincidental findings, anatomical variants and the like. This book will not replace the radiology report, and certainly every MRI should be interpreted by a board certified radiologist. However, it will aid clinicians in expanding their use of the lumbar MRI past the limitations of a written MRI report.

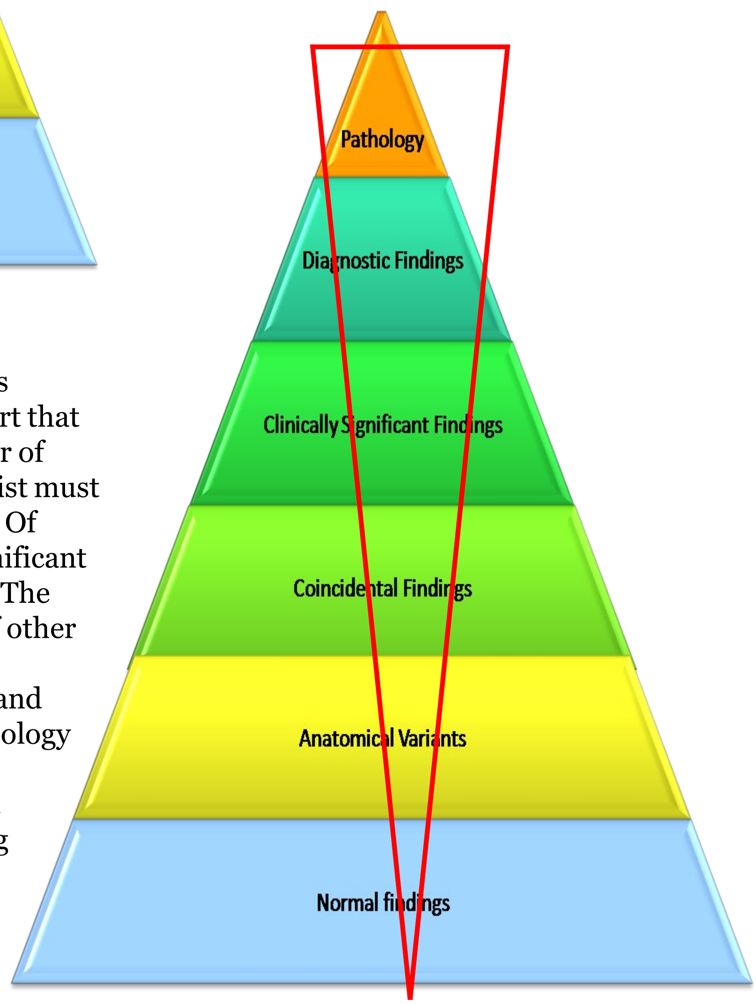


Figure 12.2.

MRI Findings in Asymptomatic Patients

Over the years there have been several studies that have found significant MRI findings in asymptomatic subjects. Many of these findings on MR had previously been considered to cause pain and infirmity. Jensen and associates[1] performed scans on 98 asymptomatic individuals. Of the 98 individuals without symptoms, only 36% had normal lumbar discs at every level, 27% had disc protrusions, 1% had an extrusion, 52% had disc bulges at one or more levels, and annular tears were present in 14%.

In another study performed by Boden[2] et al., 67 people who never had lower back pain received lumbar MRIs. In those individuals younger than 60 years old, 20% had a disc herniation, while those older than 60 had a herniation rate of 36% and 21% had spinal stenosis.

Weishagupt[3] studied 60 asymptomatic people between the ages of 20 and 50. In this population, 62-67% had lumbar disc bulges or herniations, 32-33% had annular tears, and 18% had disc extrusions.

These and other studies clearly demonstrate the need to correlate a patient's clinical presentation with the findings on lumbar MRI. Coincidental or incidental findings can lead the practitioner on a grand wild goose chase while creating anxiety in the patient. We need to be careful in discerning between findings that have clinical implications and those findings which are merely incidental.

1)Jensen et al. (1994). Magnetic resonance imaging of the lumbar spine in people without back pain. *New England Journal of Medicine*, Jul 14;331(2):69-73

2) Boden et al. (1990). Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am*. 1990 Mar;72(3):403-8.

3) Weishaupt et al. (1998). MR imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration, nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in asymptomatic volunteers. *Radiology*. 1998 Dec;209(3):661-6.

Balancing the Weight of Clinical and Radiographic Findings

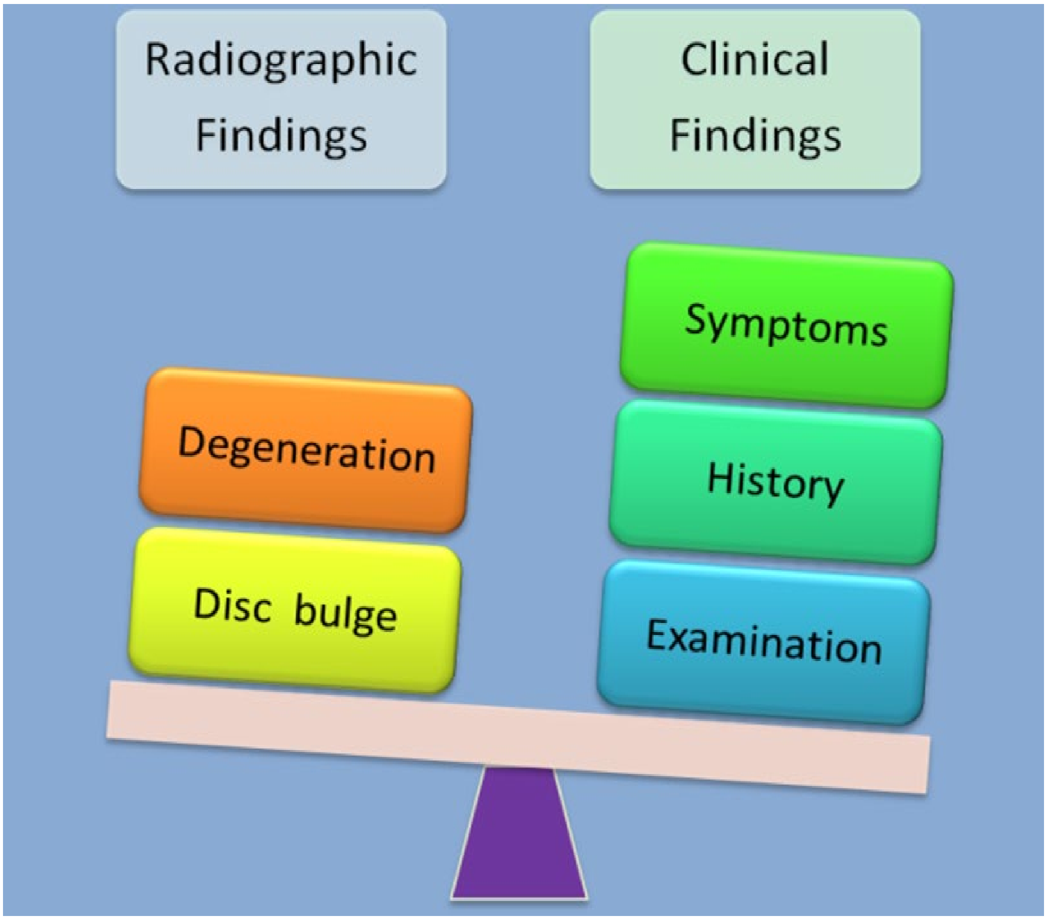


Figure 12.3.

With the incredibly large amount of detail that is visible on an MRI, it would be easy to get bogged down in the coincidental findings of an MRI. Just because there is a finding visible on MRI does not mean that it is clinically significant. Herniated discs are often seen on MRIs of patients with no clinical manifestation of the condition. The flip side of learning to read MRI is that the sensitivity of this technology is so great that there can be too much information. All radiographic findings must be correlated to history and clinical findings. So a word of warning to the non-radiologist: Do not jump to conclusions; most MRI findings should be collaborated with the patient's complaints and findings on clinical examination. The exception is the finding of pathologies which may lie dormant clinically, but still require intervention.

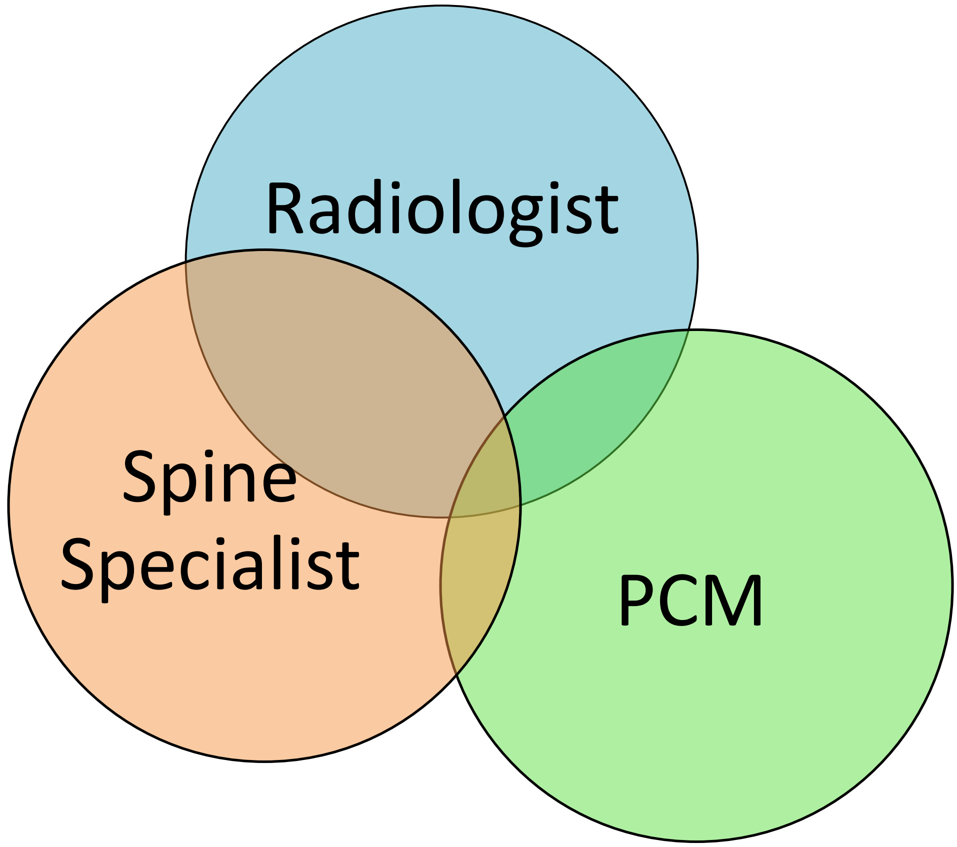


Figure 12:4.

The Venn diagram above illustrates the relationships and knowledge overlap of radiologists, spinal specialists, and primary care managers (PCM). The spine specialist and the radiologists (particularly neuroradiologists) have an intersecting body of knowledge. The spine care practitioner has some knowledge of radiology, and the radiologist has some knowledge of spinal care procedures and diagnosis. The primary care manager will have some overlap of knowledge, but it would be to a lesser degree. The PCM would be much more reliant on the written report than someone who primarily treats spinal conditions.

What is not shared with the other providers is the radiologist's in-depth knowledge of radiologic diagnostics and interventions, the spine specialist's in-depth knowledge of spinal conditions and treatments, and the PCM's broad base of medical knowledge. Each of these three team members are reliant on the others for providing optimized patient care.

13

Introduction to the Systematic Interpretation of the Lumbar MRI

Orientation and Sequencing of the Lumbar MRI

Without a systematic approach, endeavoring to interpret MRIs would be a daunting task. Efficient interpretation of the lumbar MRI entails several components: identification of the image orientation, the MRI image type (T2W, T1W, fat suppressed T2W,etc.), the knowledge of the anatomical structures (normal and variants of normal), and the ability to identify injury, abnormality, and pathology. This chapter will introduce a simple system for analyzing lumbar MRI studies.

Figure 13:1. Sagittal View

Image Orientation

There are three planes of orientation that are common in MRI studies: Sagittal, axial, and coronal.

1.Sagittal Images- Sagittal images are oriented in a lengthwise view allowing the visualization of the entire lumbar spine in one image. In some aspects the sagittal image resembles a lateral lumbar X-ray. The difference is that the sagittal image shows a slice through the body at a particular anterior to posterior slice. After identifying the sagittal image, determine the left-right orientation.

Figure 13:2. Axial view

2.Axial Images- Axial images reveal cross-sectional anatomy of the spine and paraspinal structures. In the axial image the structures appear reversed. The structures from the left side of the body will appear on the right side of the axial image. This is easier to remember and conceptualize if you envision the patient's feet being toward the viewer.

3.Coronal Images- Coronal images are full length studies that show the left to right width of the structures studied. These images are usually only included in the spotting/orientation views and are not commonly included in the detailed bulk of the lumbar MRI studies.

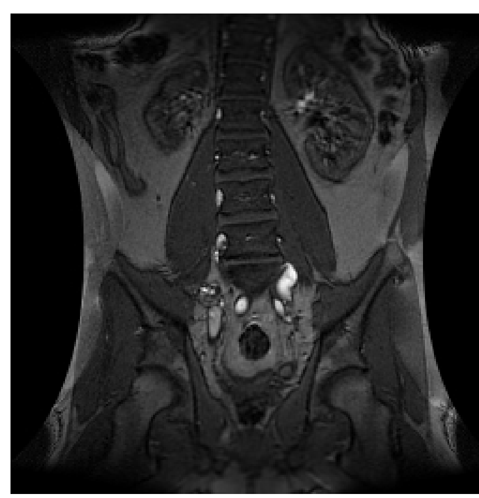


Figure 13:3. Coronal View

Orientation of Axial Images

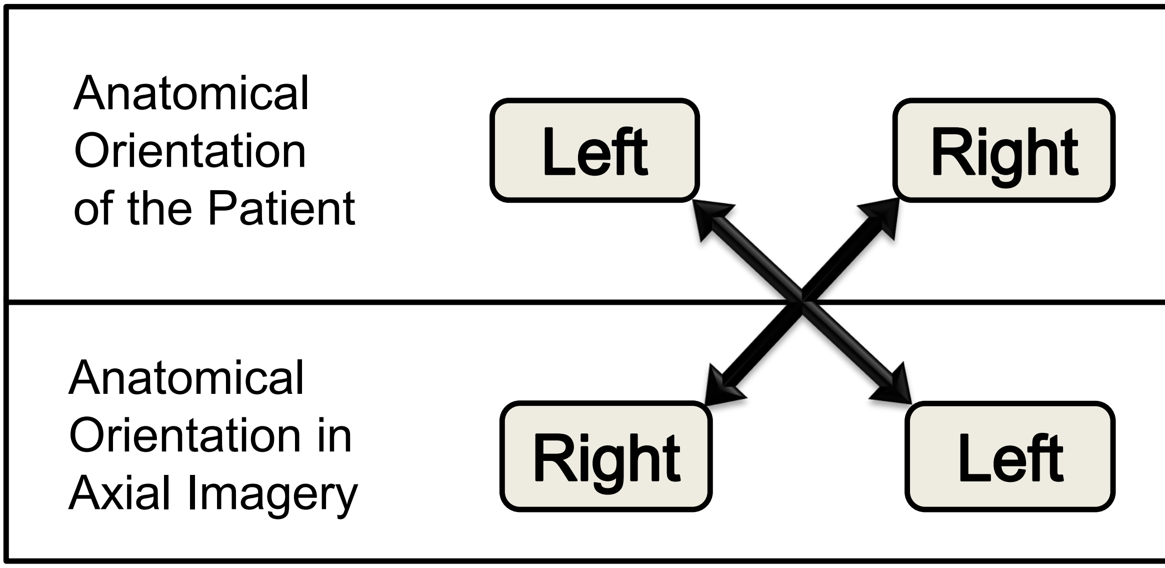


Figure 2:4.

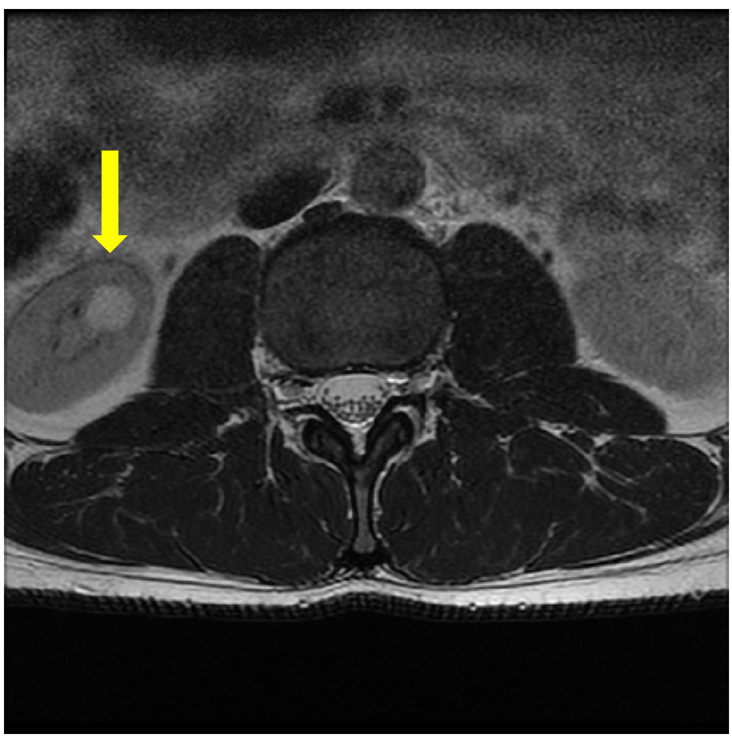


Figure 13:4.

It is important to remember that when viewing axial MRIs that left and right are reversed. If a structure is visualized on the right of the axial image, it is found on the left side of the patient. You may note that in the image above there is a simple cyst in this patient's right kidney; this is seen on the left side of the MRI (yellow arrow).

Image Orientation and Location Descriptors

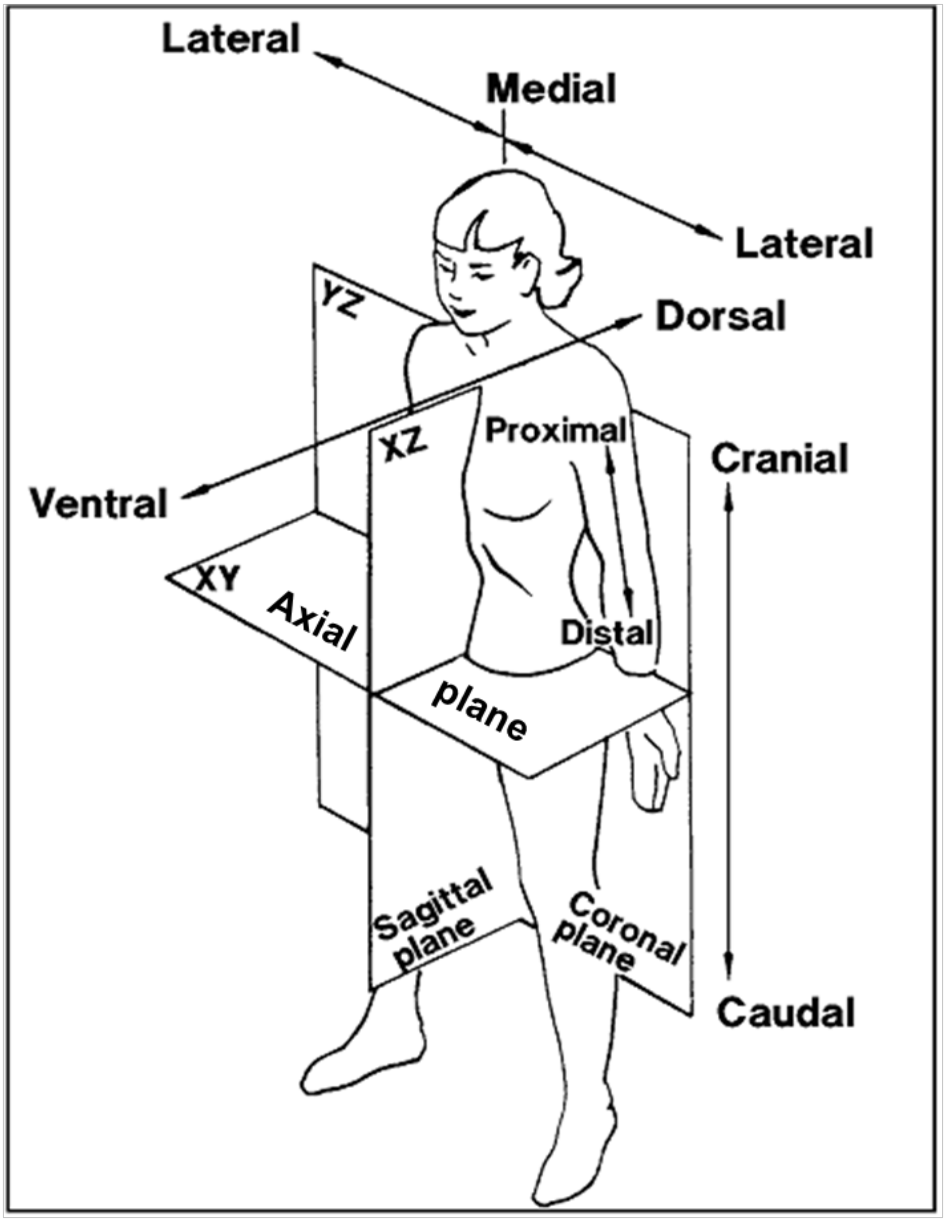


Figure 13:5.

This diagram clearly illustrates the planes available in MRI: Axial, sagittal, and coronal. It also clarifies several other terms that are commonly used in anatomical, biomechanical, and radiographic discussions. In describing locations seen on imagery, this standardized terminiology will give more complete descriptions of location. There are variations in the use of these descriptors. It is common to see cephalad, rather than cranial or anterior, and posterior, rather than ventral and dorsal in reports.

This schematic was adapted from NASA: Reference: 16, pp. III-78; NASA-STD-3000 260 (Rev A)
http://msis.jsc.nasa.gov/images/Section03/Image64.gif

Identifying Image Sequences

MRI studies typically include scout films which identify and label the slices. Understanding how to use scout films to identify image locations is fundamental in interpreting MRI studies.

Figure 13:6. The scout film for identifying the axial slices is a sagittal film with lines through it**.** These lines display each of the axial images available for viewing. This particular image identifies and labels 30 different axial slices. When viewing an axial image, the level can be identified by finding the corresponding identifying markers. These slices are uniform and made horizontally, regardless of the angles of the vertebral anatomy.

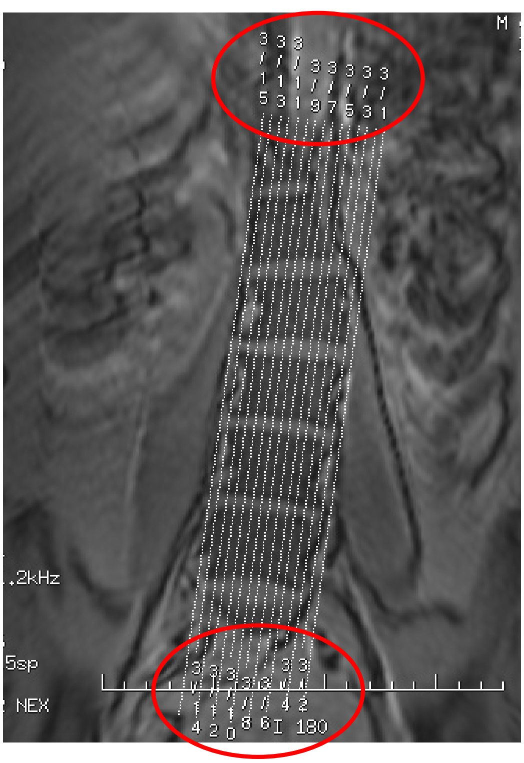


Figure 13:7. For sagittal images, the scout film is a coronal film with lines through it. These lines correspond to each of the sagittal images available for viewing. This particular image identifies and labels 15 different sagittal slices. The key to viewing sagittal imagery is to know which side of the spine you are viewing: left or right.

When viewing MRI in an electronic format sequence, identification is facilitated by the use of scout lines, linking images together, and scrolling.

Figure 13:8. Uniform horizontal slices.

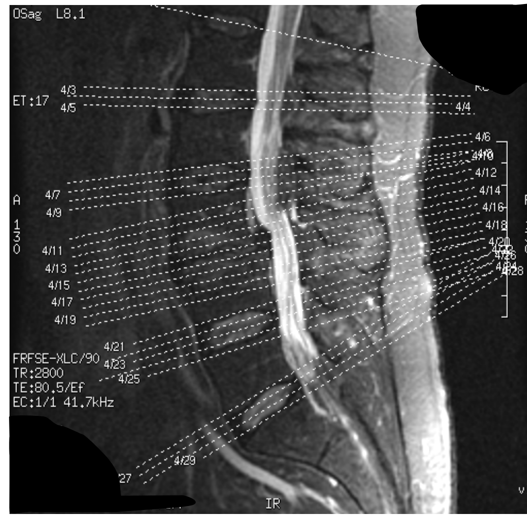


Figure 13:9. Slices along the disc planes.

In most lumbar MRIs the axial slices will be evenly spaced intervals (figure 13.8). Some studies will emphasize only special regions of anatomy or a site of concern such as an injury, degeneration, or disease; or a study may be limited to the disc spaces (figure 13:9). The axial images may even be angled to correlate to the angles of the vertebrae and disc spaces. These spotting or scout films indicate that the technician selected slices through the disc spaces and through an area of particular concern. The technician also made sure that the slice angles aligned with the anatomic variations of the lumbar segments. Note that there are areas of the lumbar vertebrae which are not visualized at all.

The red lines in the scout film of figure 13.10 reveal large areas of the lumbar spine that are not represented in axial imagery. This study was particularly intended to visualize a condition affecting the L3-4 vertebrae and disc along with the intervertebral disc spaces of the rest of the lumbar spine.

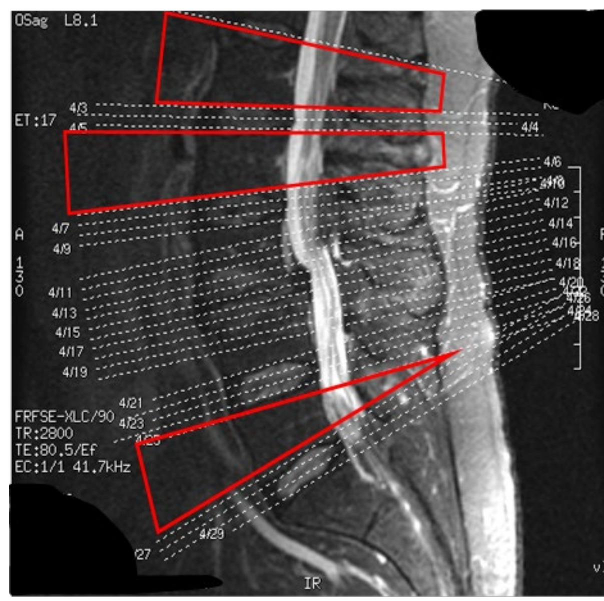


Figure 13:10. Selective slices of anatomy of particular interest. Note the red bordered sections without slices.

MRI Image Types

MRI image types enhance various tissue types differently. This allows the differentiation of tissues by the specialist. The various types of MRI images are as follows:

1. T1 Weighted Image: Water densities are dark; fat densities are bright. T1WI have greater anatomic detail than T2WI.

2. T2 Weighted Image: Water and fat densities are bright; muscle appears intermediate in intensity.

3. Fat Suppressed T2 Weighted Image: Water densities are bright; fat is suppressed and dark.

4. Intermediate T2 Weighted Image: Ligaments and cartilage are viewed as very dark.

5. Gadolinium Enhanced T1 Weighted Image: Gadolinium is an injected enhancement. It is used to identify pathology.

6. Fast Spin Echo (FSE): Frequently used in musculoskeletal imaging. Allows quicker image acquisition. Fat is bright on T2 weighted images. Marrow or subcutaneous pathology may not show unless fat suppression is used.

7. FSE STIR (Short T1 Inversion Recovery): Decreased signal intensity (brightness) from fat and an increased signal from fluid and edema. This is useful in identifying soft tissue and marrow pathologies.

8. Proton Density: Proton density uses a mixture of T1 and T2 images. It is characterized by enhanced anatomical detail and poor tissue contrast.

9. Fat Saturation: Fat saturation employs a "spoiler" pulse that neutralizes the fat signal without affecting the water and gadolinium signal. Fat saturation is used with T1 weighted images to distinguish a hemorrhage from a lipoma. When used with FSE T2 weighted images, fat saturation can enhance marrow or soft tissue pathology.

10. FIESTA (Fast Imaging Employing Steady sTate Acquisition): This method of image acquisition captures structures rapidly and provides high quality images of fluid-filled structures.

Comparing T1 to T2 Weighted Images

MRI Image Characteristics

For practical purposes the most commonly utilized types of MRI images by non-radiologists are T1 and T2 weighted images. T1 has greater anatomic detail, but T2 tends to be the favored image type for observing the intervertebral disc and the spinal cord. The chart below reflects the characteristics of each image type.

Tissue	T1	T2
Bone	Neutral	Neutral
Air	Dark	Dark
Fat	Bright	Light
Water	Dark	Bright

Figure 13:11. Tissue characteristics on MR with T1 and T2 weighted imagery.

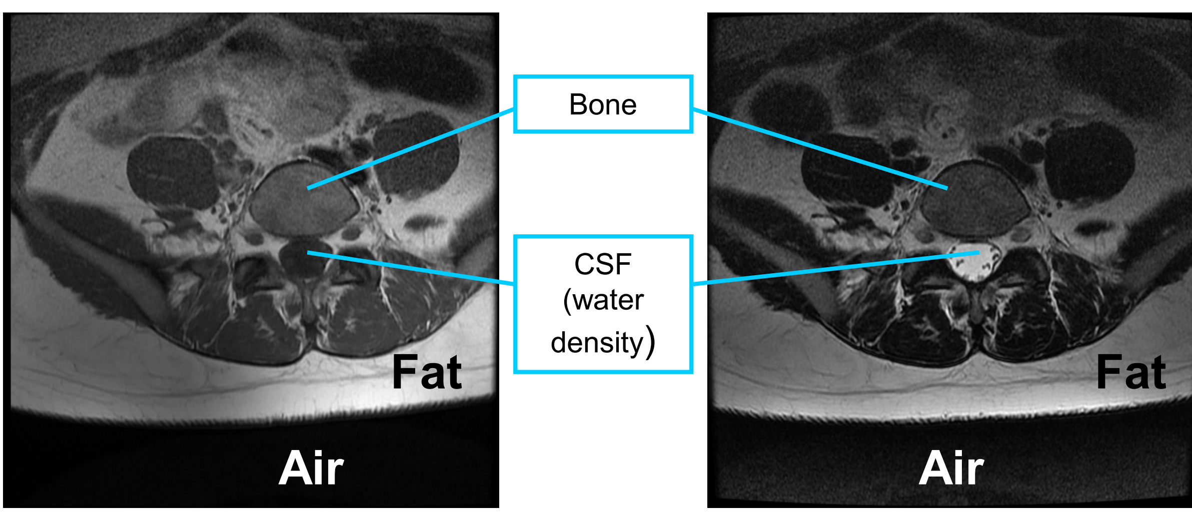


Figure 13:12. T1W Axial Image

Figure 13:13. T2W Axial Image

Note that some tissues are dark (low intensity signal) on both image types. These include gas, cortical bone, calcification, tendons/ligaments, and menisci.

How are T1 and T2 Weighted Images Alike?

For comparison purposes the two sagittal images have been placed side by side with T1 on the left and T2 on the right. Note that on both images the vertebral bodies are a neutral gray color, muscles and ligaments are dark, air is black, and fat is light-colored.

Figure 13:14. T1W Sagittal Image

Figure 13:15. T2W Sagittal Image

How do T1 and T2 Weighted Images Differ?

The difference is black and white. In T1 images water is black, while T2 images display water as white. The blackness of water in T1 images makes it more difficult to differentiate the cerebral spinal fluid from the nerves and the disc from the contents of the central canal. However, the T1 image aids in the discerning details of other anatomic structures.

Characteristics of T1 and T2 Weighted Images and Fluid-Filled Lesions

Figure 13:16. This T2 weighted axial image reveals multiple large renal cysts. These cysts are ovoid and light-colored.

Figure 13:17. In this T1 weighted axial image the renal cysts are dark.

These two images are from a patient with multiple benign renal cysts. Note the large light-colored ovoid lesions in the kidneys in the T2 weighted image (figure 13:16). The cysts are easy to distinguish from the soft tissue of the kidneys.

In the T1 weighted image (figure 13:17) the water-density cysts are dark and more difficult to distinguish from the kidneys.

Fat is light colored in both T1 and T2; muscles, ligaments, and tendons are dark.

Systematic Interpretation of the Lumbar MRI

There are several methods for systematically reviewing lumbar MRIs. This system ensures that you cover the images in a logical manner. The next two pages expand on how to analyze axial and sagittal sequences in detail. As you develop an eye for the subtleties found in lumbar MRI, you will find that sticking to a sequence of systematic observation will help you avoid missing important findings.

Sequence of Systematic Interpretation of Lumbar MRI Images

1. Verify patient identifiers and date of examination.
2. Confirm that the images and the studies are in order if using film rather than digitized images.
3. View the sagittal T2 weighted images from left to right.
4. View the sagittal T1 weighted images from left to right.
5. View and analyze the T2 weighted axial images from caudal to cephalad.
6. View and analyze the T1 weighted axial images from caudal to cephalad.
7. Review your findings and compare to the radiologist's report.
8. Determine if the radiographic findings are clinically significant or coincidental findings.
9. Integrate collaborative MRI findings into patient care.

Sequential Analysis of Sagittal Images

1. **Identify the left-right orientation.** Sagittal images represent anatomic slices in a vertical plane which travel through the body from posterior to anterior and divide the body into right and left components. Scroll from left to right. If you are unable to identify the orientation of the sagittal images, remember that the aorta is on the left and that the inferior vena cava lies on the right. The aorta typically has a greater girth and a more symmetrically round appearance.

2. **Analyze the spine from a global view.** Scan through the sagittal images and look for larger, more obvious findings:

   Alignment of the spine – Spondylolisthesis and retrolisthesis can usually be discerned on sagittal inspection. Scoliosis can be a little more difficult. On sagittal imagery a scoliosis will present with partial views of structures and a contorted view of the spinal canal and vertebral bodies.

   Vertebral body shape- Identify endplate disruption, Schmorl's nodes, compression fractures, block vertebrae, and fusion.

   Vertebral body content- Analyze the cortical bone for edema, tumors, fatty infiltration, and hemangiomas.

   Posterior Elements- Evaluate the facets, the pars, the spinous processes, the pedicles, and the lamina.

   End plates- Look for sclerotic changes and alterations in signal intensity. Also, look for disruptions or fractures of the endplates.

3. **Intervertebral foramina:**

   The IVF should be a light-colored peanut-shaped image with a gray dot in the middle. The light color is due to the fact that it is in the foramina. When displaced, the light-colored fat will alter in shape. The gray dot in the foramina is the exiting nerve root.

4. **The discs and the canal:**

   Look for alterations in disc height. Increased disc height may occur with discitis. Loss of disc height and reduced water content is indicative of degeneration. Disc tears and derangements may also be observed in sagittal imagery. Note disruptions of the thecal sac, the cauda equina, and nerve roots.

   High intensity zones (HIZ) may be observed in T2 weighted images. These bright-colored zones indicate the presence of disc tears, scarring, or vascularization of the annulus.

   The cord should terminate at about the level of L1. Increased signal (brightness) on T2 weighted images may indicate a cyst, tumor, syrinx, or demyelination.

Sequential Analysis of Axial Images

1. **Identify left and right**. Axial images are backwards; structures that you see on the left of an axial image represent structures found on the right of the patient.
2. **Begin your analysis caudally proceeding cephalad.** The sacrum will be easily recognizable. Observe the S1 nerve roots. Look for perineural (Tarlovs' cysts) which occur most commonly at the S2 and S1 nerve roots.
3. **As you scroll superiorly, observe the L5-S1 disc.** Note the circumferential margin of the disc and inspect it for derangement. Scroll past the disc to the L5 vertebra. Note that L5 is commonly shaped like a lemon when viewed axially. Observe the bony integrity of L5. Look for elongation of the central canal which may be indicative of a spondylolisthesis.
4. **The canal should be intact and not effaced.** Look for effacement or disruption of the thecal sac by discs, osteophytes, spondylosis, or other space occupying lesions.
5. **Look at the lumbar discs.** Evaluate for tears, herniations, nerve compression, and degeneration.
6. **Identify the ligamentum flavum.** Look for signs of hypertrophy and subsequent stenosis.
7. **Evaluate the posterior elements of the vertebrae.** Look for pars defects, spina bifida, facet hypertrophy, and overall posterior ring integrity.
8. **Examine the retroperitoneal space.**
9. **Assess non-spinal structures.** In addition to examining the spinal structures, evaluate and note the paraspinal muscles, multifidus muscles, iliopsoas muscles, the great vessels, and the kidneys.
10. **After scrolling up the lumbar spine, reverse direction and descend the spine to follow the course of nerve roots.** Start cephalad and scroll (if using a computer) caudally. If looking at film move from slide to slide. Follow the migration of the nerve rootlets from the cauda equina from their posterior central location to the lateral anterior portion of the thecal sac and then leaving the sac as traversing nerve roots.

Which Radiological Studies Should You Order?

Develop a relationship with your radiologist and be willing to consult with the radiologist prior to ordering a patient's studies. Explain the history and work with the radiologist to determine the best study for each patient.

Trauma	•Plain films may be used initially to determine if there is an unstable injury or displacement •Non-contrast CT •MRI to evaluate cord integrity
Tumors	MRI with contrast enhancement
Inflammation and Vascular Disorders	MRI with contrast enhancement
Scoliosis	Plain films, unless pathology is suspected; then MRI
Congenital anomalies	MRI without contrast enhancement
Infections	MRI with contrast enhancement
Nerve Root Compression	MRI
Spondylolisthesis	•Plain film radiographs •CT •MRI if there is a need to evaluate neuronal involvement

Note: There is an inherent danger in using contrast enhancements. These risks include allergic reaction, shock, and death.

CTs are less expensive than MRI and are the medium of choice for head and neck trauma. CTs utilize significant doses of radiation and increase the risk of cancer.

14

Anatomical Atlas of the Lumbar Spine on MRI

Anatomy

In addition to knowing the image orientation and MRI image type, it is important to have a good foundation in the anatomy of the lumbar spine as viewed on MRI. This chapter will review the lumbar anatomy as viewed in various sequences.

This sagittal T2 weighted image demonstrates typical vertebrae, sacrum, and intervertebral discs. The light-colored disc in a T2 weighted image is indicative of a healthy well-hydrated disc. The light-colored zones in the nucleus pulposa appear brighter than the annular fibers. The vertebrae remain neutral gray in color. A normal lumbar lordosis is visualized.

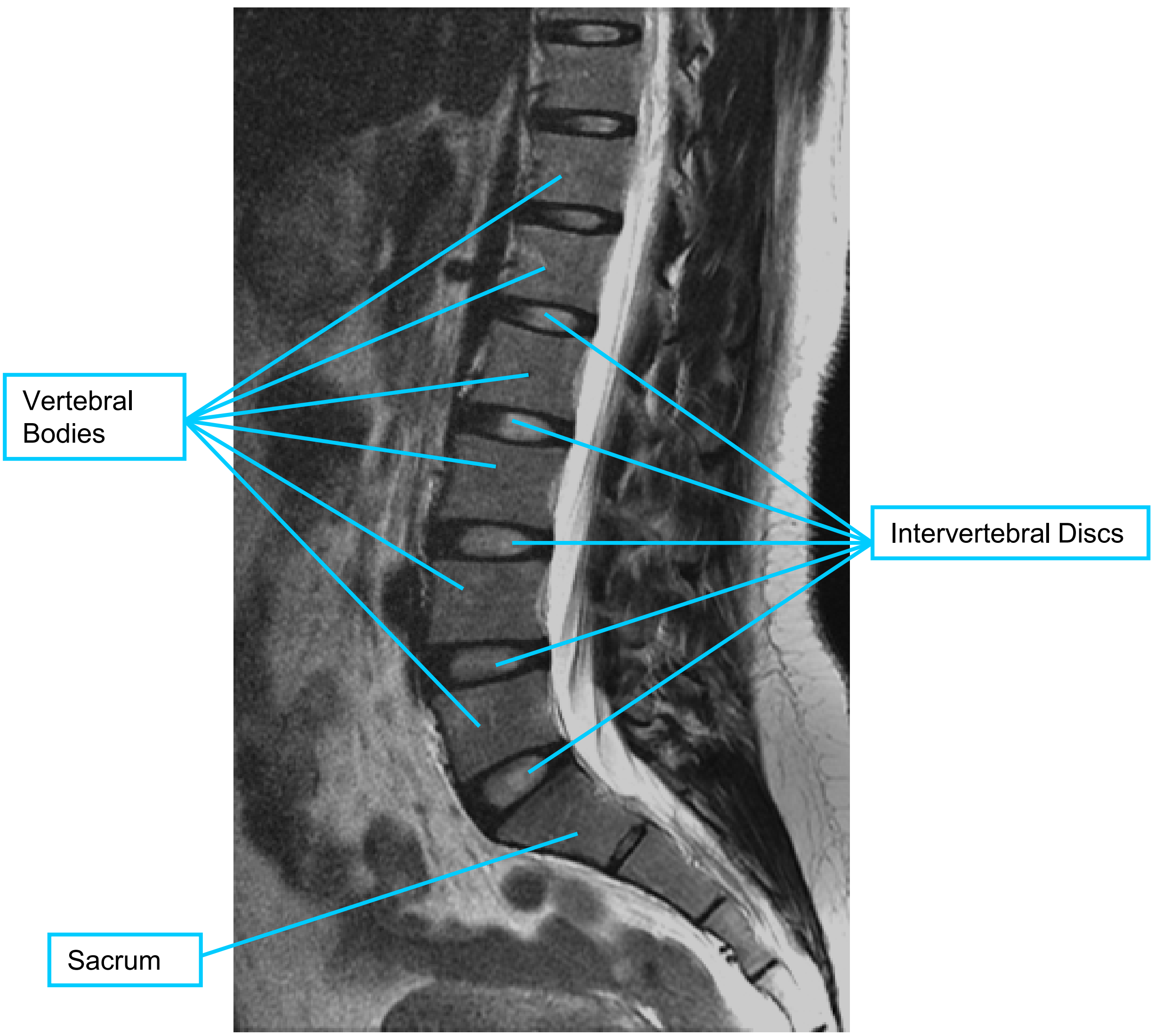


Figure 14:1

Anatomy

This image, also a T2W sagittal slice, identifies the five lumbar vertebrae and the top three sacral segments. The discs are identified by their adjoining vertebrae; the disc between L5 and S1 is called the L5-S1 disc. Sacral disc remnants are difficult to see on plain film X-rays, but are often visible on MRI. This can result in confusion when using plain films to identify structures found on MRI.

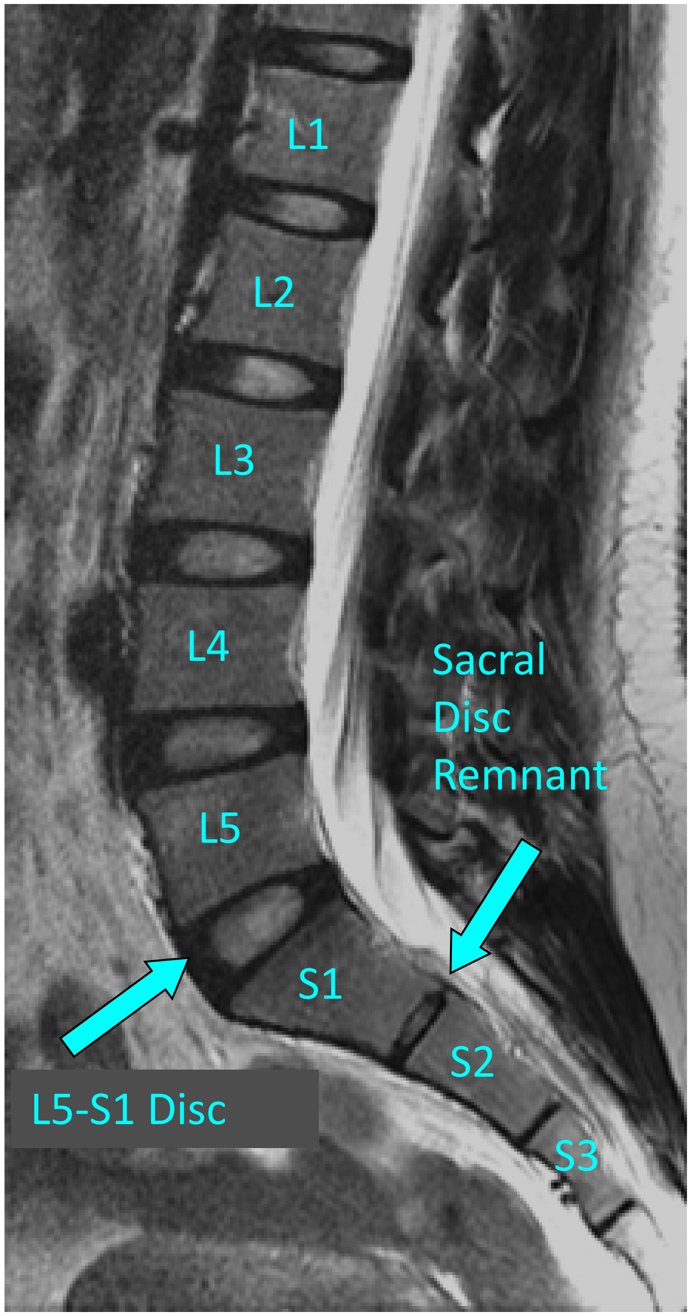


Figure 14:2.

Anatomy

The figure below displays the components of the intervertebral discs as viewed on a sagittal T2 weighted image. The nucleus pulposa of the L4-L5 intervertebral disc is demarcated by a red dotted line. The arrows indicate the location of annular fibers of the disc: the blue arrows indicate the boundaries of the posterior portion of the L2-L3 disc, the yellow arrows identify the anterior portion of the annular fibers of L3-L4. Note that on this T2 weighted image, the nucleus is lighter in color than the annular portion of the discs. This is due the increased hydration of the nucleus versus the annular fibers. As a disc ages and dehydrates, the entire disc will appear dark on T2WI.

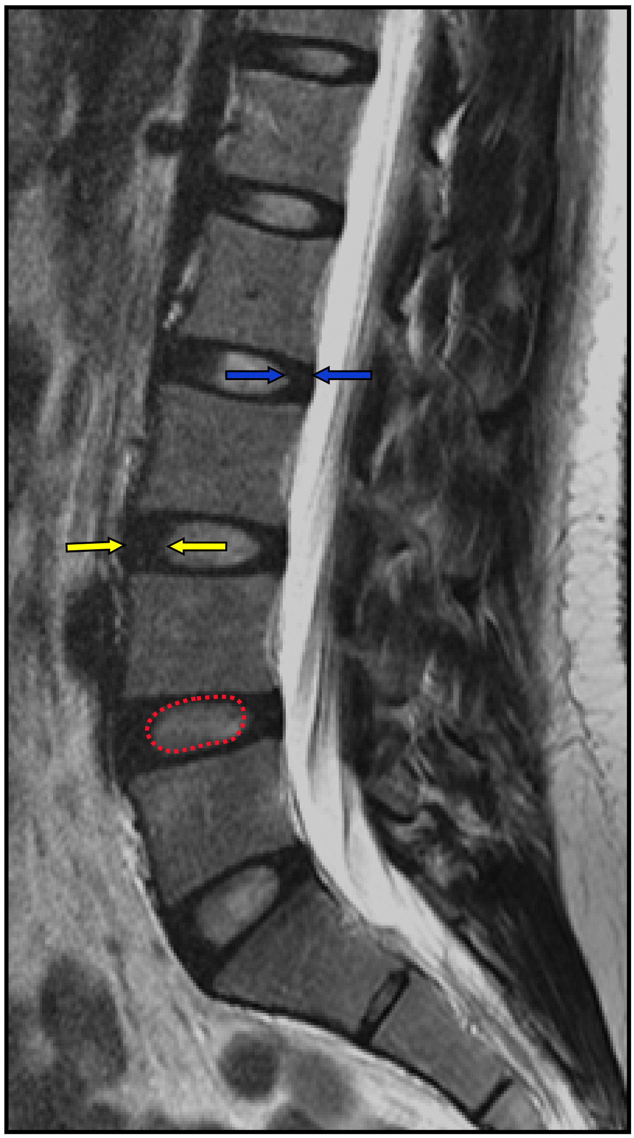
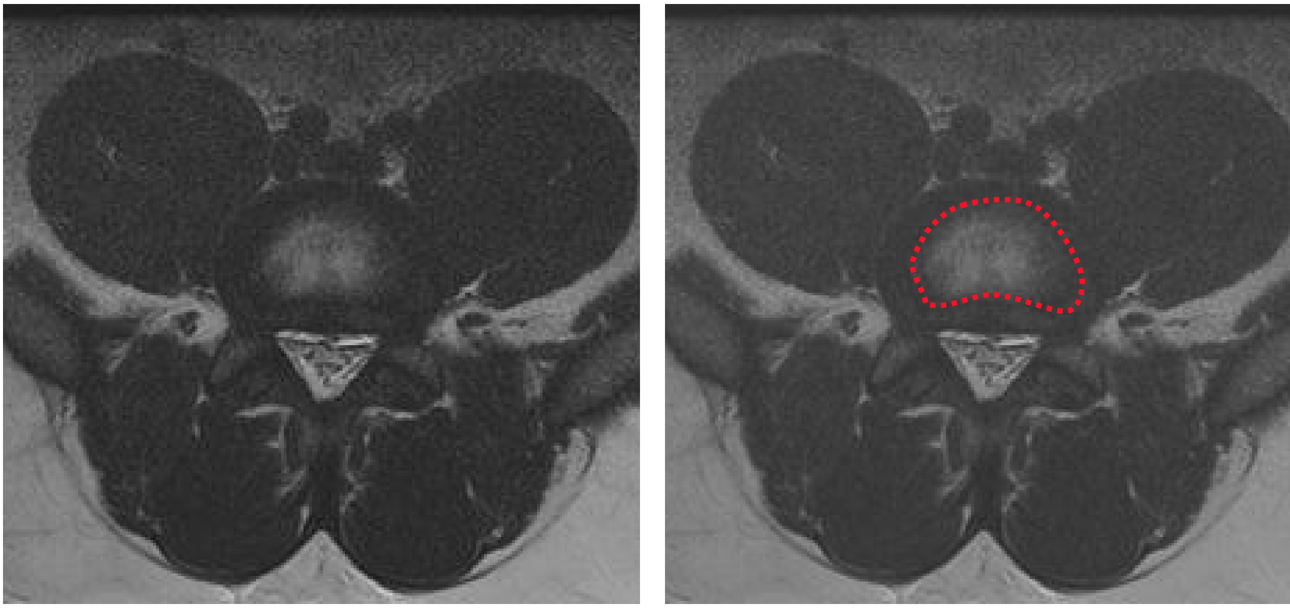


Figure 14:3.

Normal Disc Appearance



Figures 14:4 and 14:5. The appearance of a normal disc on axial T2 weighted MR. The nucleus is light in color (indicating normal fluid content), while the annular ring is dark. Figure 14:4 is the same slice as figure 14:5, but with the margins of the nucleus pulposus denoted by a red dotted line.

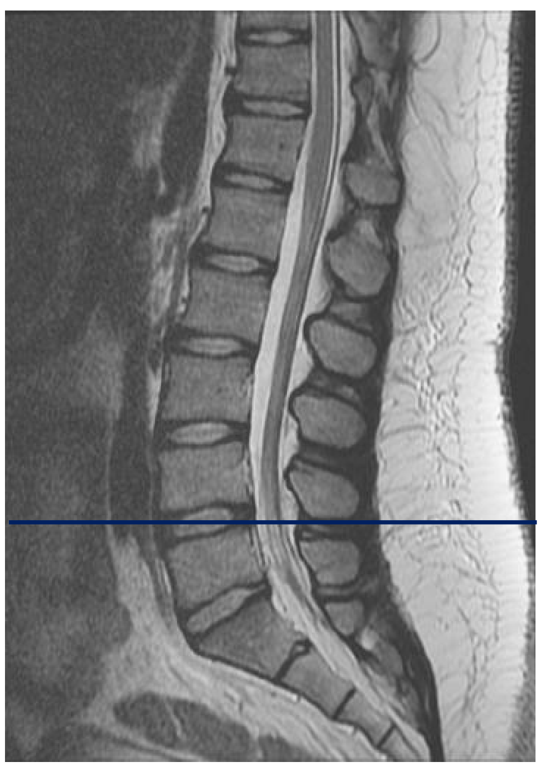


Figure 14:6. This sagittal image shows the level of the axial slice seen in figures 14:4 and 14:5.

The Central Canal

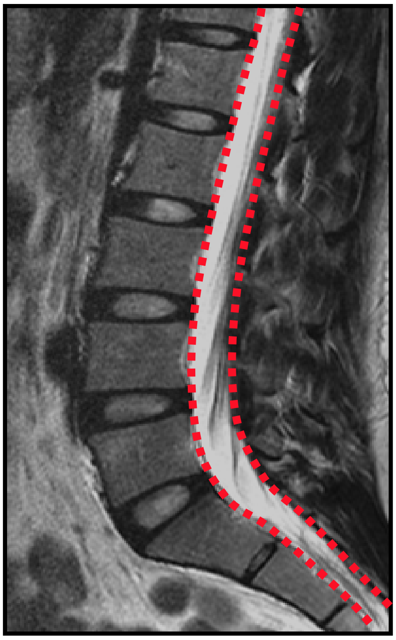


Figure 14:7.

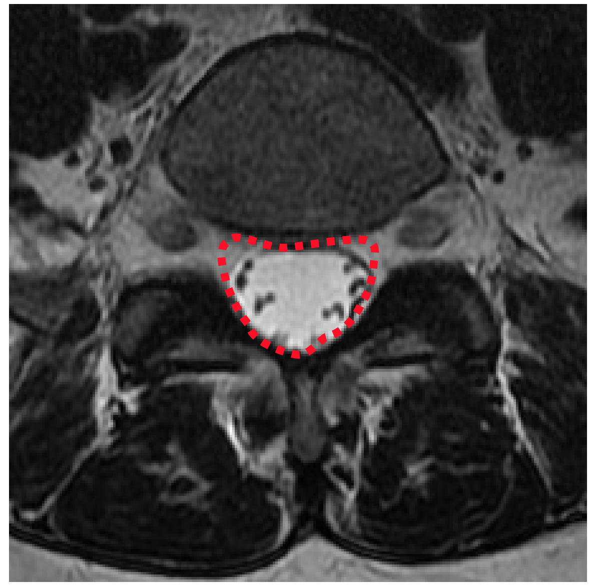


Figure 14:8.

The central canal is outlined with a red dotted line in these sagittal and axial T2 weighted images.

Anatomy of an Axial Slice Through L5

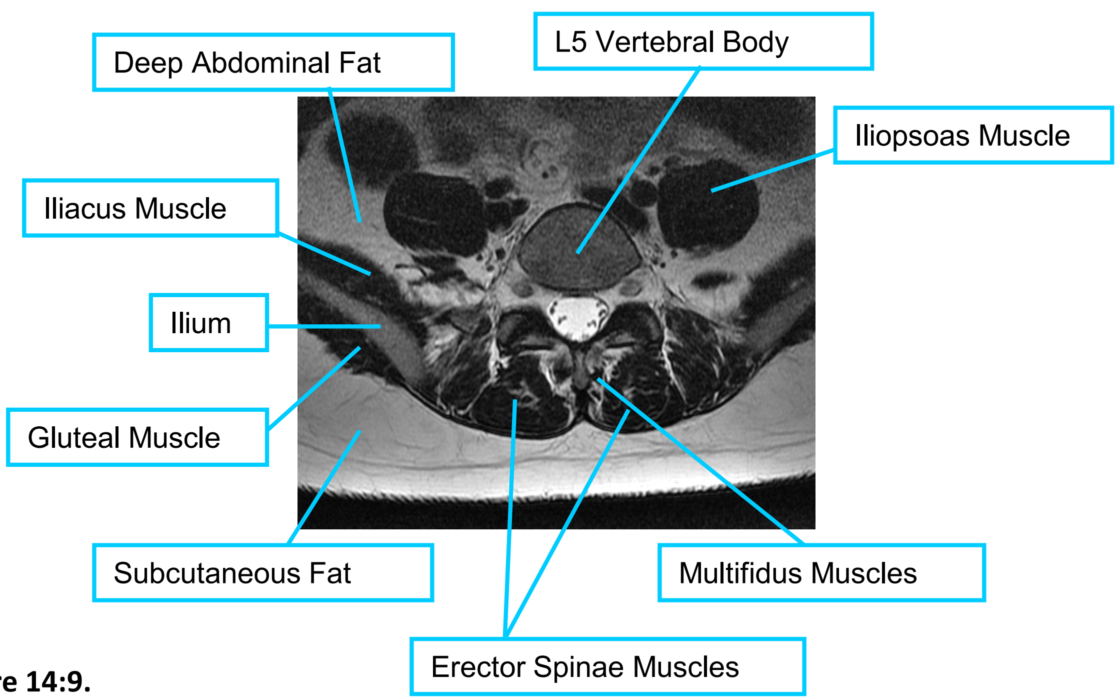


Figure 14:9.

This image, a T2W sagittal slice through the level of L5, reveals the cross-sectional anatomy of this plane. Recall that in T2 images water density is bright, fat is light-colored (but not as bright as water), air is black, muscles are dark, and bone is a neutral gray.

Expanded L5 Axial Image

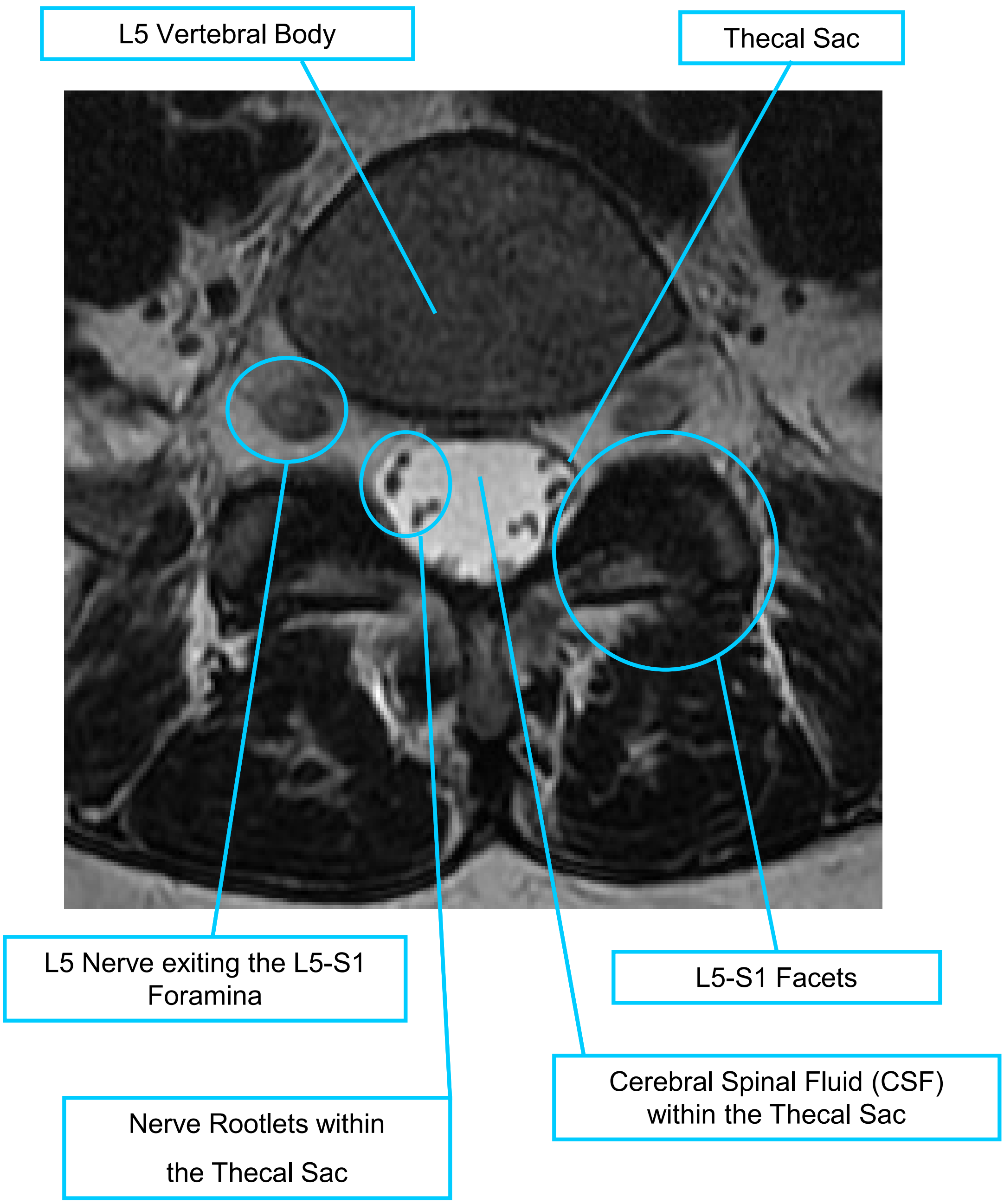


Figure 14:10.

Conus Medullaris

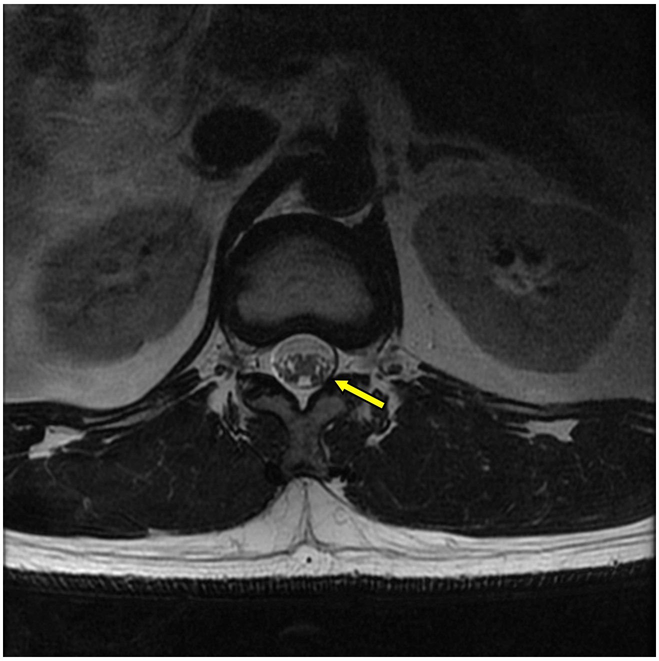


Figure 14:11. T2 weighted axial of the conus medullaris (yellow arrow).

The conus medullaris is the terminal end of the spinal cord. It typically terminates at the level of T12 or L1, but is occasionally seen terminating at L2. Though the spinal cord terminates with the conus medullaris, the spinal nerves continue inferiorly within the thecal sac in the cauda equina. These dangling nerves resemble a horse's tail hence the Latin description cauda equina which literally translated is *horse's tail.*

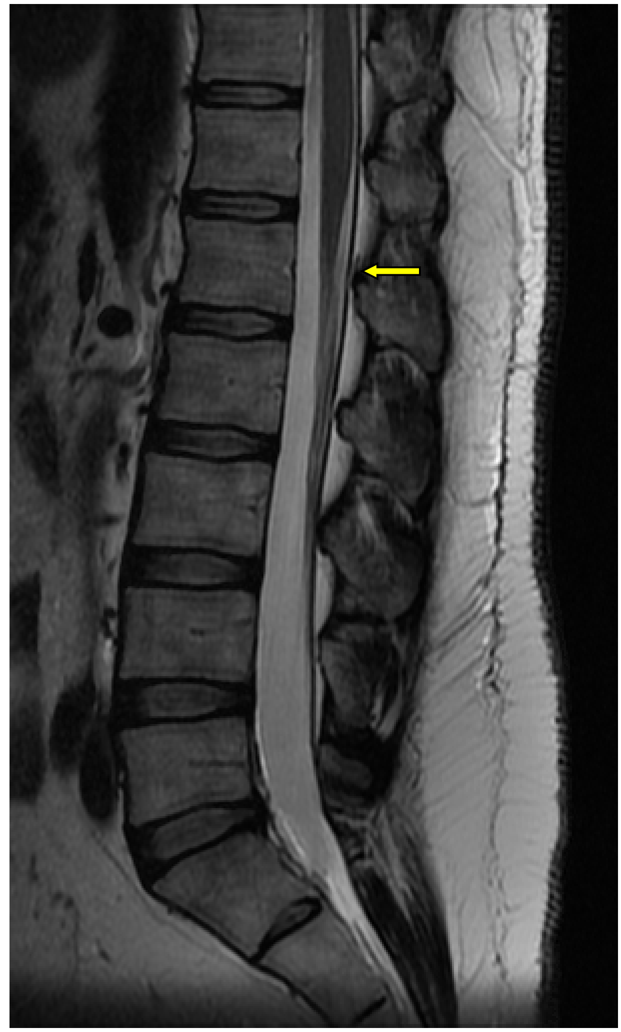


Figure 14:12. T2 weighted sagittal image of the lumbar spine showing a normal termination of the conus medullaris posterior to the vertebral body of L1 (yellow arrow).

Spinal Nerves

The exiting nerve root expands into the dorsal root ganglion as it exits the intervertebral foramina. The nerve roots are surrounded by fat from the point at which they exit the thecal sac and transverse the foramina. Within the thecal sac, nerve rootlets (identified by blue in the lower figure) are surrounded by cerebral spinal fluid (CSF) which is bright in color. These nerve rootlets are known as the cauda equina.

Figure 14:13.

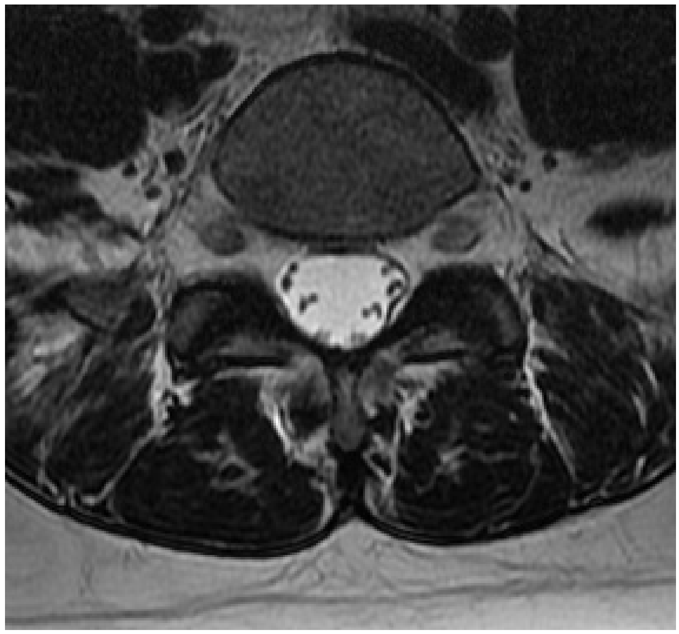
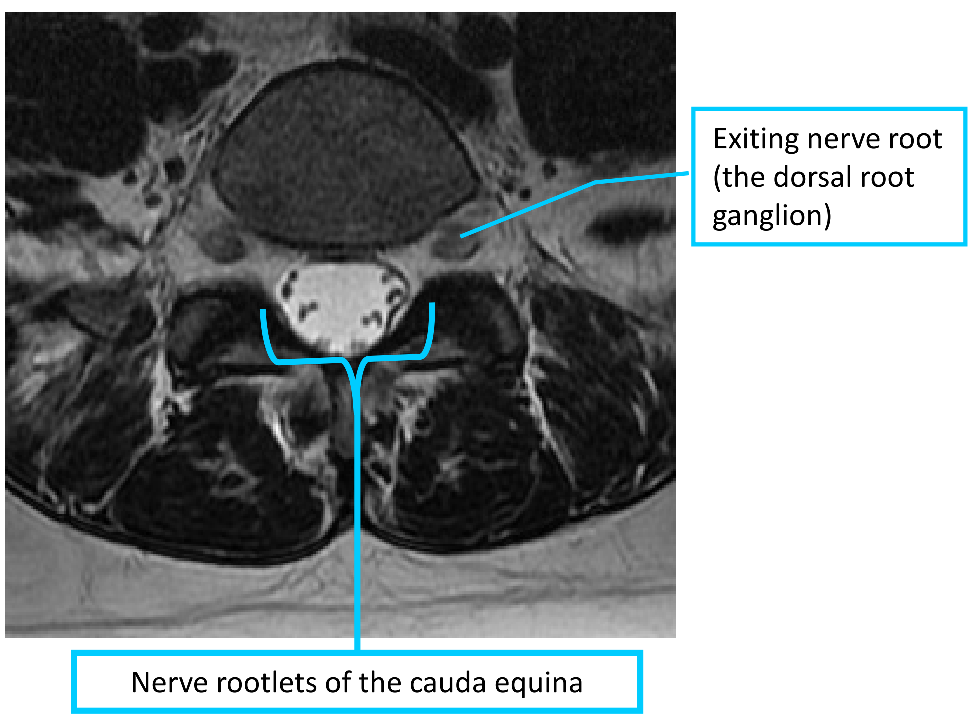


Figure 14:14.



The Unique Shape of L5 on Axial Imagery

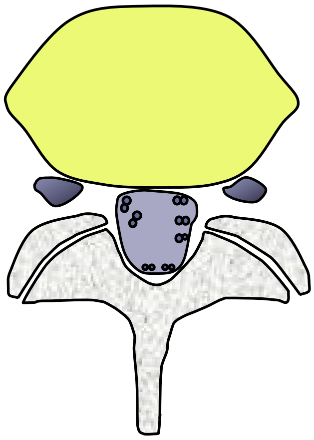


Figure 14:15.

Figure 14:16.

While not an ironclad landmark, the L5 vertebra can frequently be identified by its lemon shape when viewed in an axial plane. These axial images are characteristic of the appearance of the L5 vertebra in an axial orientation.

Figure 14:17.

Figure 14:18.

Anatomy of a Vertebra

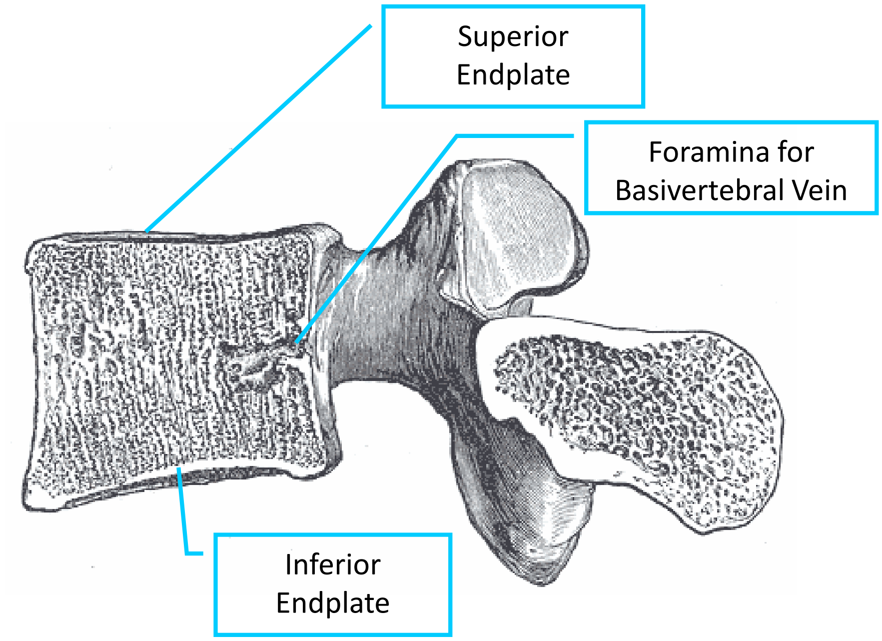


Figure 14:19. Cross-section of a lumbar vertebra.

Images adapted from Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

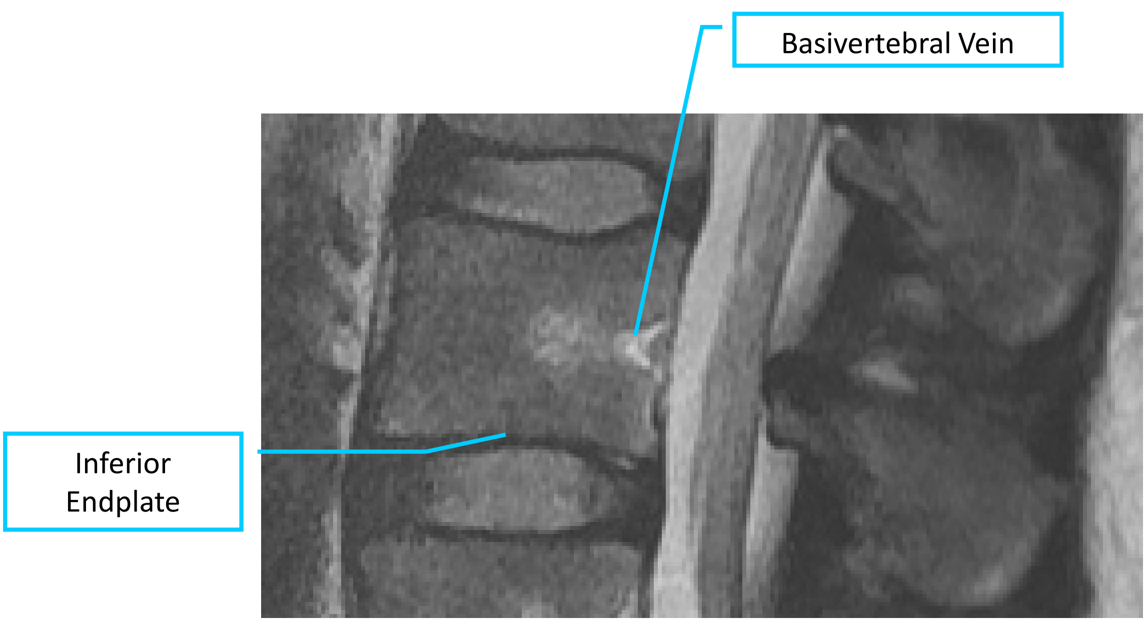


Figure 14:20. T2 sagittal of a lumbar vertebra.

Axial Image of the Sacrum

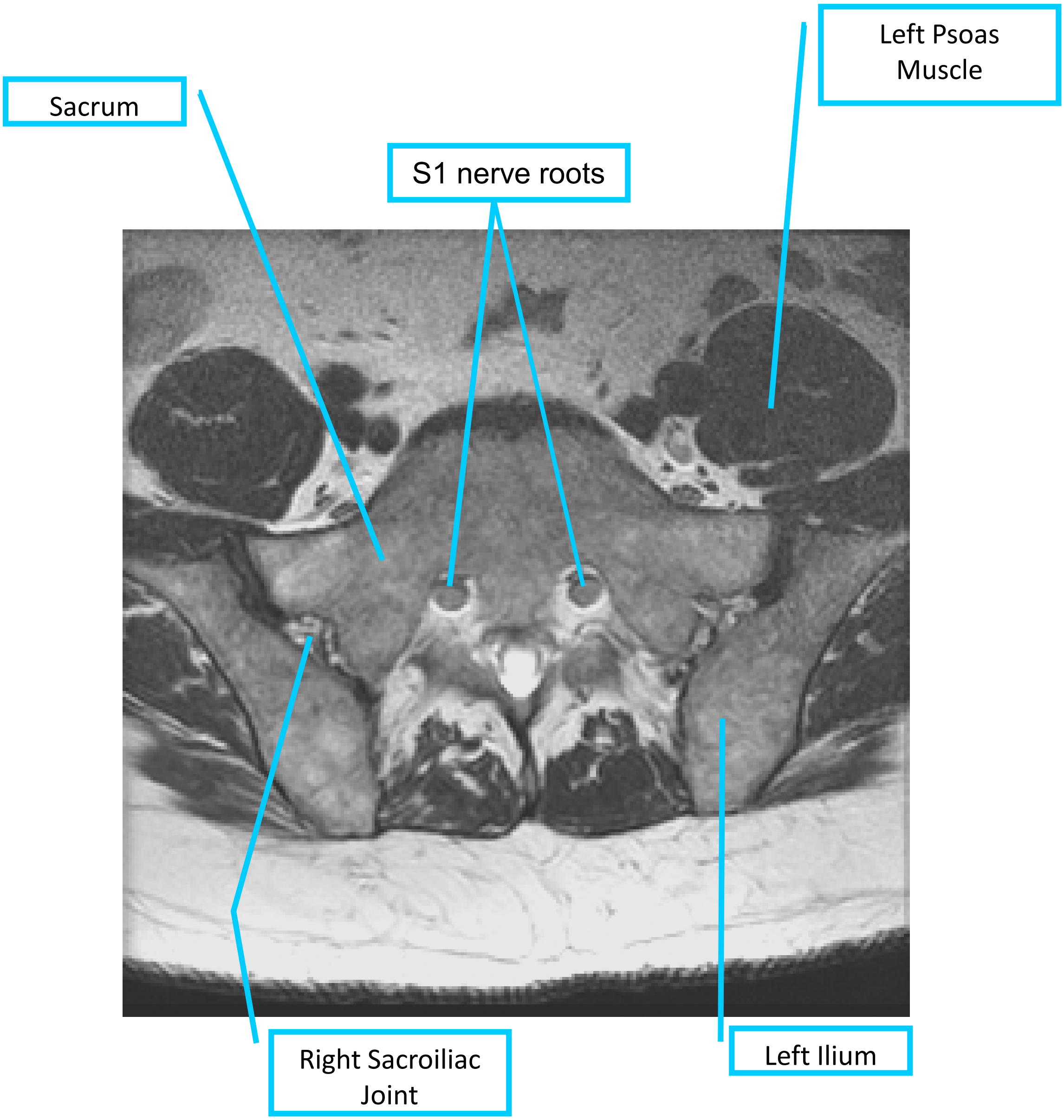


Figure 14:21. Lumbopelvic anatomy on axial imagery.

Ligamentum Flavum

There are several ligaments that stabilize and support the spine. Of those, the ligamentum flavum is of particular interest to the clinician. It comprises the posterior boundary of the spinal canal and normally appears as a "V" on axial slices (red arrows). On sagittal images the ligamentum flavum is seen at the posterior of the spinal canal (yellow arrows).

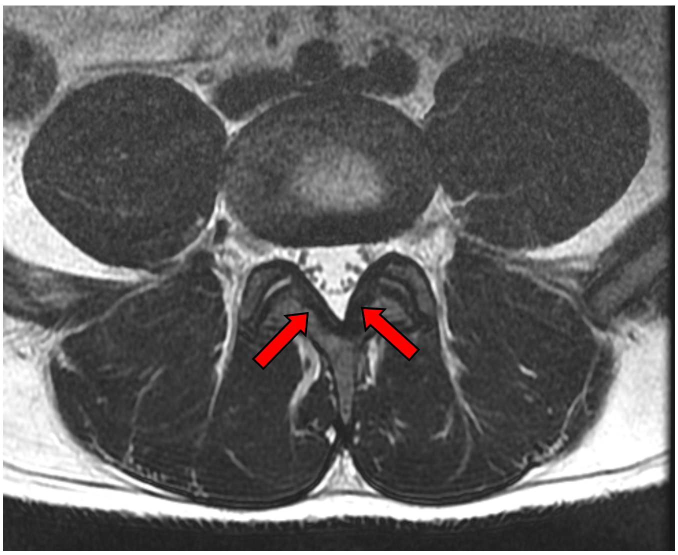


Figure 14:22. Ligamentum Flavum on T2 axial.

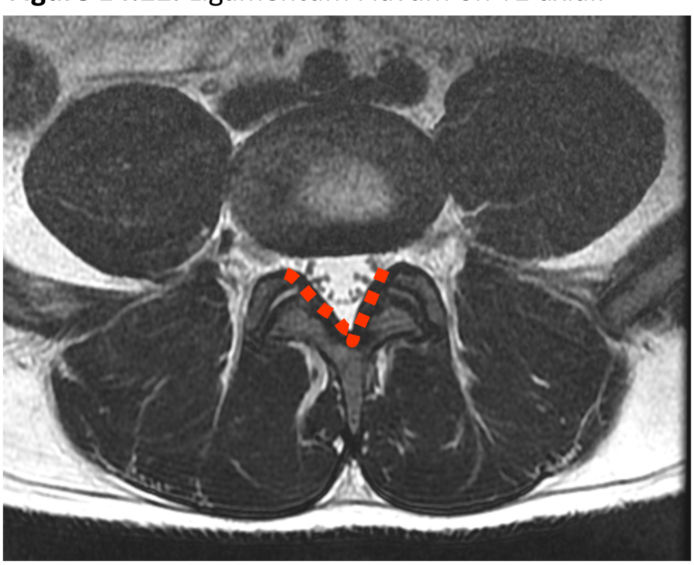


Figure 14:23. Ligamentum flavum on T2 weight axial image.

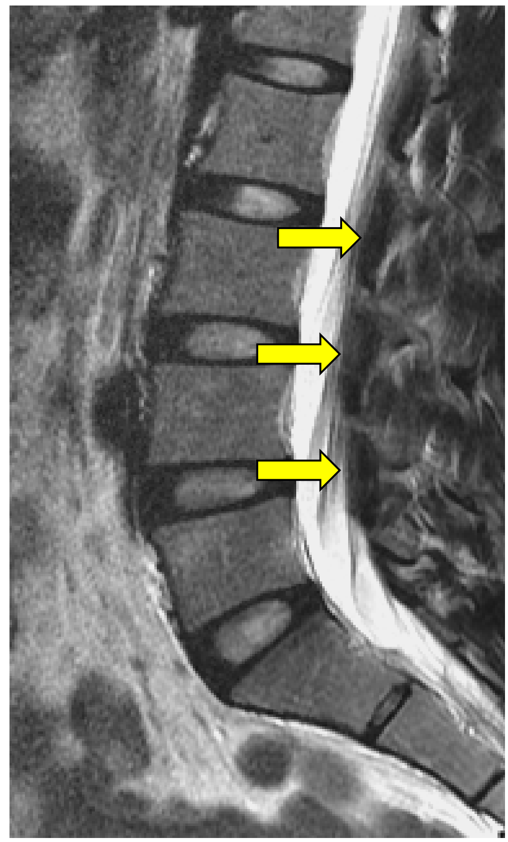


Figure 14:24. Ligamentum flavum on T2 sagittal image.

Sagittal Lumbopelvis

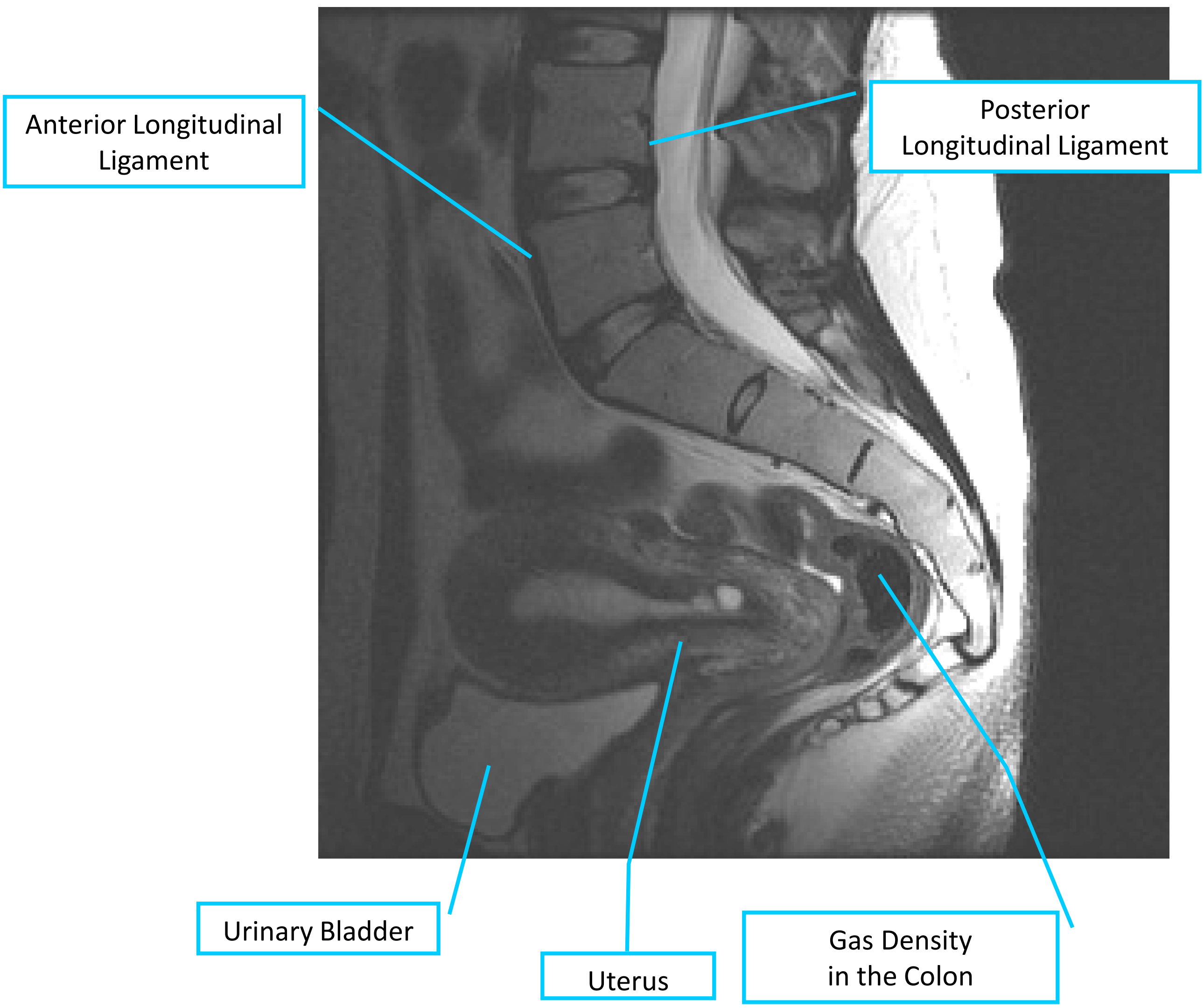
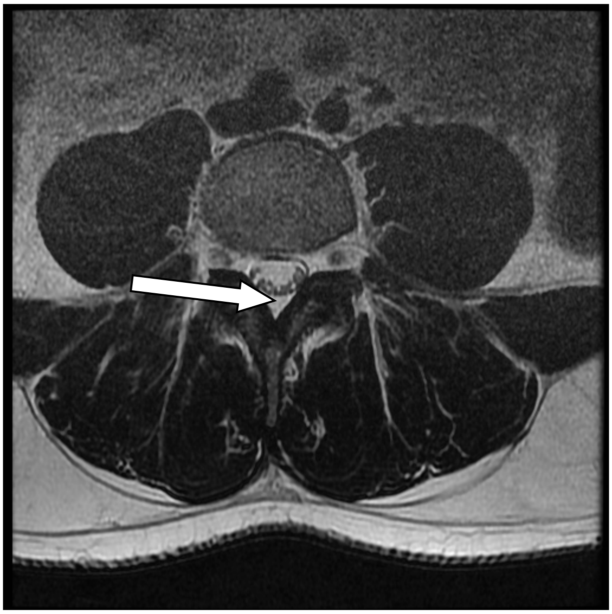
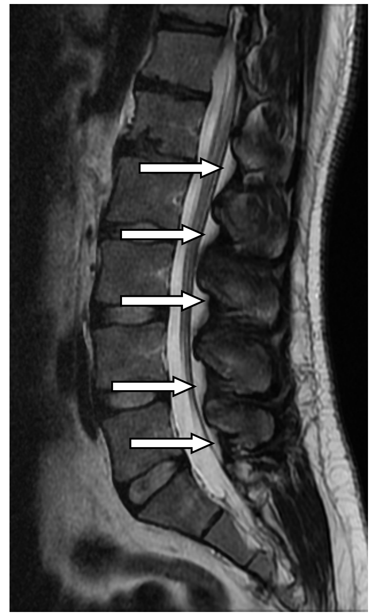


Figure 14:25. Lumbopelvic anatomy.

Normal Spinal Fat Distribution





Figures 14:26 and 14:27. Normal fat distribution within the spine. Epidural fat is located in the posterior recess of the spinal canal. The white arrows identify normal epidural fat which appears light in these T2WI.

The exiting nerve roots are surrounded by fat (fat is light on both T1 and T2 weighted images) as it traverses the IVF.

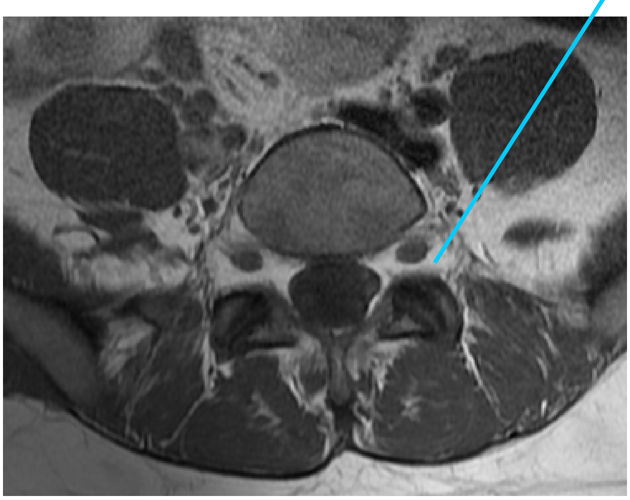


Figure 14:28. T1 weighted axial image

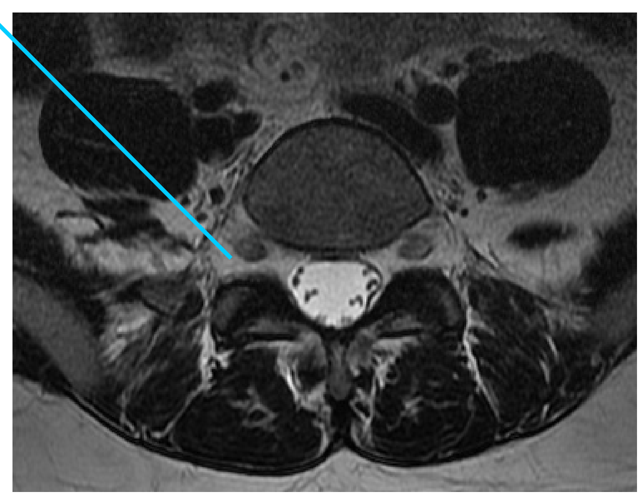


Figure 14:29. T2 weighted axial image

The nerves are surrounded by fat as they traverse the IVF. Note the water density of the CSF is bright on the T2 and dark in the T1 images. Absence or displacement of the fatty tissue may be clinically significant.

Anatomy from a Coronal Orientation-1

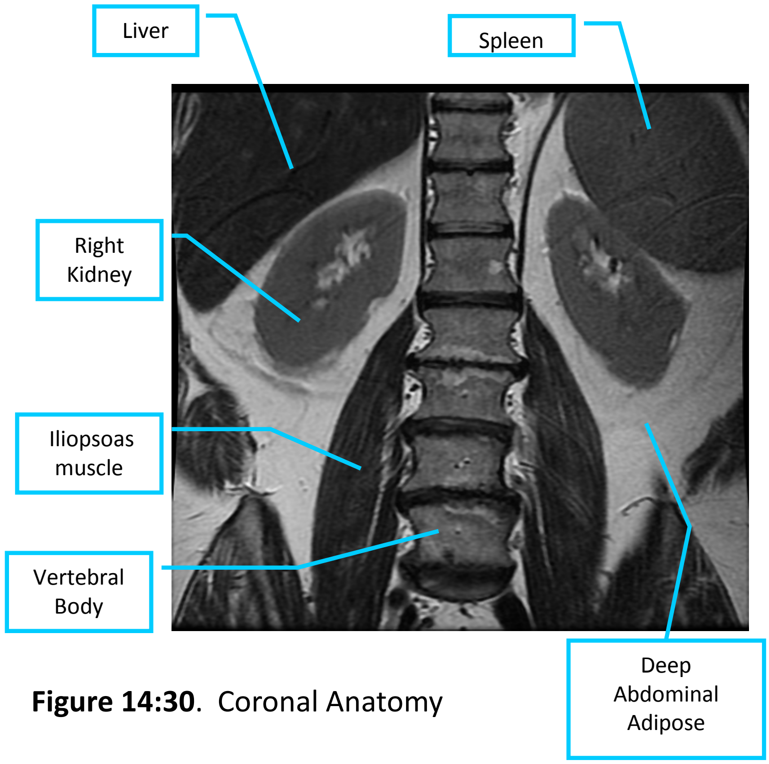
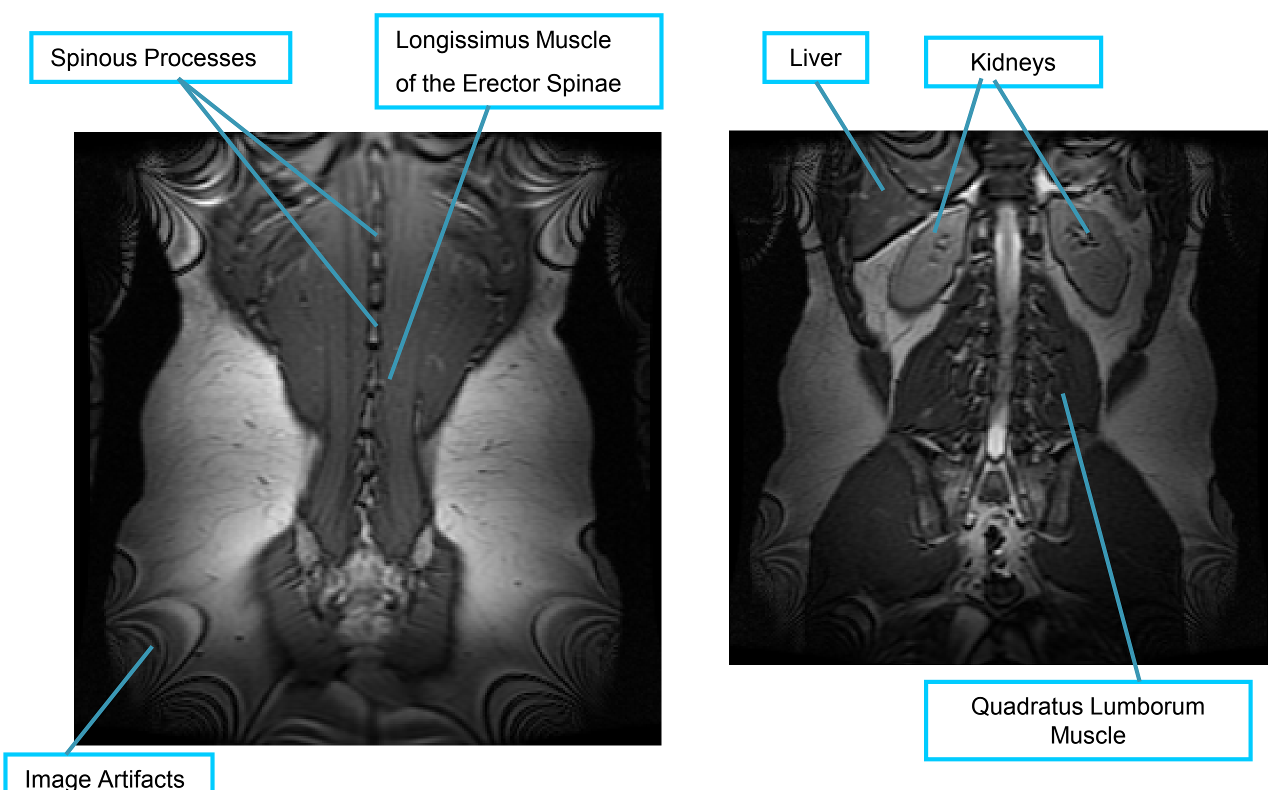


Figure 14:30. Coronal Anatomy



Figures 14:31 and 14:32. Anatomy of coronal images.

The Lumbar Disc on MRI

15

Nomenclature and Classification of Lumbar Disc Lesions

Speaking the same language is foundational for optimized integrated spine care. Physicians need to have a reliable set of terms and criteria that transcend the various specialty jargon. Guided by the need to establish a standardized and universally acceptable classification system for identifying lumbar disc pathology, an interdisciplinary task force created a collective set of guidelines. Again we reference the guidelines that were presented in 2001 through the combined efforts of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology[1]. All spine practitioners are encouraged to read the original work of this task force located in volume 26, Number 5, Spine 2001.

Normal

The normal disc is defined as a young, hydrated disc that does not shown signs of degeneration, loss of disc height, dehydration, bony edema, or degenerative changes.

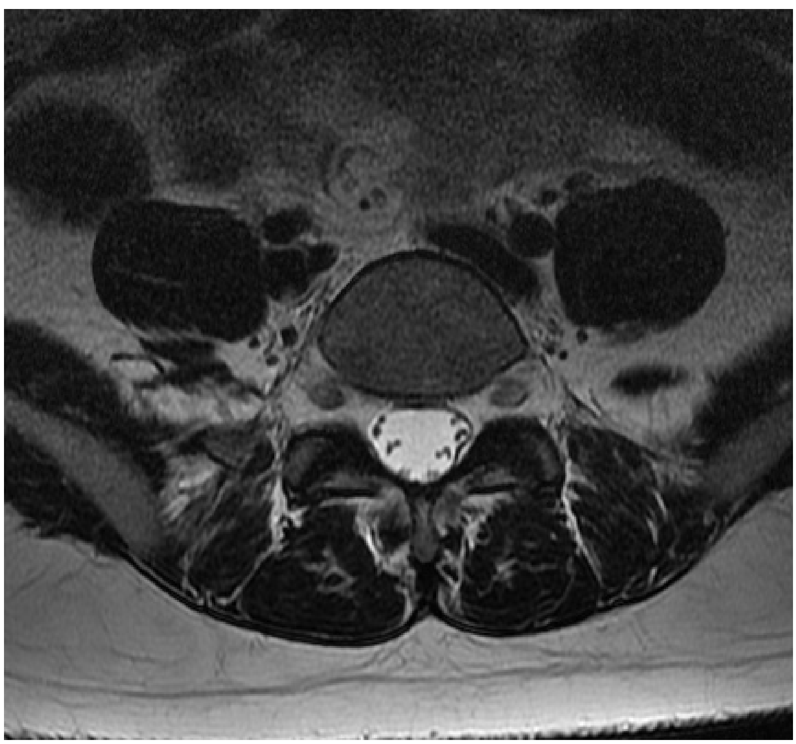


Figure 15:1. A normal axial image.

[1] Fardon DF, Milette PC. Nomenclature and classification of lumbar disc pathology: recommendations of the combined task forces of the north American spine society, American society of spine radiology, and American society of neuroradiology. Spine, Volume 26(5).March 1, 2001.E93-E113

Classification of Lumbar Disc Derangements

Differentiating between an *Intra*vertebral and *Inter*vertebral Disc Herniation

The *inter*vertebral space is the region between two adjacent vertebral bodies. This space is typically occupied by the intervertebral disc. The peripheral boundaries of the intervertebral space is marked by the border of the vertebral body. An intervertebral herniation occurs when disc tissue migrates outside of the intervertebral boundaries.

*Intra*vertebral herniations occur when the disc migrates into the vertebral body. This usually occurs with axial compression from trauma, excessive load bearing, or a reduction in the bony integrity of the endplate and underlying cancellous bone. Longstanding intravertebral herniations are usually considered a coincidental finding.

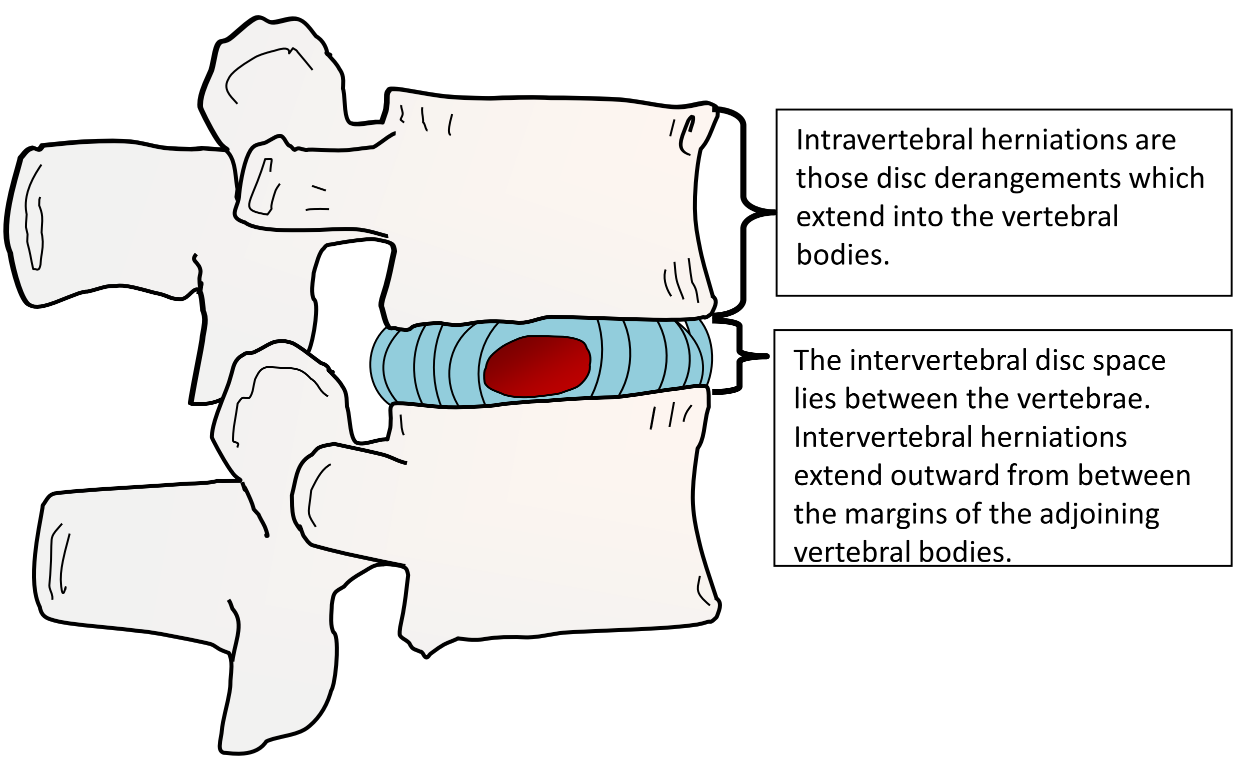


Figure 15:2. Intervertebral lumbar segments

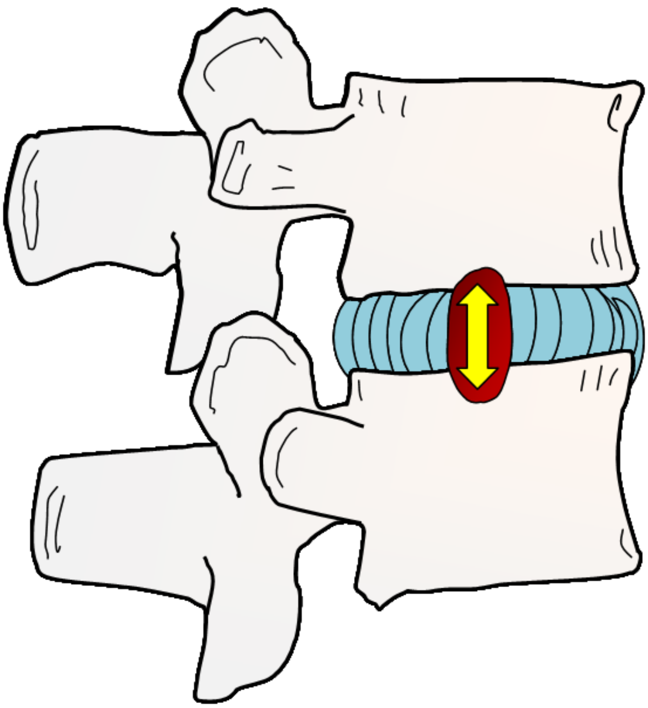


Figure 15:3. Intravertebral herniations occur when the disc breaks through the vertebral endplate of an adjoining vertebra. This schematic shows both an inferior and superior intravertebral herniation. These are commonly called Schmorl's nodes.

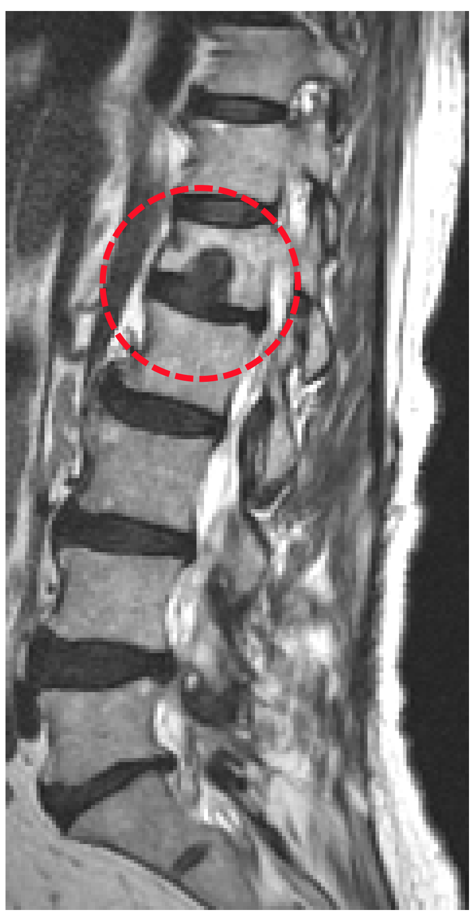


Figure 15:4. This sagittal T2 weighted image reveals a large intravertebral herniation through the inferior endplate of L1.

Axial Images

Axial schematics will be used for much of the remainder of this chapter to illustrate the characteristics of intervertebral herniations. The schematics will be based on an oval shape of the disc. This is not how the disc typically appears, but it aids understanding the concept of classifying disc derangements.

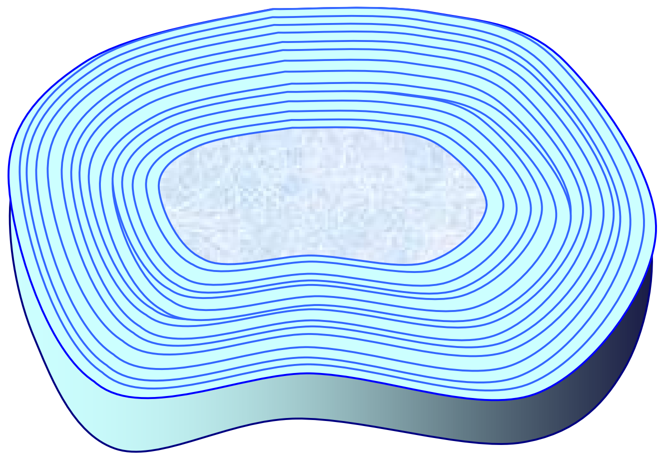


Figure 15:5. Intervertebral discs are not uniform in shape or symmetry.

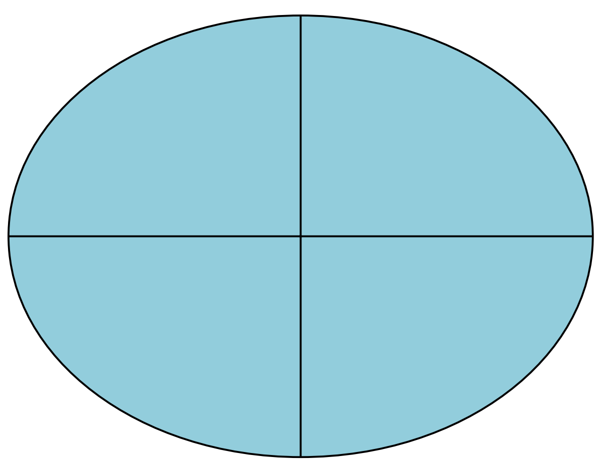


Figure 15:6. For the sake of clarity we will treat the intervertebral disc as a symmetrical oval as we describe the nomenclature of classifying disc derangements.

Classification Parameters of Intervertebral Disc Derangements

To simplify the classification of disc derangements the disc is reduced to a two dimensional oval model that is divided into four quadrants. Each 90° quadrant represents 25% of the total circumference of the disc. Using axial MRI imagery and this simple guideline allows the delineation between broad-based and focal herniations, between symmetrical and asymmetrical disc bulges, and between extrusions and protrusions of the disc.

Normal Disc

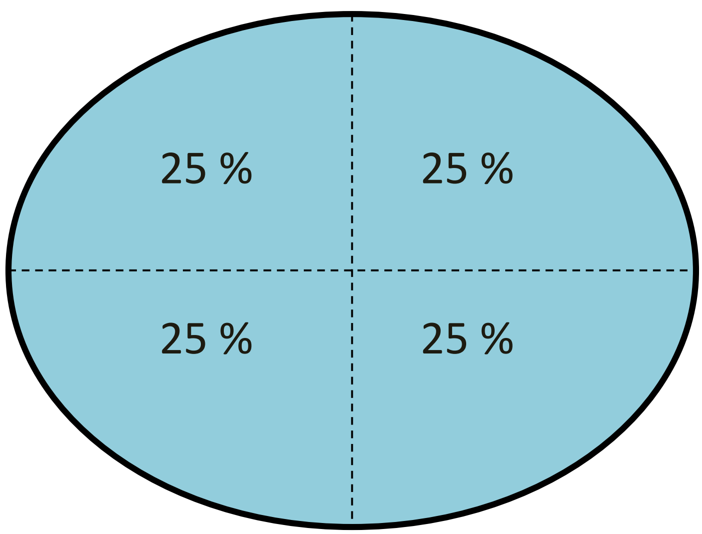


Figure 15:7. The normal disc.

Symmetrical Disc Bulge

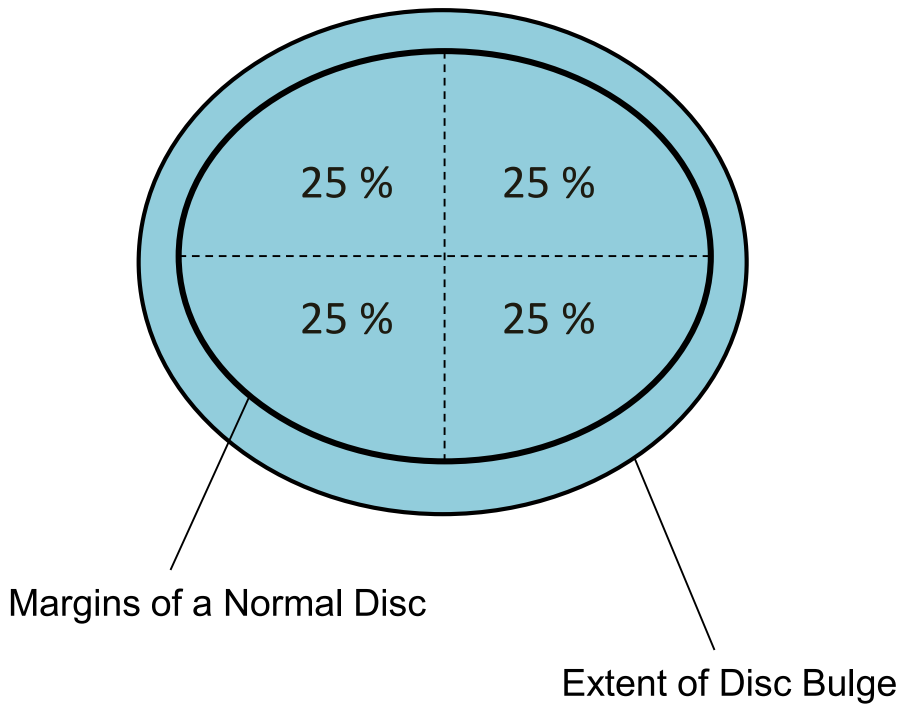


Figure 15:8. Symmetrical disc bulge.

Disc bulges are categorized as disc migration (beyond the border of the vertebral apophyses) of more than 50% (180°) of the disc circumference. Symmetrical disc bulges have a symmetrical appearance of bulging between 50 and 100 percent of the circumference of the disc. The above schematic depicts a symmetrical disc bulge. Disc bulges are not considered a herniation. Herniations, by contrast, are disc derangements which involve less than 50% of the circumference of the disc.

Symmetrical Disc Bulge

This axial T2 image reveals a nearly uniform disc bulge extending out in all directions. It involves 100% of the circumference of the disc. In the lower image the dotted line signifies the boundary of the vertebra, and the solid line reveals the extent of disc migration. This is a good example of a symmetrical disc bulge.

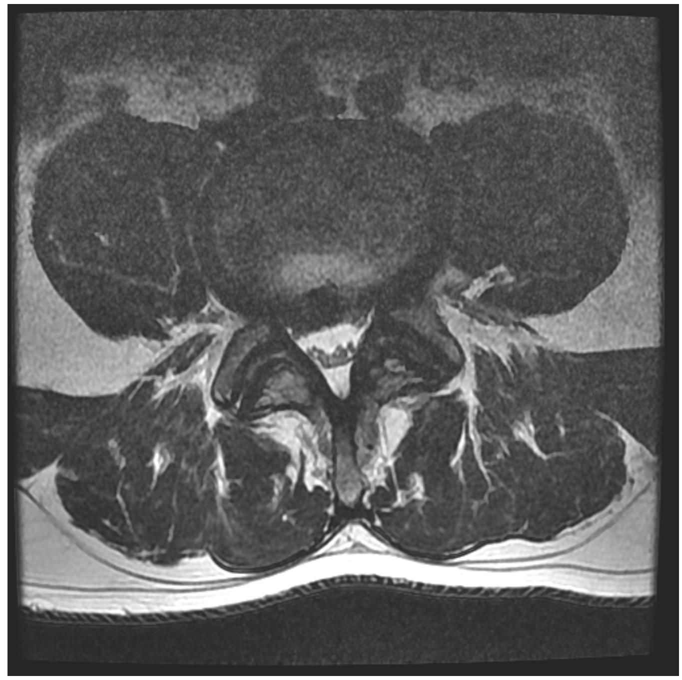


Figure 15:9. Symmetrical disc bulge on T2W axial image.

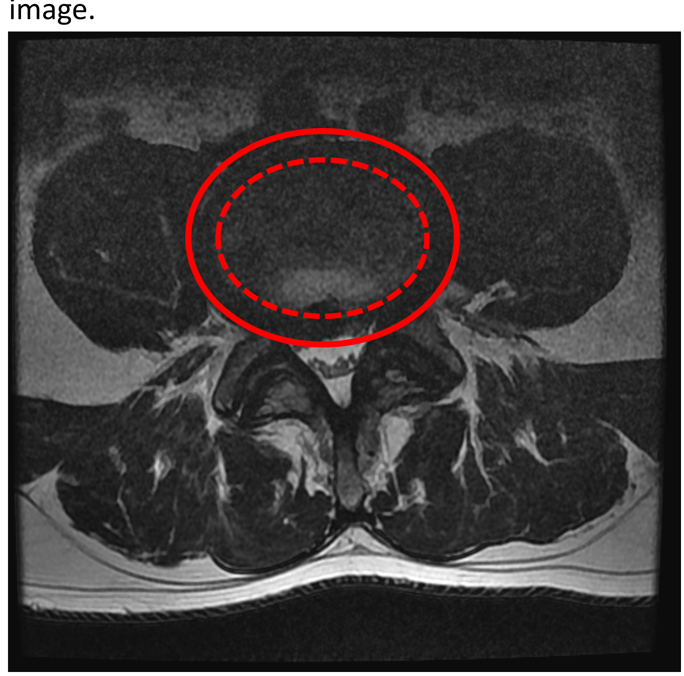


Figure 15:10. Symmetrical disc bulge. This is the same MRI slice as in figure 5:9, but the boundaries of the vertebral bodies are demarcated by a dotted red line, and the extent of the disc bulge is represented by a solid red line.

Asymmetrical Disc Bulge

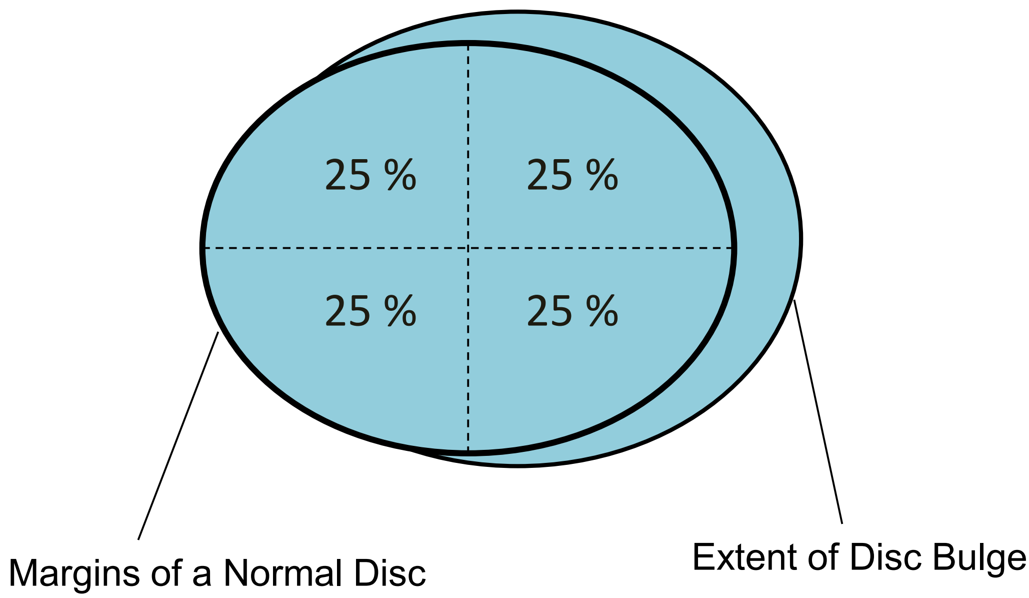


Figure 15:11.. Asymmetrical disc bulge.

Asymmetrical disc bulges are categorized as disc derangements that are asymmetric, but involve outward migration of disc material along at least 50% of the disc's circumference. They have an asymmetrical appearance of bulging greater than 50% of the disc circumference. This schematic depicts an asymmetrical disc bulge.

Asymmetrical Disc Bulge

These images are of the same axial T2 slice and reveal an asymmetrical disc bulge. It is categorized as a bulge rather than a herniation because it occupies more than 50% of the circumference of the disc. In the bottom image the white arrows indicate the border of the vertebra, and the yellow arrows point to the margins of the asymmetrical disc bulge.

Figure 15:12. Asymmetrical disc bulge on T2W axial imagery.

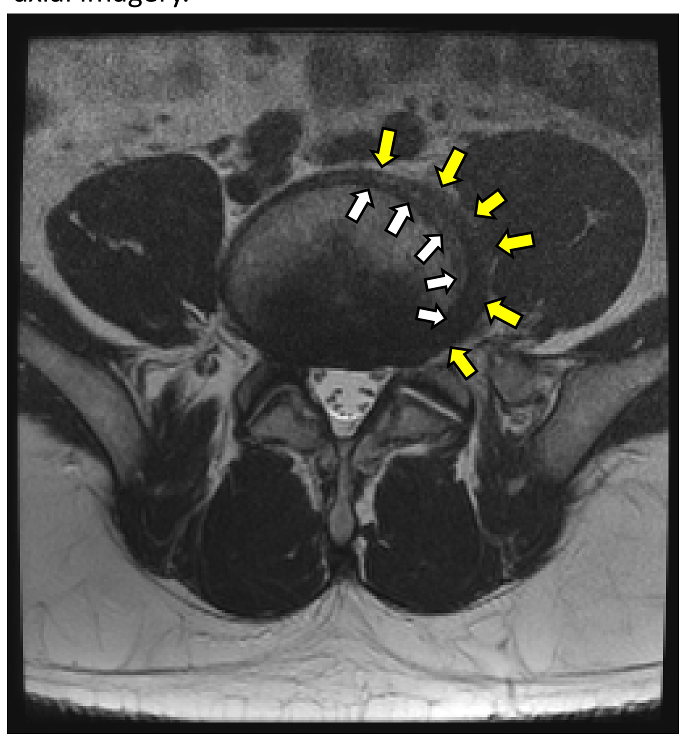


Figure 15:13. Enhancement of the image above. The white arrows point to the boundary of the vertebra, and the yellow arrows indicate the boundary of the disc bulge.

Disc Herniation

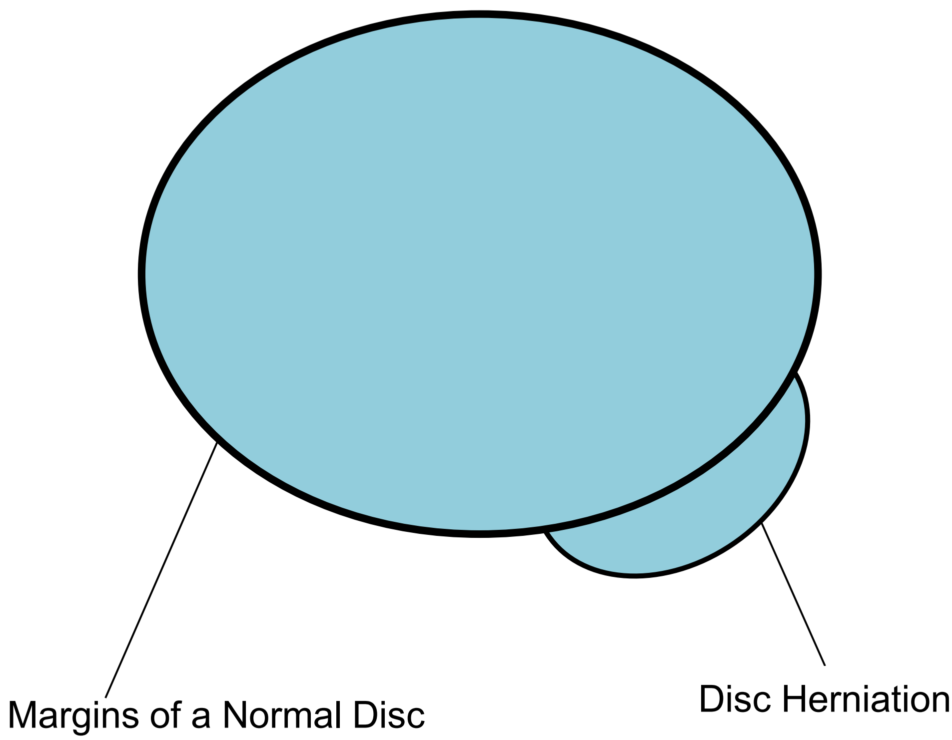


Figure 15:14. Schematic of a disc herniation.

Disc herniations are migrations of disc tissue more localized in appearance and occupying less than 50% of the disc's circumference. There are several subcategories of disc herniation.

Disc Herniation

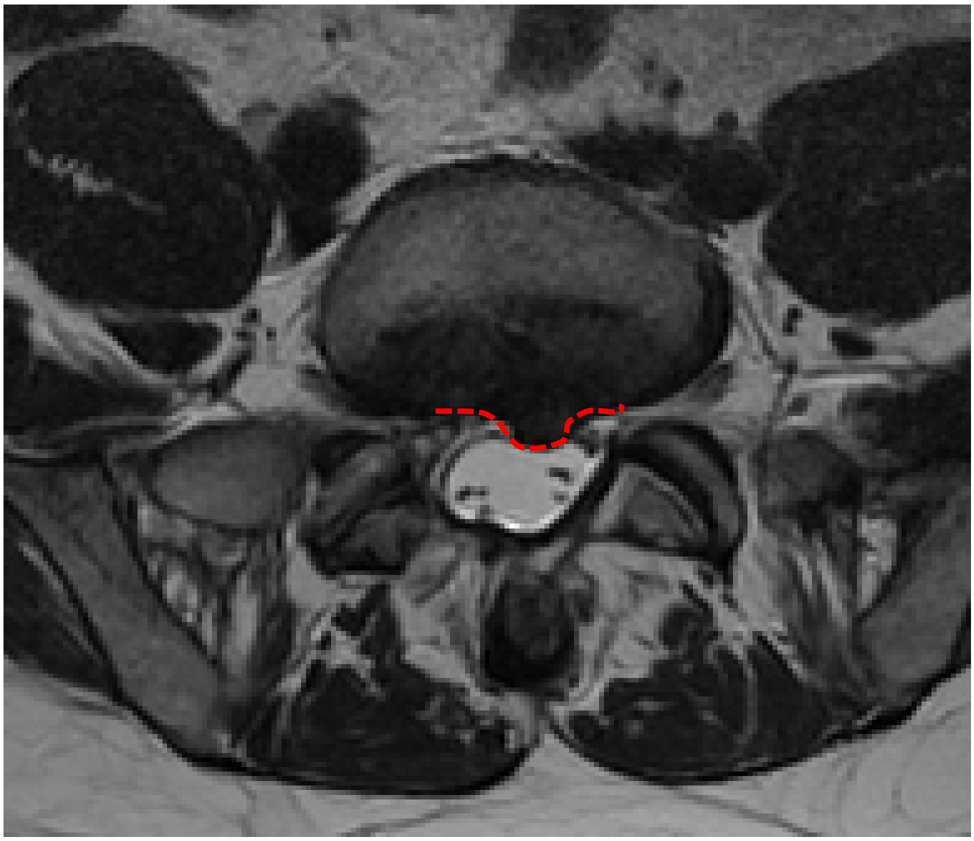


Figure 15:15. This herniation affects less than 50% of the disc circumference, so it would be labeled a herniation rather than a bulge.

Differentiating between a Focal and a Broad-Based Disc Herniation

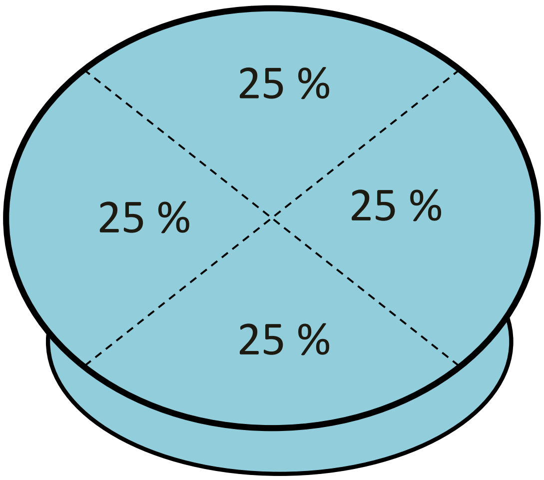


Figure 15:16. A broad-based herniation occupies 25-50% of the disc circumference.

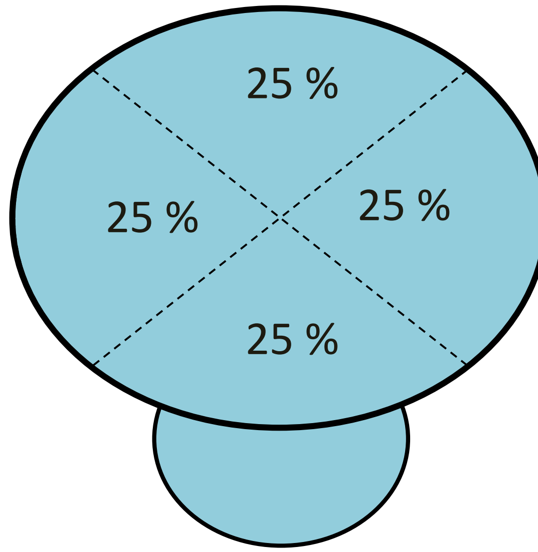


Figure 15:17. A focal disc herniation occupies less than 25% of the disc circumference. Recall that a disc bulge occupies more than 50% of the circumference of a disc.

Broad-based Disc Herniation

This broad disc herniation involves more than 25%, but less than 50% of the circumference of the disc. Therefore it is designated as a broad-based disc herniation.

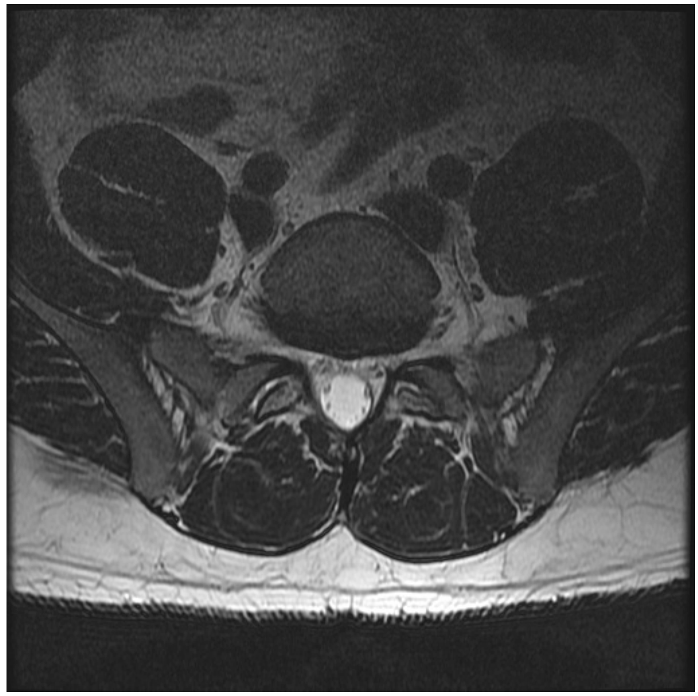


Figure 15:18. A broad-based herniation on a T2W axial image.

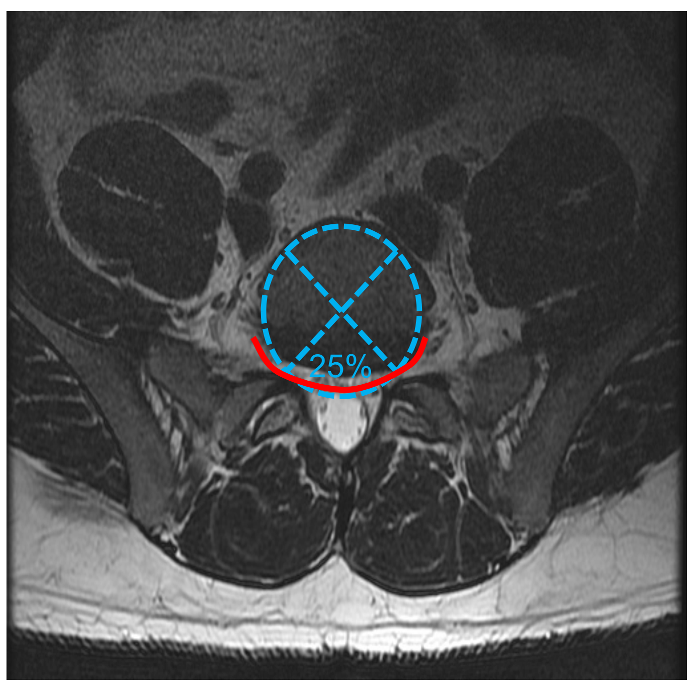


Figure 15:19. A broad-based herniation on a T2W axial image. A broad-based herniation occupies 25-50% of the disc circumference.

This disc herniation clearly involves less than 25% of the circumference of the disc. It is designated as a focal disc herniation.

Figure 15:20. A focal herniation on a T2W axial image.

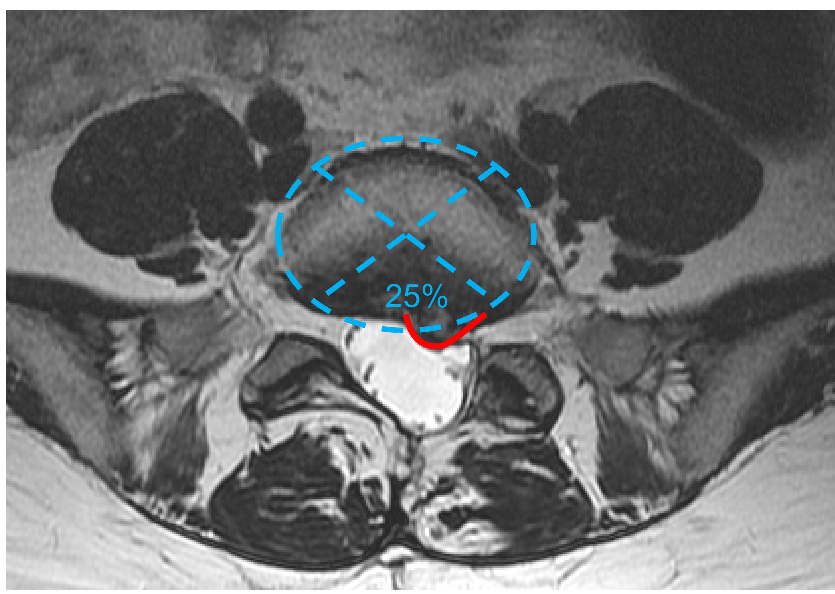
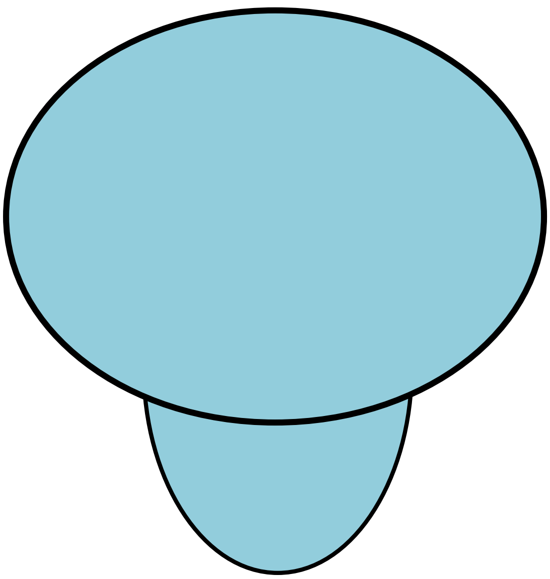


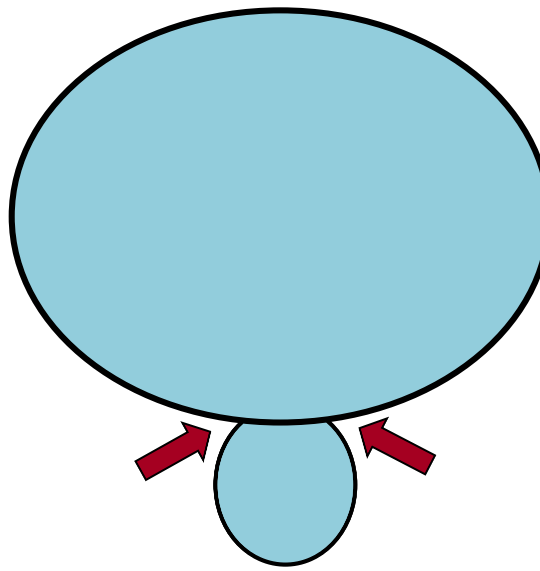
Figure 15:21. A focal herniation occupies less than 25% of the circumference of a disc.

Differentiating between a Protrusion and an Extrusion



Disc Protrusion

Figure 15:22. A disc protrusion has a base wider than the tip.



Disc Extrusion

Figure 15:23. A disc extrusion has a "waist" that is more narrow than the tip.

A disc protrusion is wider at the base than it is at the tip. In contrast, a disc extrusion mushrooms out, having a narrowed waist at the base as indicated by the arrows.

Disc Extrusion

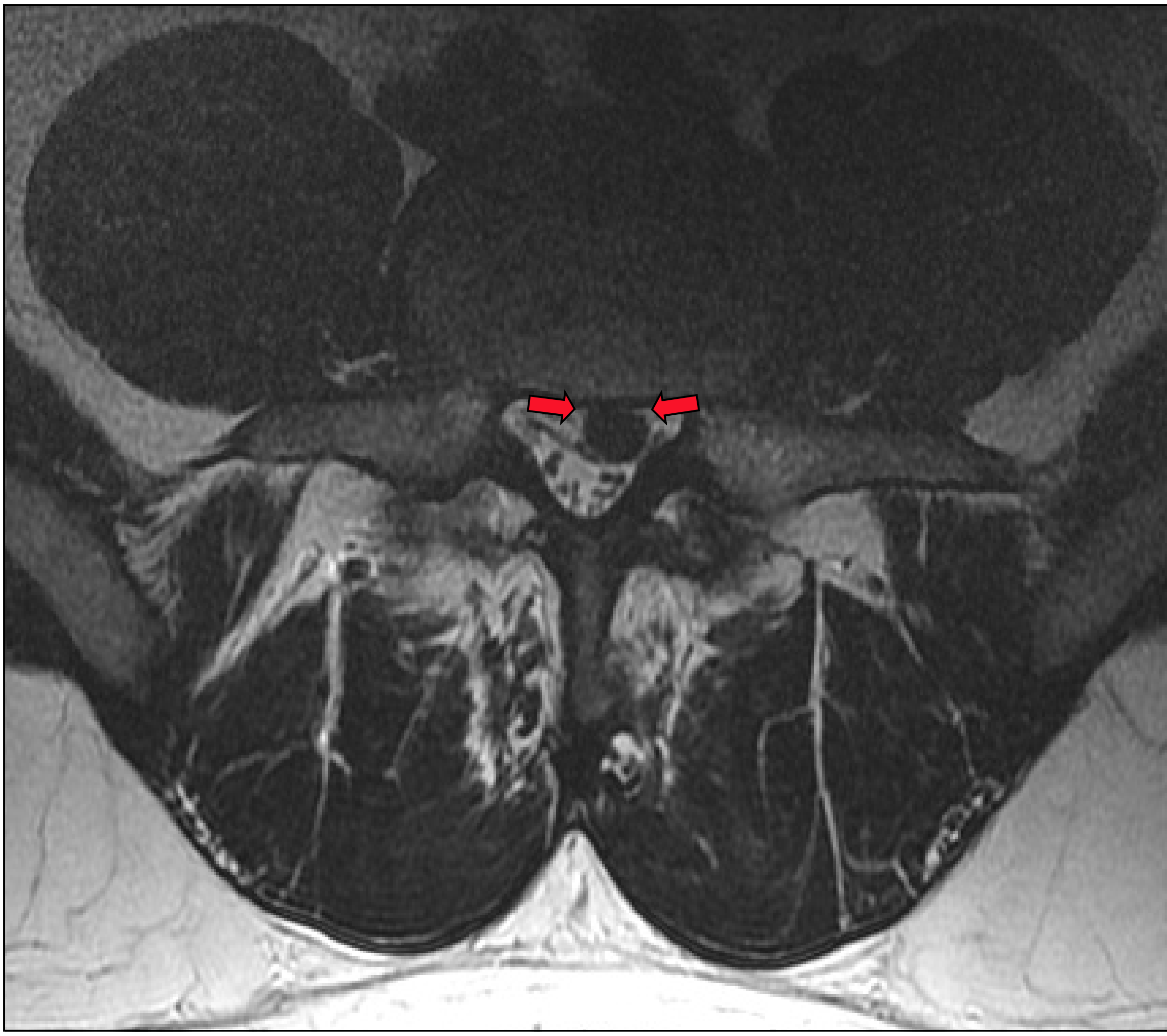


Figure 15:24. Disc extrusion with a narrowed waist (red arrows).

An extrusion is demonstrated on axial imagery by either the narrowed waist that joins the herniated portion of the disc with the rest of the disc or by the absence of a clear bridge between the herniated portion and the main body of the disc. The red arrows indicate the space between the vertebral body and the extruded disc.

Disc Extrusion

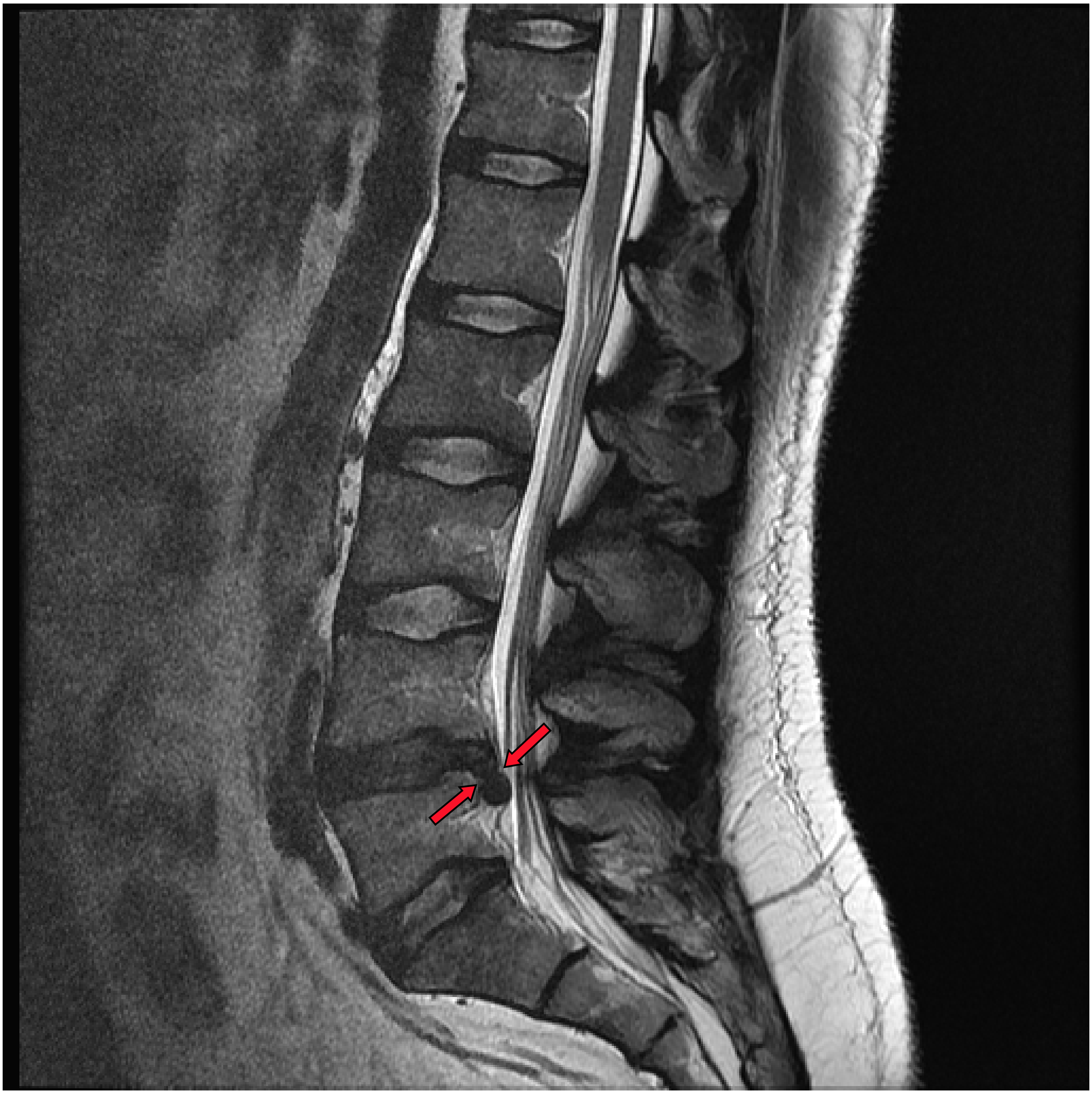


Figure 15:25. This T2 weighted sagittal image shows the characteristic waist of an extrusion.

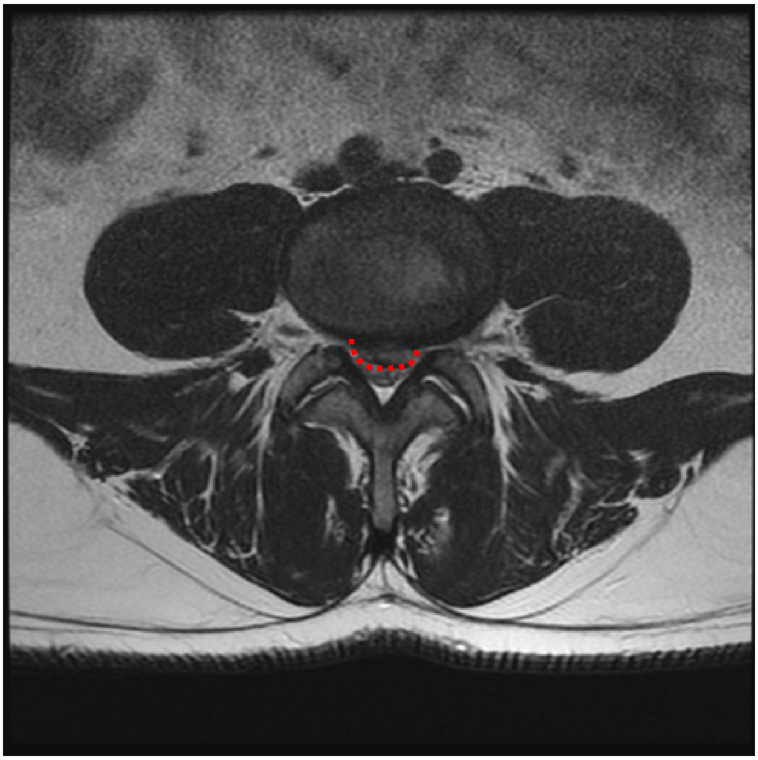


Figure 15:26. Axial image of a herniation with its base wider than its tip.

These T2W images depict protrusions. Note the base of these herniations are wider than the tips, and there is no narrowed waist.

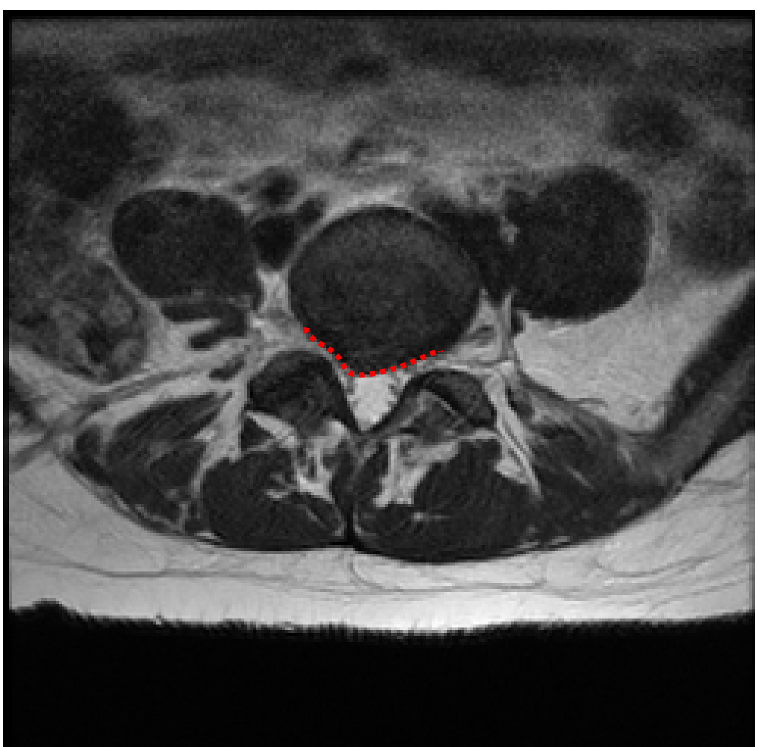


Figure 15:27. Axial image of a protruded disc.

Sagittal Views of Protrusions and Extrusions

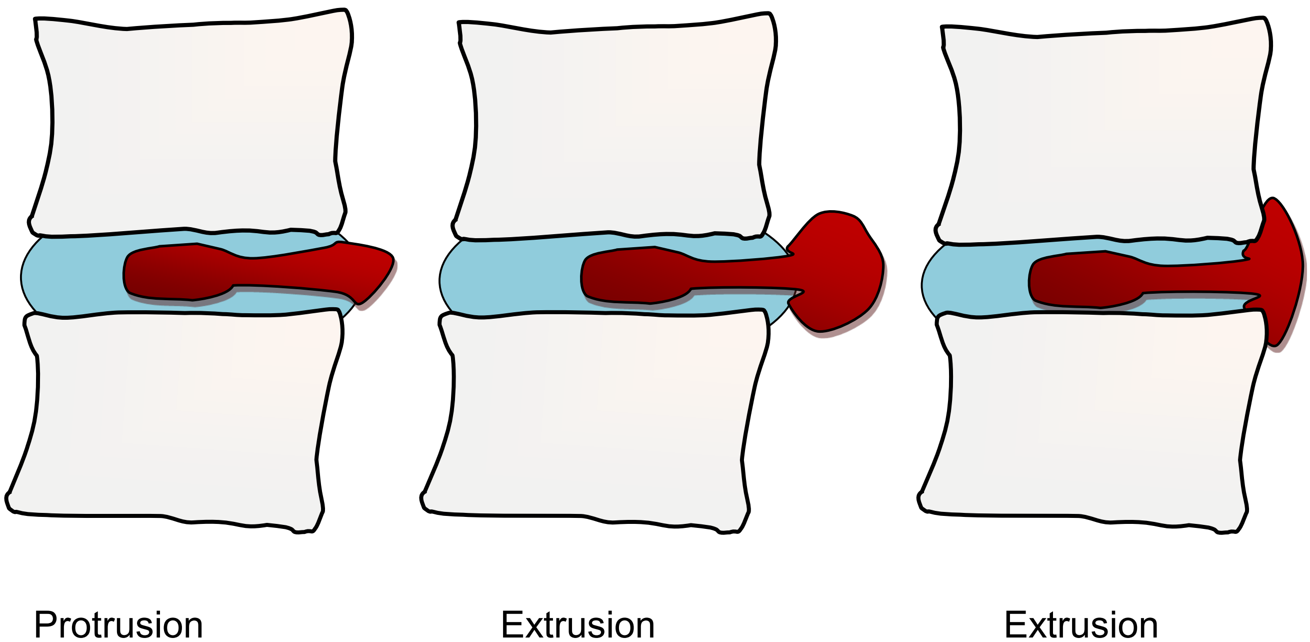


Figure 15:28. Schematics of protrusion and extrusion.

Disc extrusions can be diagnosed in either the axial or sagittal plane. A protrusion is a herniation that has a wide proximal base that narrows as it extends distally from the center of the disc. An extrusion has an expansive herniation that widens after it leaves the intervertebral space. Even if the herniation appears to have a wide base like a protrusion, it is considered an extrusion if it expands along the vertebral body to a width wider than the disc (see image on right). A protrusion does not exceed the cranio-caudal boundaries of the intervertebral disc.

Clarification of Extrusion versus Protrusion

To further clarify the difference between a protrusion and an extrusion, axial and sagittal images of the same disc herniation have been selected. On the axial image the disc herniation looks like a disc protrusion; the base of the herniation appears wider than the tip. However, when viewing the same herniation from the sagittal orientation, you can see there is a narrowed waist of the disc where it exits the intervertebral space, and the disc expands out, albeit a modest spreading of disc material. A disc extrusion is present when an expansion is visualized in either the axial or sagittal views or if a sequestered fragment is present.

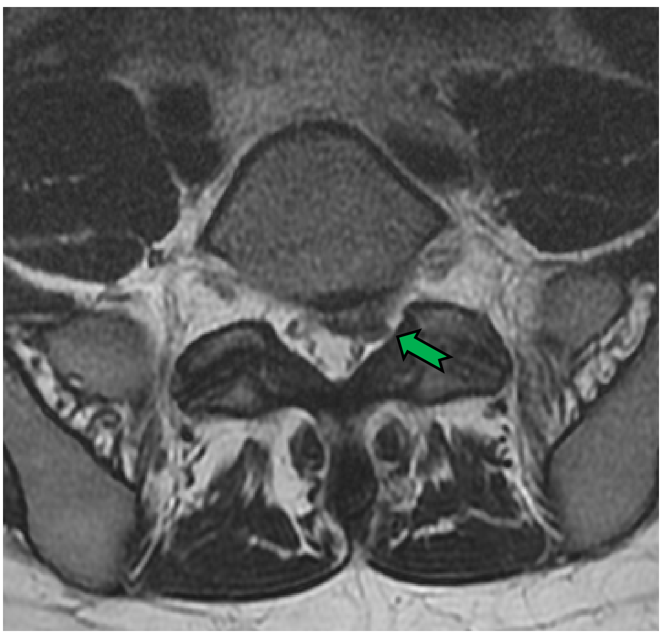


Figure 15:29. This axial image appears to be a protrusion (green arrow). Its base is wider than its tip.

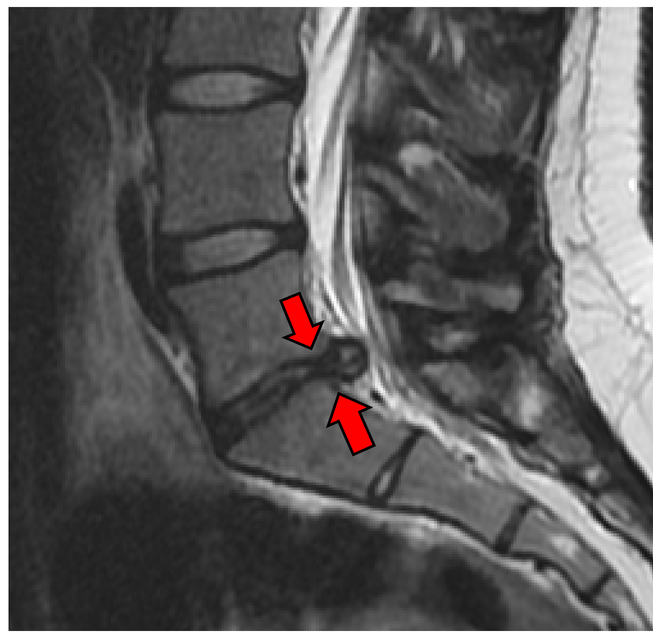


Figure 15:30. This sagittal image of the same herniation in figure 15:29 shows a narrowed waist (red arrows), making this an extrusion, regardless of its appearance on axial imagery.

Sequestered Fragment

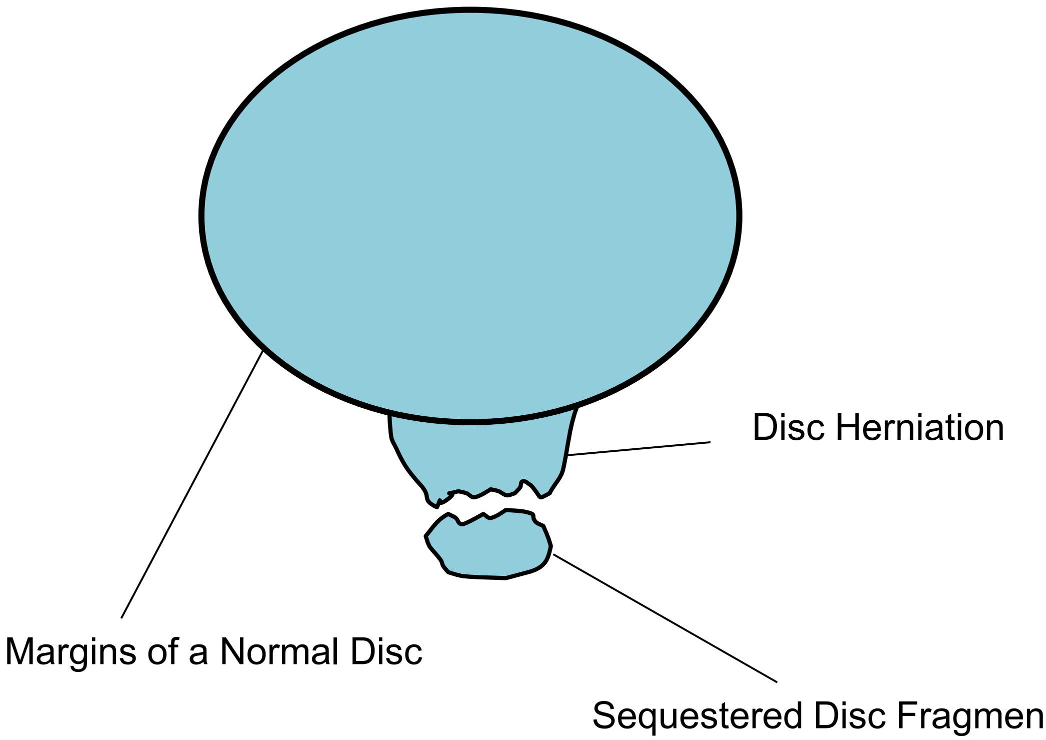


Figure 15:31. Sequestered disc fragments have broken off and are no longer contiguous with the rest of the disc.

Another category of disc extrusion is the sequestered fragment. A sequestered fragment is the designation given to a disc derangement in which a portion of the disc breaks free from the rest of the disc. Sequestered fragments can migrate from their mother discs. They are considered a category of disc extrusions. Sometimes these are referred to as "free fragments."

Sequestered Fragment

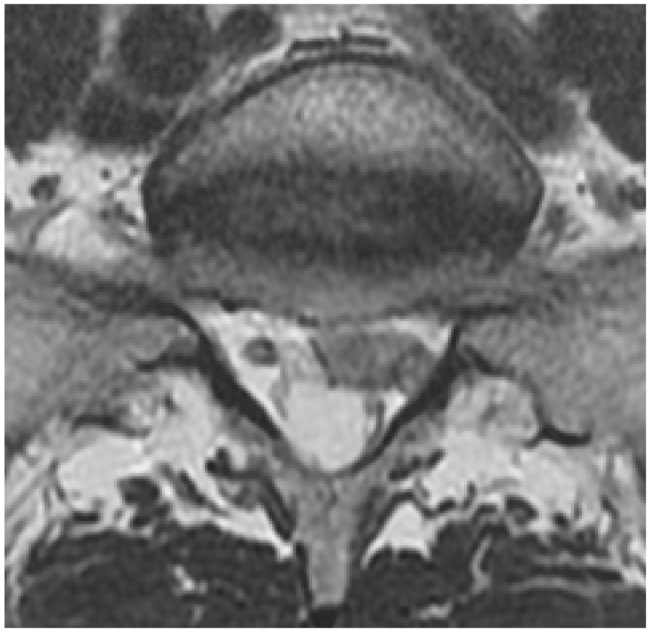


Figure 15:32. A large sequestered disc fragment in the central canal of L5 displacing and compressing the S1 nerve root.

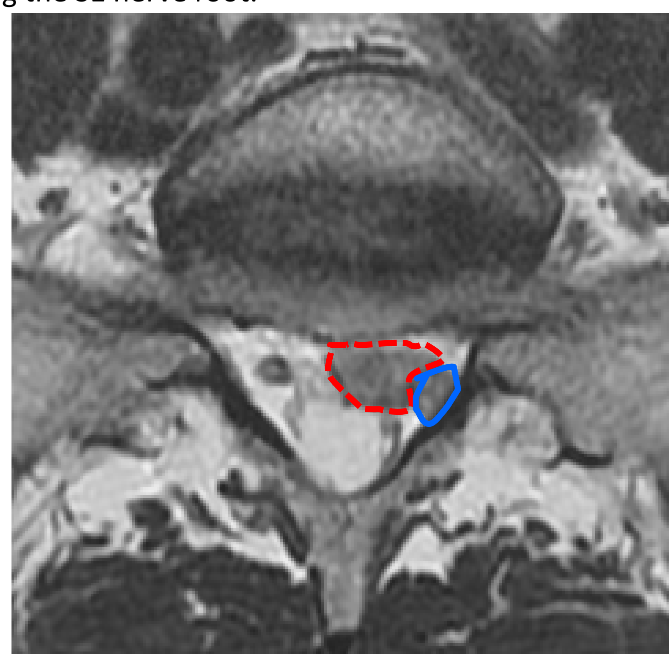
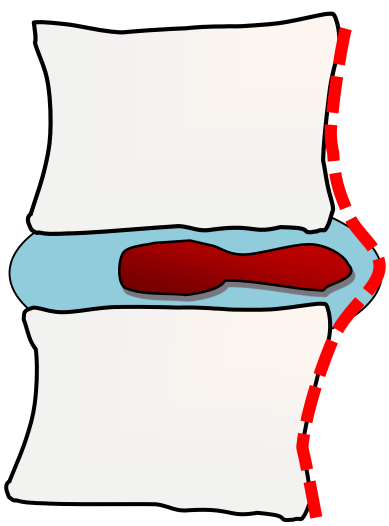


Figure 15:33. The axial image from figure 15:32 is enhanced here. The red dotted line outlines the sequestered disc fragment, and the blue line outlines the S1 nerve root.

This image contains a sequestered disc fragment that displaces and compresses the left S1 nerve root. The bottom version of this MR slice highlights the sequestered disc fragment with a red dotted line around it. The compressed nerve root is identified by a solid blue line. Note the degree of swelling of the displaced left nerve root in comparison to the right nerve root.

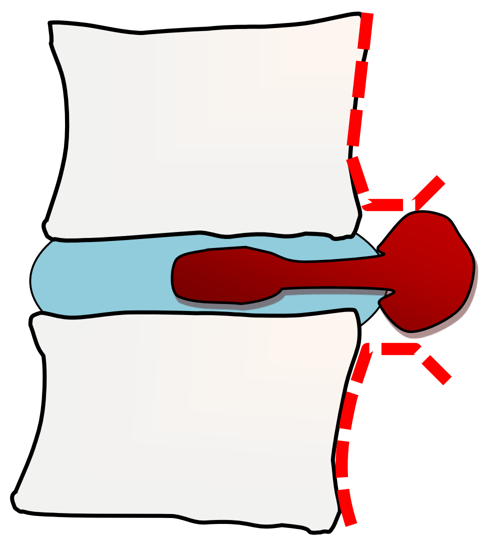
Contained versus Non-contained Herniations

Another identifier describing disc derangements is the relationship of the derangement to the outer annulus and the posterior longitudinal ligament (PLL). The PLL lies over the posterior vertebral bodies and the posterior portion of the disc. If the PLL and the outer annulus is intact and contains the disc derangement, it may be categorized as a sub-ligamentous or contained herniation. If the disc has violated the outer annulus, it is categorized as a non-contained herniation. If the disc derangement disrupts and passes through the posterior ligaments it has been called an extra-ligamentous herniation.



Sub-Ligamentous and Contained

Figure 15:34. A sub-ligamentous herniation does not violate the integrity of the ligaments, specifically the posterior longitudinal ligament (red dotted line). A contained disc derangement remains confined within the annular fibers.



Extra-ligamentous and Non-Contained

Figure 15:35. An extra-ligamentous herniation violates the integrity of the posterior longitudinal ligament. A non-contained disc derangement denotes disc material escaping the confines of the annular fibers.

http://www.asnr.org/spine_nomenclature/discussion.shtml

Normal Axial Slice

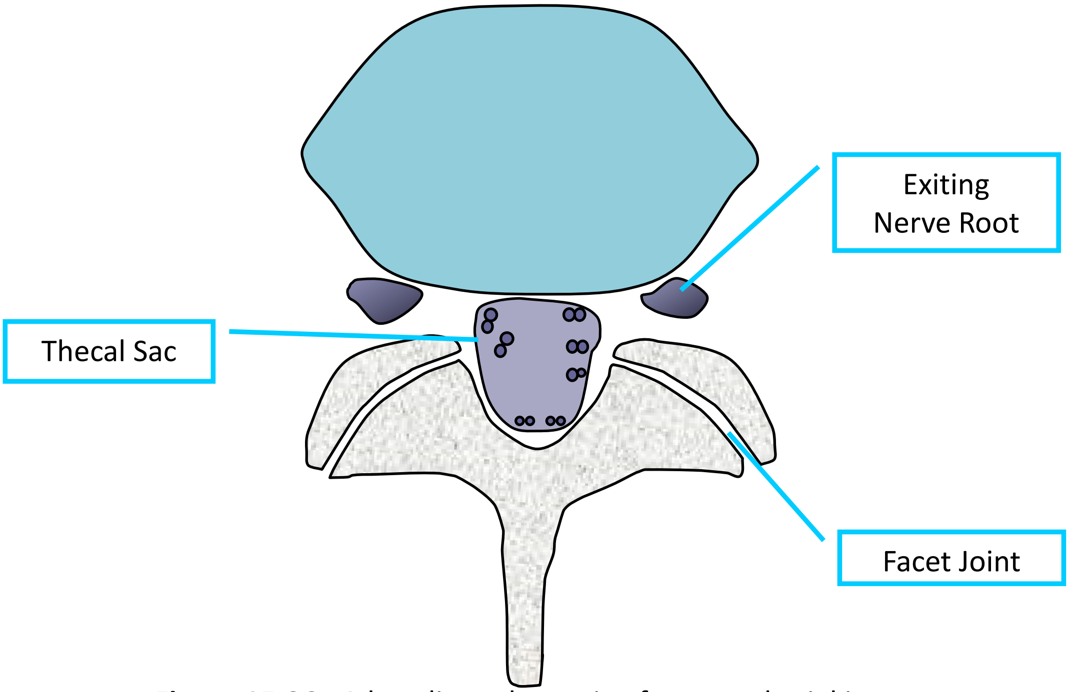


Figure 15:36. A baseline schematic of a normal axial image.

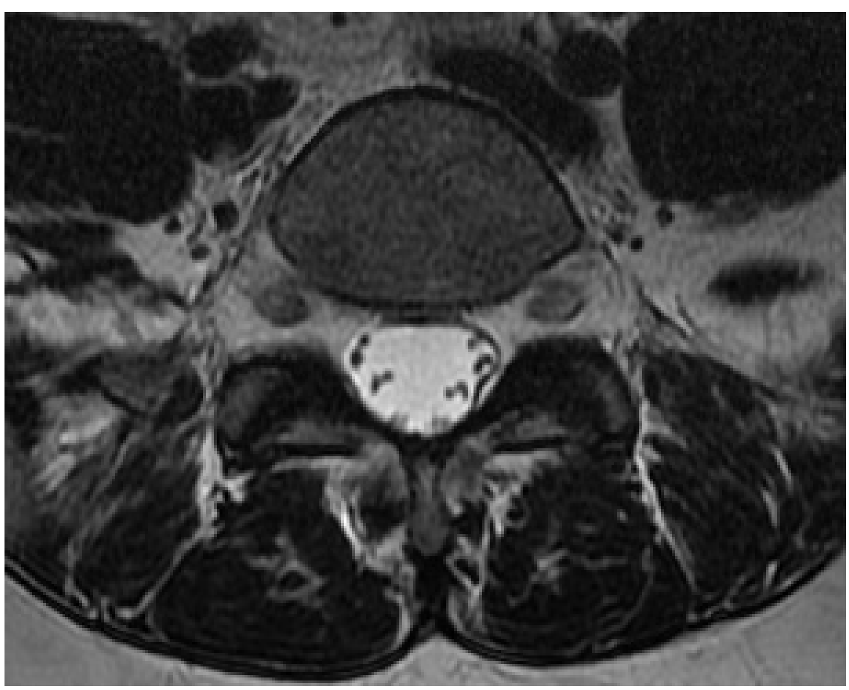


Figure 15:37. A baseline T2W axial image of a normal lumbar segment.

Central Disc Herniation

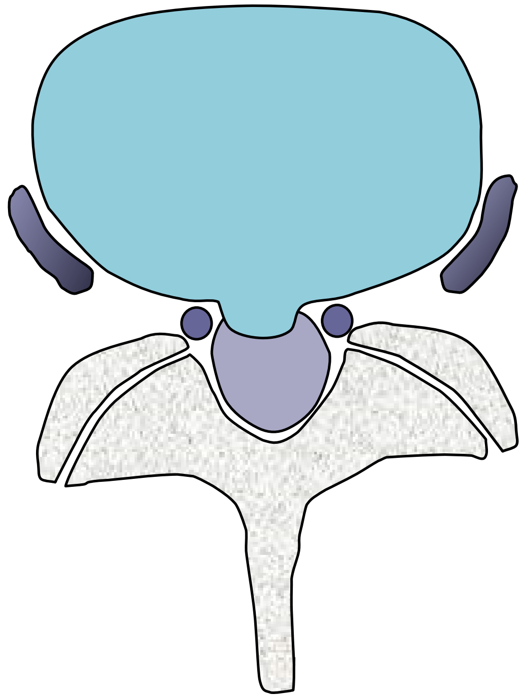


Figure 15:38. An axial schematic of a central disc herniation.

Figure 15:39. Axial image of a small focal central disc herniation.

Para-central Herniation Displacing a Nerve Root

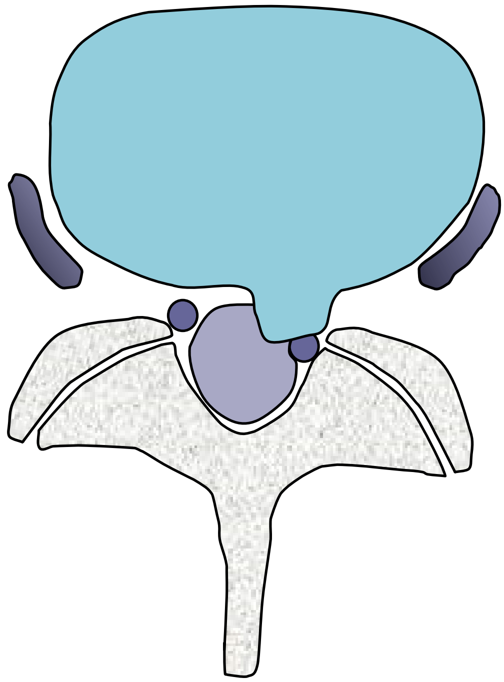


Figure 15:40. Axial schematic of a para-central herniation displacing an S1 nerve root.

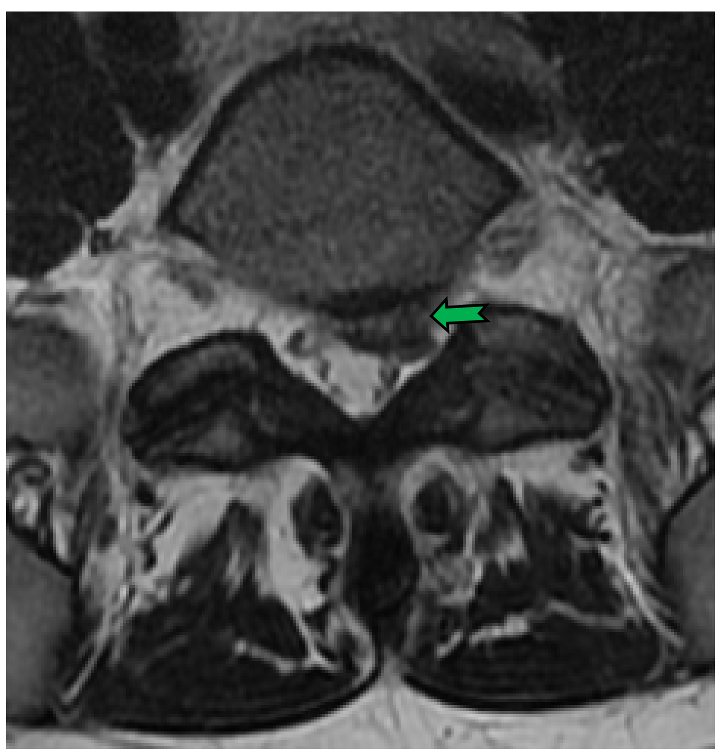


Figure 15:41. Axial image of a para-central disc herniation (green arrow) that contacts and displaces the left S1 nerve root.

Nerve Root Compression

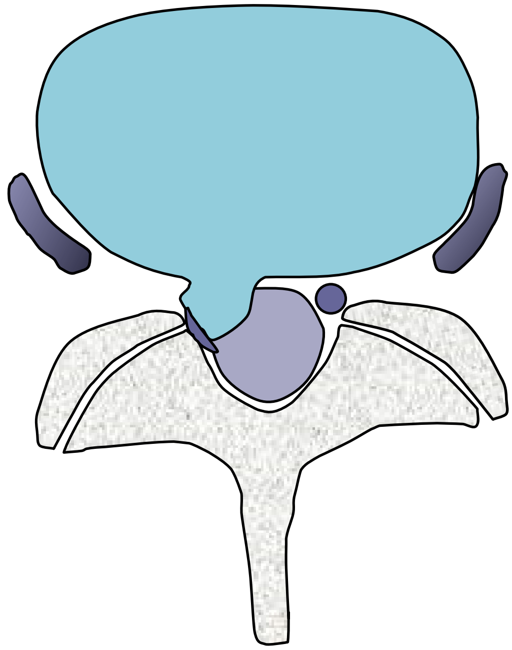


Figure 15:42. Schematic of a focal disc herniation compressing an S1 nerve root.

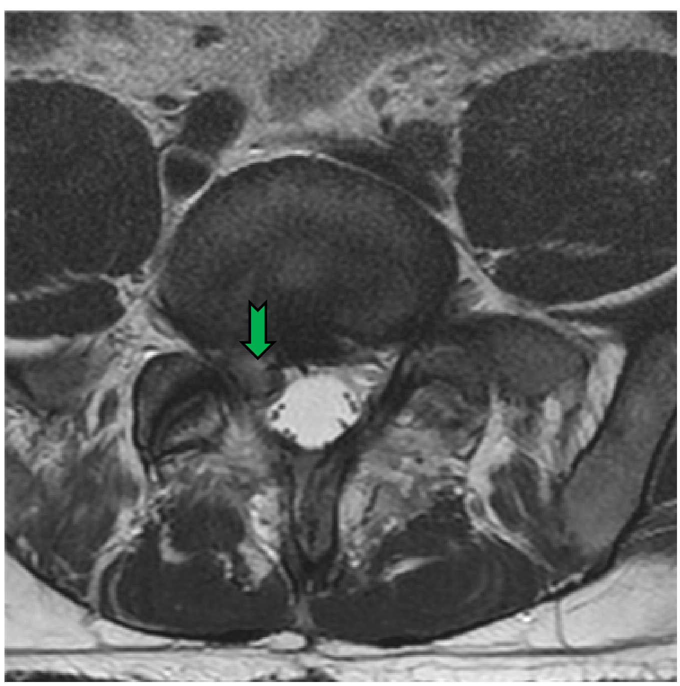


Figure 15:43. This axial MRI demonstrates a herniation (green arrow) that contacts and displaces the right S1 nerve root, compressing the nerve root against the bony posterior portion of the spinal canal.

Anterior Disc Herniation

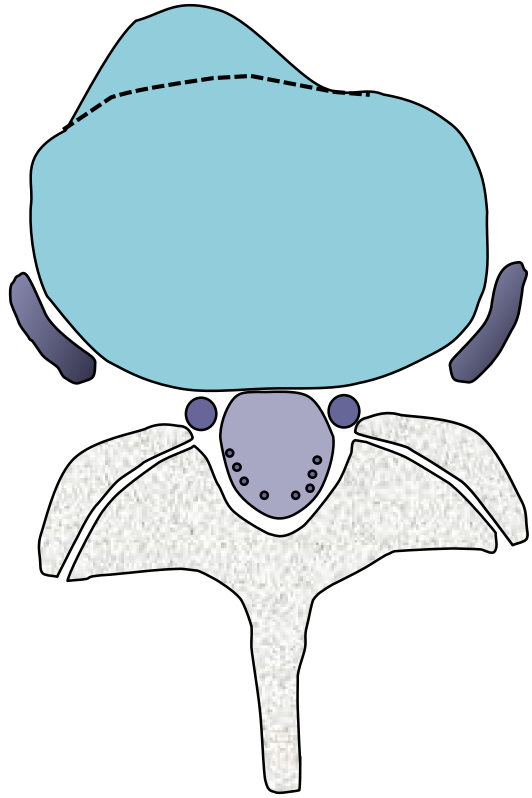


Figure 15:44. Schematic of an anterior disc herniation.

Figure 15:45. Sagittal image of a large anterior herniation (red arrow).

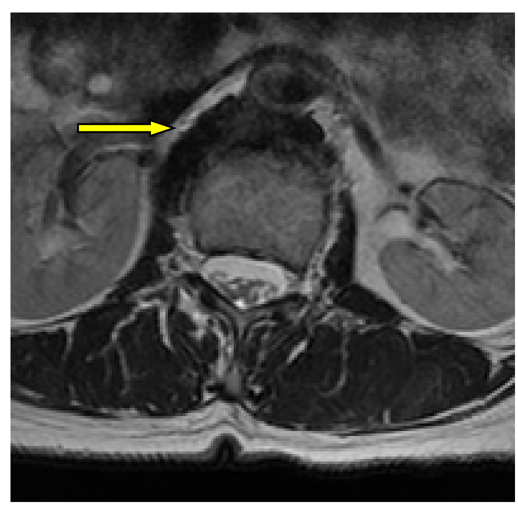


Figure 15:46. Axial image of a large anterior herniation (yellow arrow). This is the same herniation seen in image 15:45.

Anterior disc herniations do not compromise the spinal cord, the thecal sac, or the nerve roots, but may be a source of pain and indicative of biomechanical failure.

Foraminal Disc Herniation

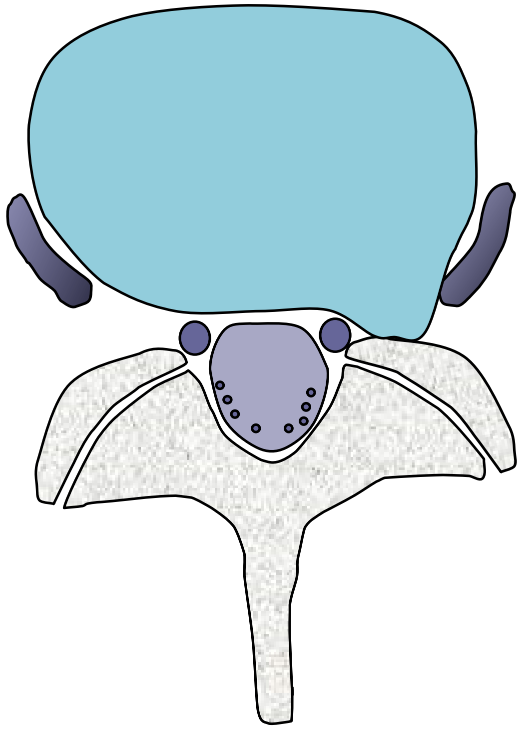


Figure 15:47. Schematic of a foraminal herniation.

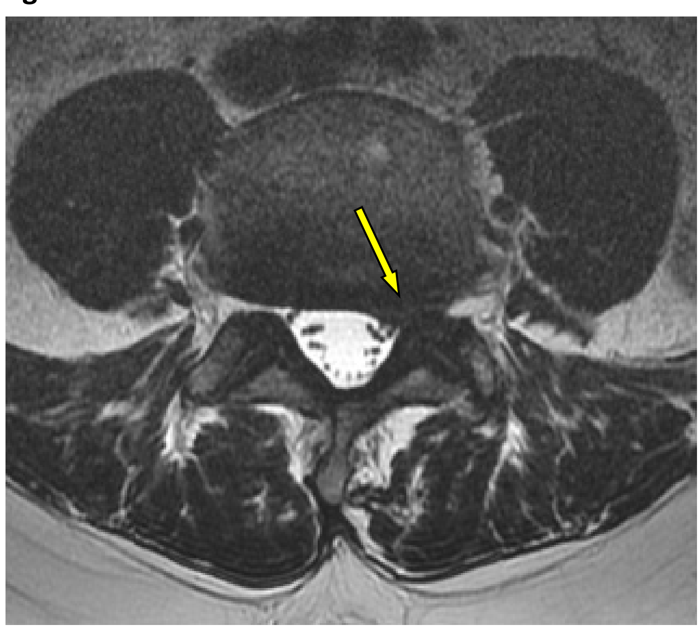


Figure 15:48. Axial image of a foraminal herniation.

Herniations into the foraminal canal can compromise the exiting nerve roots. Even a small herniation in the foraminal canal can cause significant nerve impingement.

Far Lateral Foraminal Disc Herniation

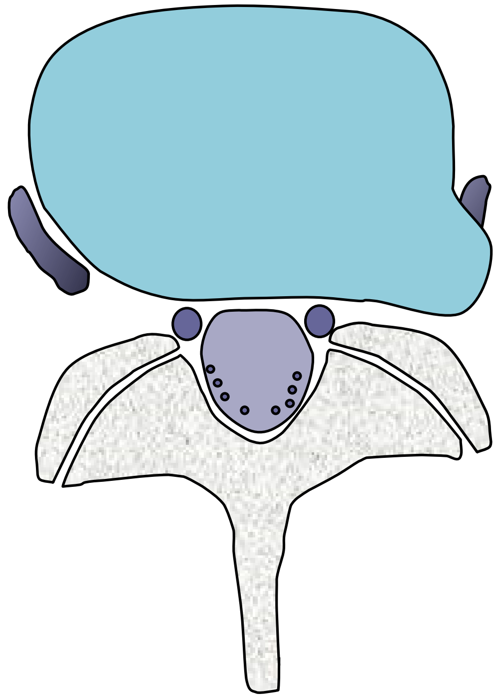


Figure 15:49. Schematic of a far lateral herniation.

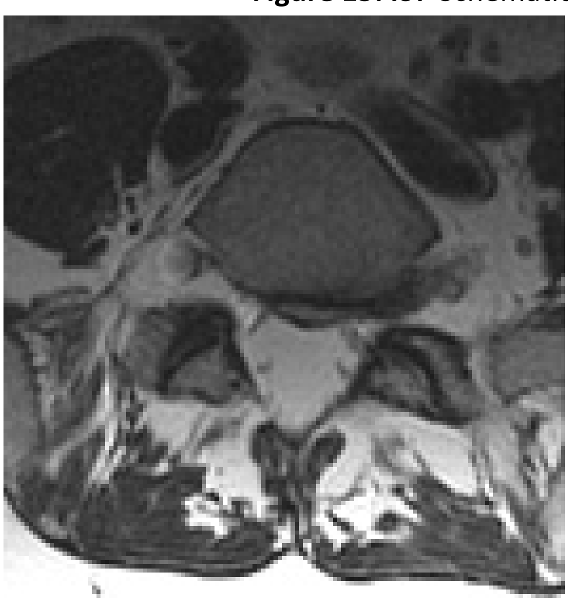


Figure 15:50. Axial image of a far lateral herniation.

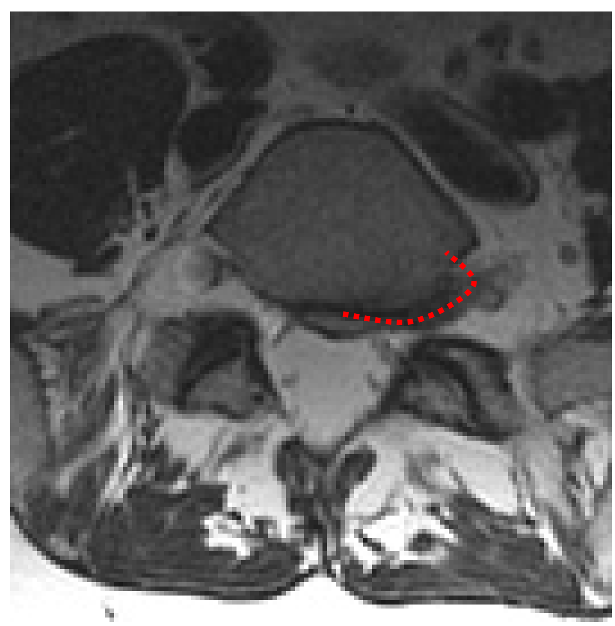


Figure 15:51. Axial image of a far lateral herniation with the herniation outlined by a red dotted line.

Far lateral herniations may contact and affect the exiting nerve root after it leaves the intervertebral foramen. The image on the right outlines this far lateral herniation making it better visualized.

Volume Descriptors

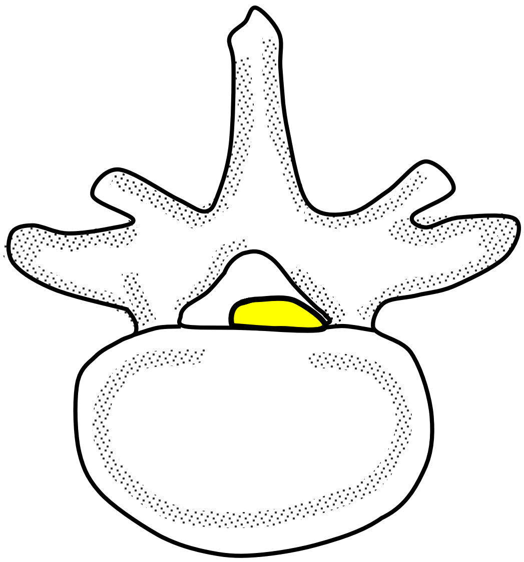


Figure 15:52. Mild herniation

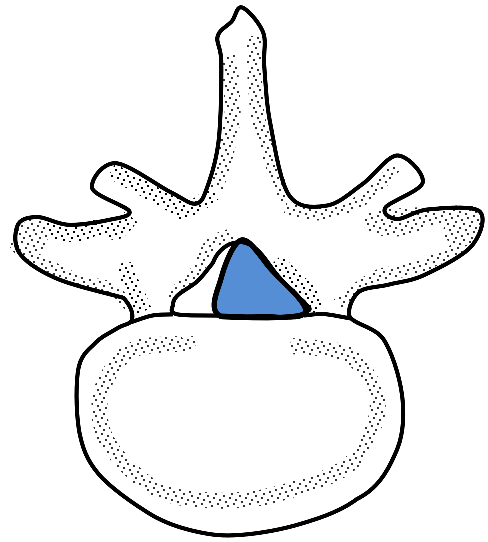


Figure 15:53. Moderate herniation

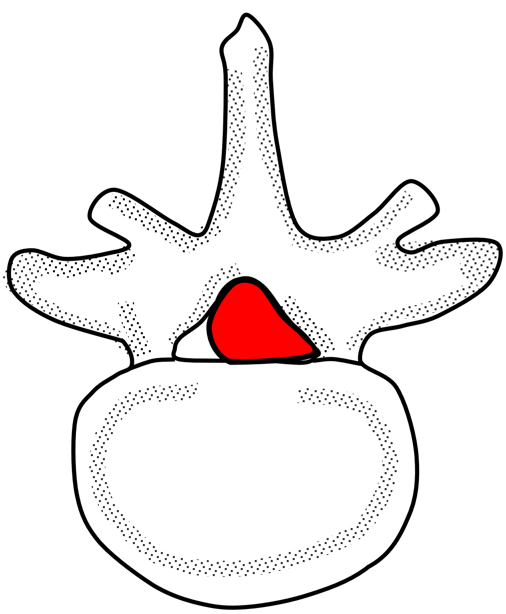


Figure 15:54. Severe herniation

The volume descriptors for the amount of disc material herniated into the central canal as observed on axial imagery at the level of the most severe compromise are as follows:

- A herniation that occupies less than one-third of the canal is a *mild herniation. (figure 15:52)*
- *A* herniation that is between one-third and two-thirds of the canal is considered *moderate (figure 15:53)*.
- Lastly, a herniation that occupies over two-thirds of the canal is *severe (figure 15: 54)*.

This grading method can also be utilized in describing foraminal involvement.

Volume Descriptors for IVF Involvement

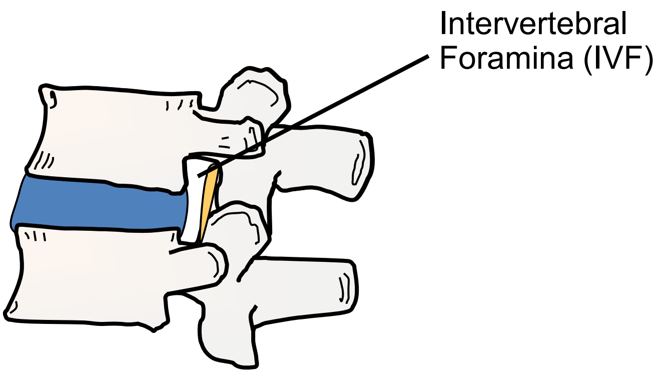


Figure 15:55. Normal/patent foramina

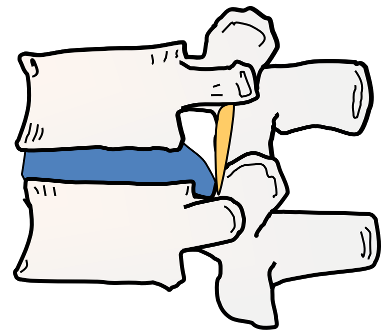


Figure 15:56. Mild foraminal occlusion

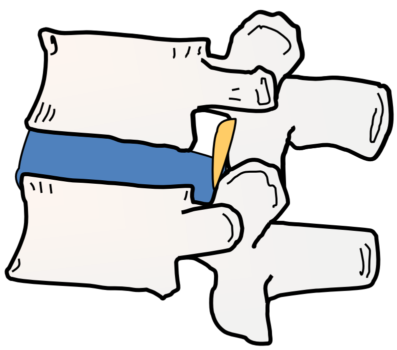


Figure 15:57. Moderate occlusion

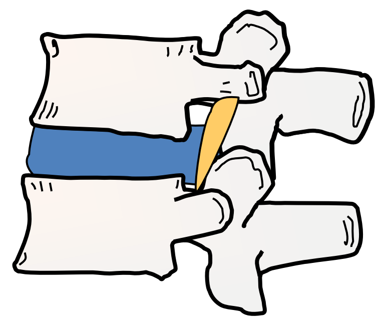


Figure 15:58. Severe IVF occlusion

The descriptors for IVF occlusion are similar to the volume descriptors used for notating the size of disc herniations. When the IVF is occluded less than one-third, it is considered mild *(figure 15:56)*. When it is occluded between one-third and two-thirds, it is considered moderate (*figure 15:57*), and over two-thirds occlusion is severe (*figure 15:58*).

16

Classification of Annular Tears

Annular Tears

The term annular tear or annular fissure is used to categorize separation between the annular fibers, avulsion of the fibers from the vertebral body, or a tear through the fibers. A common misconception is that trauma is always indicated in a tear. Annular tears may occur from trauma or over time as part of a degenerative process. Some experts prefer the term annular fissure since it is less implicative of trauma. There are three categorizations of annular tears: radial tears, transverse tears, and concentric tears. Annular tears may be clinically significant or may be asymptomatic coincidental findings. As with many findings on MRI, just because a lesion is visible does not mean that it is clinically significant.

Radial Tears

Radial tears begin centrally and progress outward in a radial direction. Radial tears may precede the migration of nucleus material radially, resulting in a disc herniation.

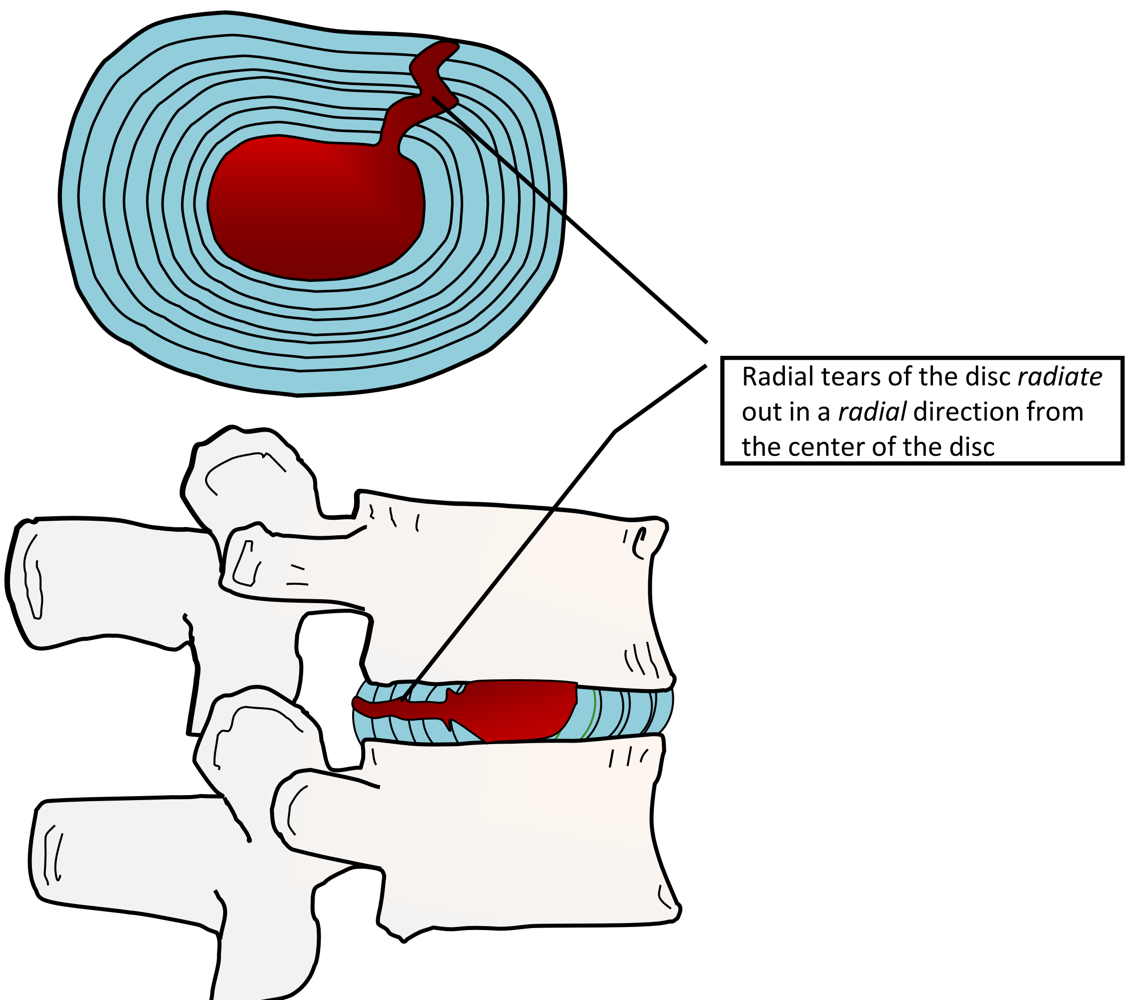
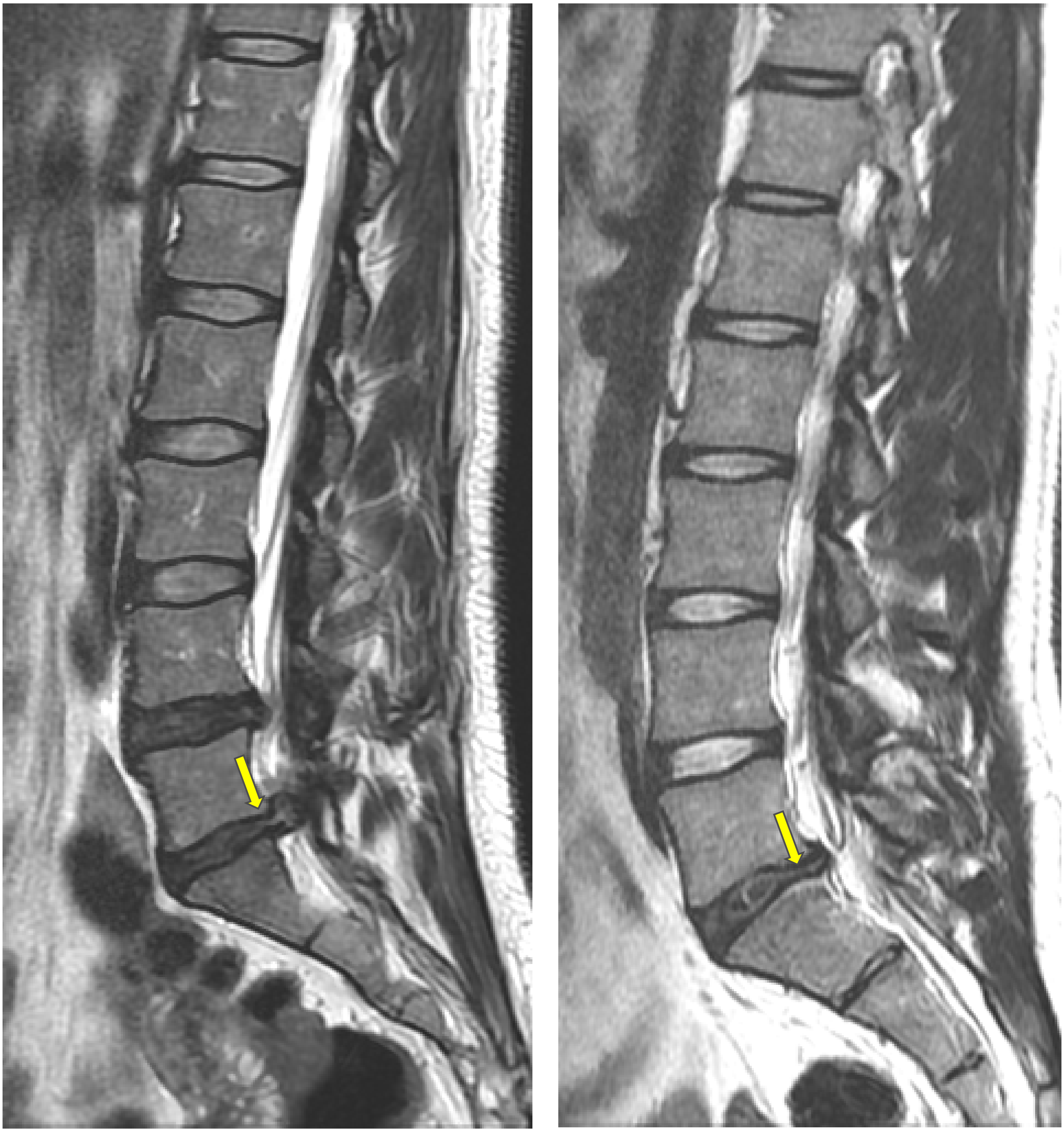


Figure 16:1. Radial disc tears.



Figures 16:2 and 16:3. Radial disc tears denoted by yellow arrows in T2W sagittal images.

Radial Tears

These T2 sagittal images demonstrate radial tears of the annulus of the disc between L5 and the sacrum .

Transverse Tears

Transverse tears have also been called rim lesions. Transverse tears are horizontal lesions that may involve the disc tearing away from the endplate. This lesion may involve disruption of Sharpey's fibers (the matrix of connective tissue that binds the disc to the vertebral endplates) and the disc. Transverse tears appear to have a causal effect in degenerative disc disease and the formation of osteophytic spurring. They are typically small and limited to the joining of the annular attachments to the apophyseal ring, the rim of the vertebra, hence the term "rim lesion."[1]

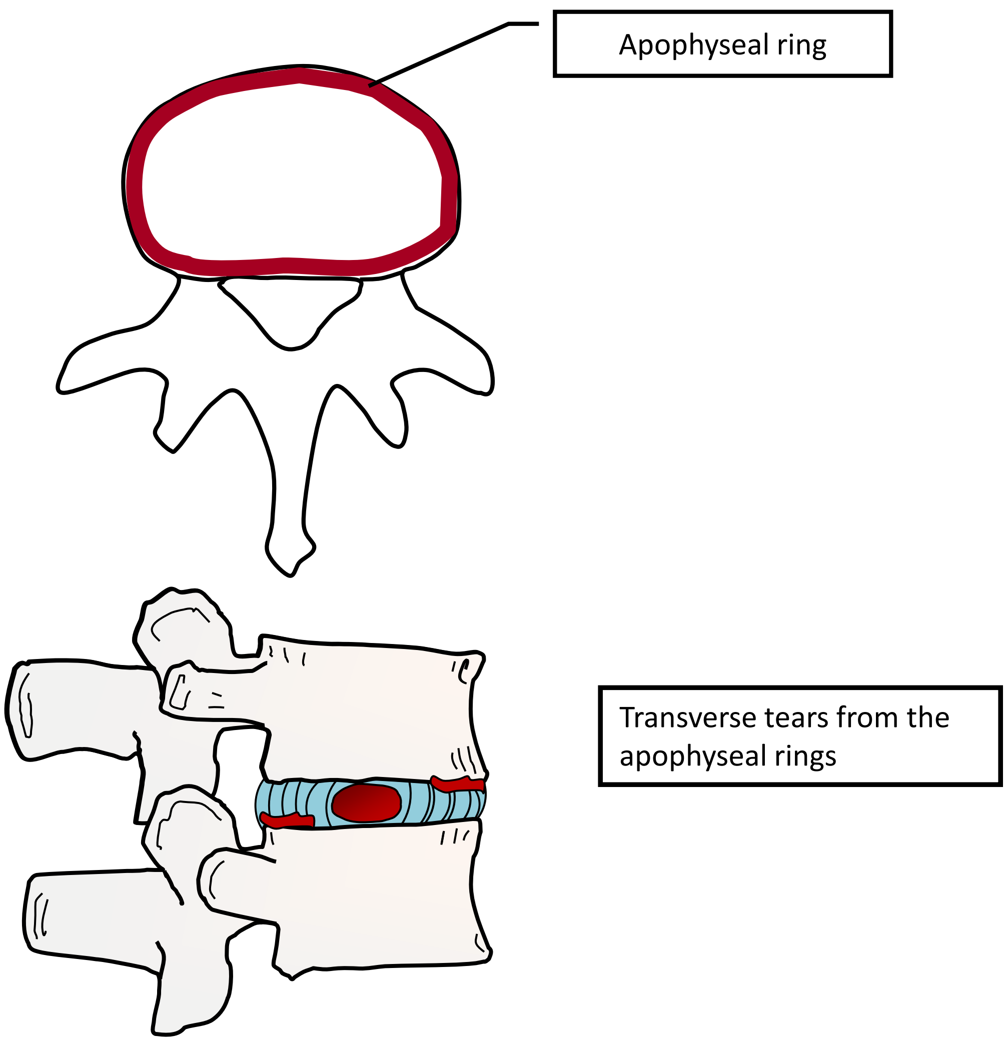


Figure 16:4. Transverse disc tears.

1. Schmorl G, Junghans H, "The human spine in health & disease". New York: Grune & Stratton, 1971

Transverse Tears

Figures 16:5 and 16:6. T2WI of an L5-S1 posterior transverse tear.

The images above show a transverse annular tear from the superior endplate at the posterior margin of the sacrum. These T2 weighted images are from the same patient. Below is an image from a different patient with a small tearing of the annulus fibers from the superior apophyseal ring of the sacrum. Annular tears are well-demonstrated in T2 images and appear as high-intensity zones, thus appearing white in T2 weighted images.

Figure 16:7. Transverse disc tear.

Concentric Tears

Concentric tears are a separation of the concentric annular bands that surround the nucleus. Normally the outer third of the annulus is affected by concentric tears. Incidentally, it is the outer third of the annular fibers that are the most richly innervated and susceptible to nociception.

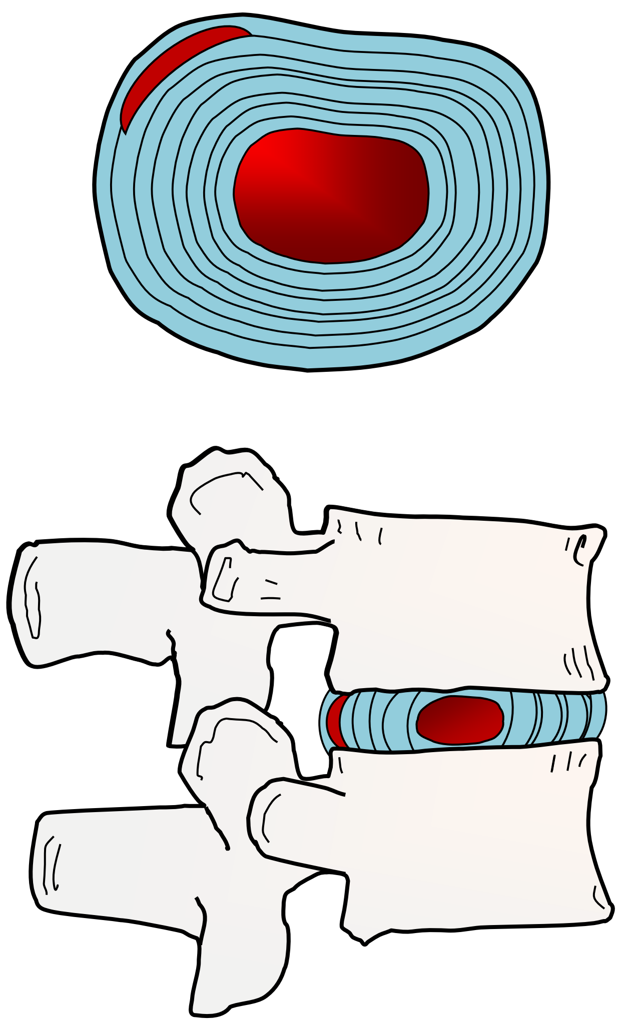


Figure 16:8. Concentric disc tear. Concentric tears separate bands of the annular rings of cartilage. They are characterized by high intensity zones (white appearance) on T2 weighted images. Most concentric tears occur in the outer portion of the disc.

Figure 16:9. Concentric disc tear in a T2W sagittal image.

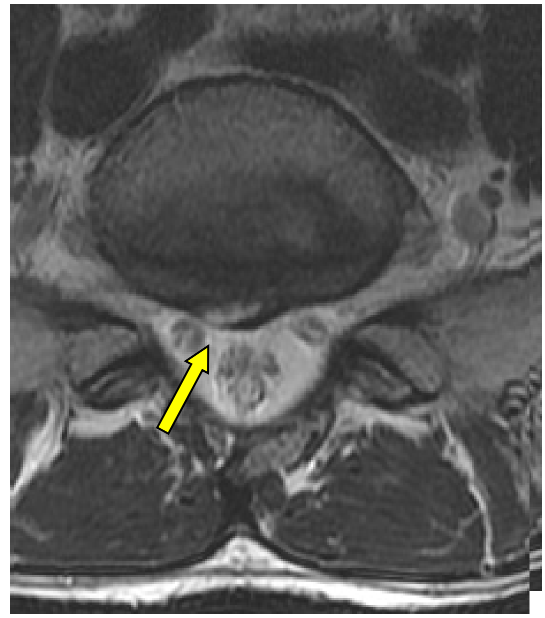


Figure 16:10. Concentric disc tear in a T2W axial image.

The two images above show a transverse concentric tear involving the posterior portion of the L5-S1 disc. These T2 weighted images are from the same patient. Below is an image from a different patient with a lateral concentric tear. Most concentric tears occur in the outer rings of the annulus.

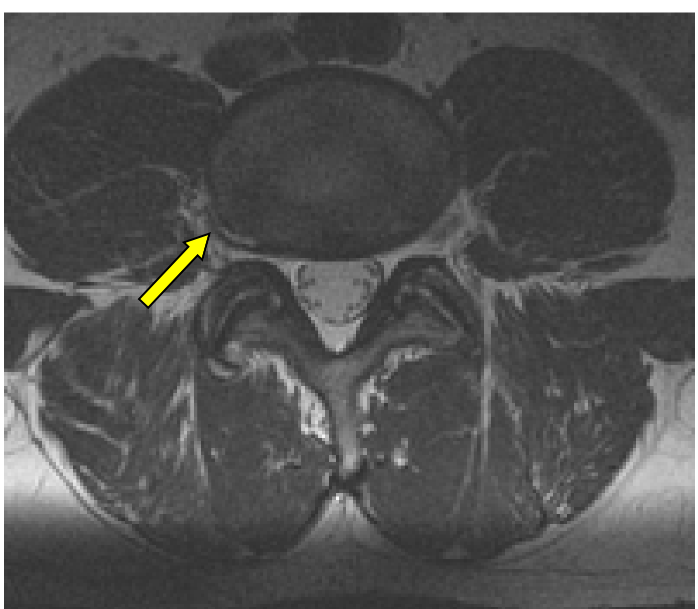


Figure 16:11. Posterior lateral concentric disc tear in a T2W axial image.

References

Ahn SH, Ahn MW, Byun WM. Effect of the transligamentous extension of lumbar disc herniations on their regression and the clinical outcome of sciatica. Spine. 2000;25:475–80.

Autio RA, Karppinen J, Niinima¨ki J, Ojala R, Kurunlahti M, et al. Determinants of Spontaneous Resorption of Intervertebral Disc Herniations. Spine. Volume 31, Number 11, pp 1247–1252.

BenEliyahu DJ. MRI and clinical follow-up study of 27 patients receiving chiropractic care for cervical and lumbar disc herniation. JMPT. 1996;19(9):597-606.

Bozzao A, Gallucci M, Masciocchi C, Aprile I, Barile A, Passariello R. Lumbar disk herniation: MR imaging assessment of natural history in patients treated without surgery. Radiology. 1992;185:135–41.

Cherkin DC, Deyo RA, Loeser JD, Bush T, Waddell G. An international comparison of back surgery rates. Spine. 1994;19:1201–6.

Choudhry NK, et al. Systematic review: The relationship between clinical experience and quality of health care. Annals of Internal Medicine. 2005; 142: 260–273.

Cribb GL, Jaffray DC, Cassar-Pullicino VN. Observations on the natural history of massive lumbar disc herniation. J Bone Joint Surg Br. 2007;89:782–4.

Delauche-Cavallier MC, Budet C, Laredo JD, Debie B, Wybier M, et al. Lumbar disc herniation. Computed tomography scan changes after conservative treatment of nerve root compression. Spine. 1992;17:927–33.

Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, Von Korff M, Waddell G. Outcome measures for low back pain research. A proposal for standardized use. Spine. (Phila Pa 1976). 1998 Sep 15;23(18):2003-13.

Komori H, Shinomiya K, Nakai O, Yamaura I, Takeda S, Furuya K. The natural history of herniated nucleus pulposus with radiculopathy. Spine. 1996;21:225–9.

Matsubara Y. Serial changes on MRI in lumbar disc herniations. Neuroradiology. 1995;37:378-383.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. JMPT. 2001; 24: 596-602.

Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). Spine. 1995; 20: 2513-21.

Matsubara Y, Kato F, Mimatsu K, Kajino G, Nakamura S, Nitta H. Serial changes on MRI in lumbar disc herniations treated conservatively. Neuroradiology. 1995;37:378–83.

McKenzie RA. The lumbar spine. Mechanical diagnosis and therapy. Waikanae: Spinal Publications; 1981.

Modic MT, Ross JS, Obuchowski NA, Browning KH, Cianflocco AJ, Mazanec DJ. Contrast-enhanced MR imaging in acute lumbar radiculopathy: a pilot study of the natural history. Radiology. 1995;195:429–35.

McMorland G, Suter E, Casha S, du Plessis SJ, MD, Hurlbert RJ, MD. Manipulation or microdiskectomy for sciatica? A prospective randomized clinical study. J Manipulative Physiol Ther. 2010 Oct;33(8):576-84.

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine. (Phila Pa 1976). 1990 Jul;15(7):683-6.

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. Mar-Apr 2006;6(2):131-137.

17

Inflammation and Disc Injuries

Inflammation

Inflammation: Friend or foe?

In the case of a disc herniation, inflammation is both friend and foe. When the nucleus herniates from the confines of the annular fibers, the body's immune system does not recognize it and "tags" the nucleus as an invader. This initiates an immune response: inflammation. Inflammation causes swelling, irritation, and increased blood flow. The increased blood flow aids the white blood cells in traveling to the site of injury to battle this perceived invader. Macrophages, white blood cells known for producing pro-inflammatory chemicals and consuming invading organisms, arrive and begin to consume the herniated disc. Much of the pain associated with a herniated disc results from the immune system's inflammation response.

When people take anti-inflammatory drugs, it confounds the immune response and reduces the irritation. This may be good in the early stages of a herniation. However, since the macrophages are inhibited by taking anti-inflammatory drugs, it may impair the body's ability to absorb a herniation. Long-term use of anti-inflammatory drugs may impede your body's ability to reabsorb a disc herniation and may cause other health problems such as gastric bleeding.

Many spine experts agree that spontaneous regression of a disc herniation is caused by inflammation-mediated reabsorption. It appears that macrophages act as the body's microscopic spine surgeons. Free fragments of disc material appear to be a foreign invader to the body's immune system.

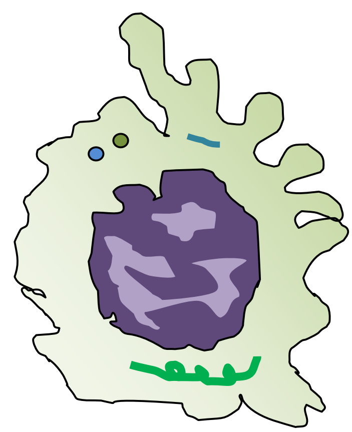


Figure 17:1. The macrophage.

Phagocytosis

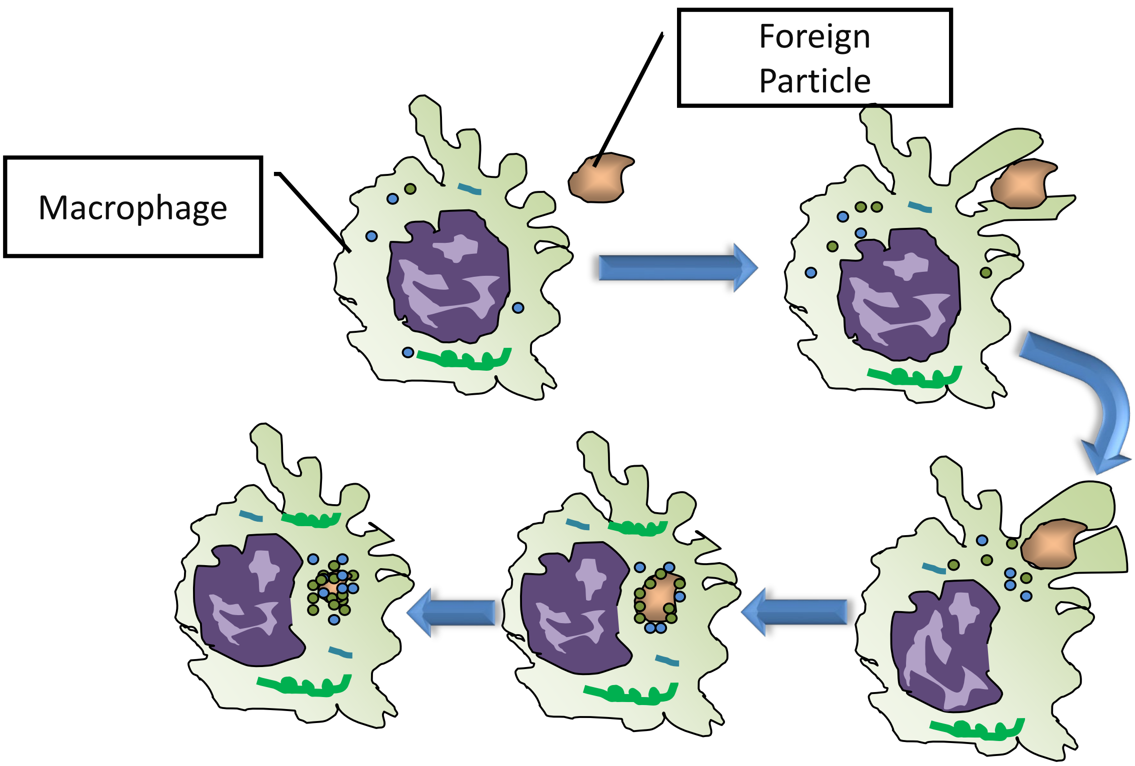


Figure 17:2. Macrophages (Greek for "large eater") typically attack and consume invading foreign organisms. Macrophages are believed to be responsible for degrading and consuming disc material after herniation. When a white blood cell like a macrophage consumes a foreign particle, it is called *phagocytosis*.

Inflammation

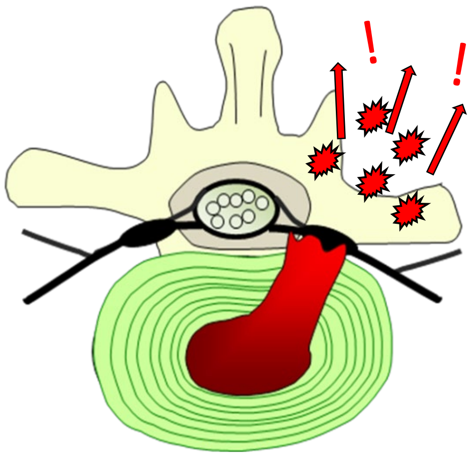


Figure 17:3. When a disruption in the disc wall occurs, inflammatory mediators are released.

If the inner nucleus of the disc ruptures through the wall of the disc, particular chemicals are released that produce inflammation. These chemicals attract white blood cells which release even more inflammatory chemicals. In turn, the inflammation produces pain and swelling.

White blood cells are attracted to the site of the herniation. These cells promote further inflammation and pain, attracting even more white blood cells. Initially this overly vigorous immune response may magnify symptoms. In time, white blood cells will help to degrade and reabsorb herniated disc material. You may be prescribed non-steroidal anti-inflammatory drugs (NSAIDs) initially in an attempt to inhibit the negative effects of this immune response. While potentially beneficial in the early stages of care, inhibiting the function of these white blood cells could hamper their ability to reabsorb the herniation. Certainly long-term use of NSAIDs is not the preferred management of disc injuries.

One study* that sought to predict which disc herniations would reabsorb versus those which would not, found that increased inflammatory margins of the herniated disc showed an increased likelihood that the disc would be reabsorbed.

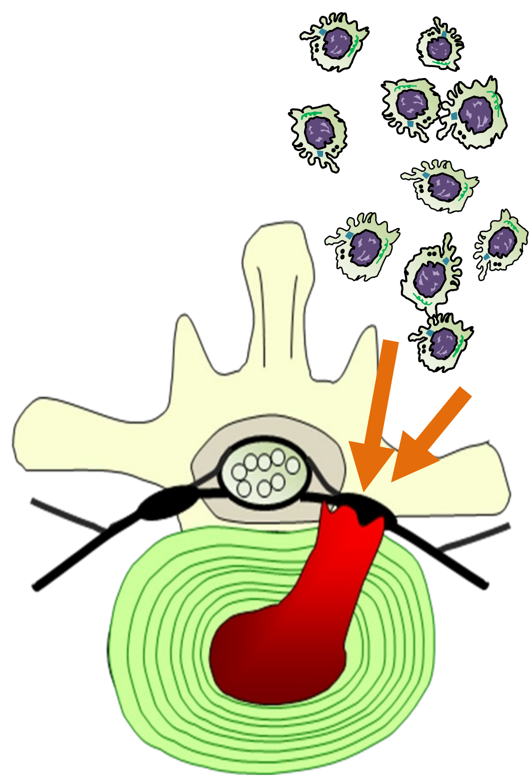


Figure 17:4. Macrophages are attracted to the injured disc.

* http://www.med.nyu.edu/pmr/residency/resources/general%20MSK%20and%20Pain/determinants%20of%20HNP%20resorption_Spine.pdf

Why Disc Bulges Resist Reabsorption

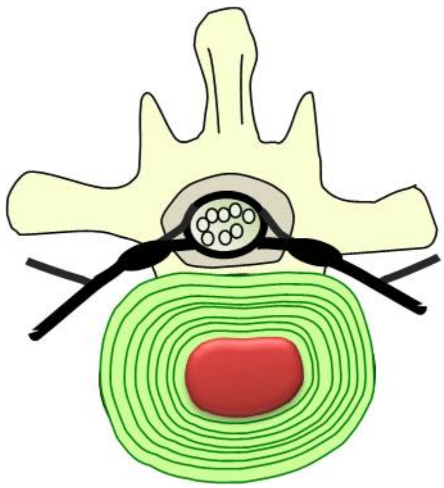


Figure 17:5. Normal lumbar disc.

As long as the nucleus of the disc remains intact and isolated from the immune system (figure 17:5), it does not attract the attention of the immune response.

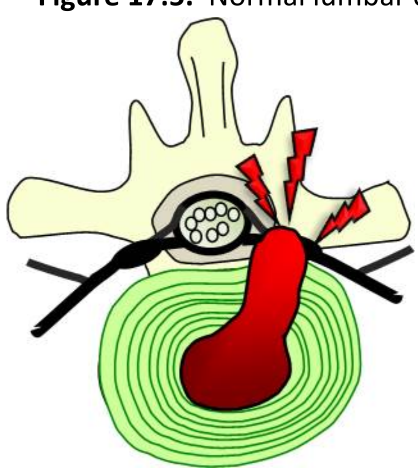


Figure 17:6. Herniated lumbar disc.

When a disc herniates (figure 17:6) and breaks free from the confines of the annular fibers, it is tagged by the immune system as foreign. As a result, it is attacked and consumed by white blood cells. Ironically, the larger the herniation, the greater the likelihood that it will be reabsorbed.

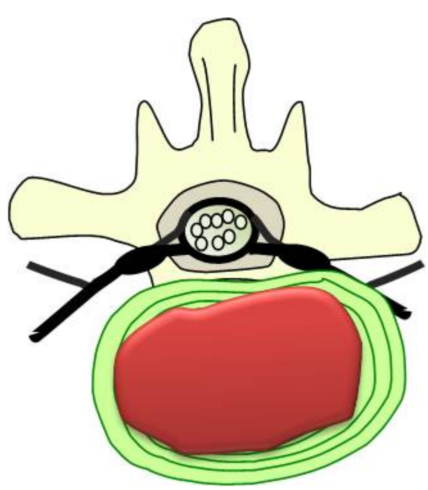


Figure 17:7. Bulging lumbar disc.

Disc bulges (figure 17:7) are diffuse expansions of the disc that do not break through the outer rings of the disc. The nucleus of the disc is never exposed to the immune system. Consequently, the immune and inflammatory responses are not engaged, and reabsorption does not occur. While disc herniations may be reabsorbed, disc bulges will not.

18

Creep

Creep

"Creep" is a term used in physics and engineering to describe plasticity and elasticity. The human frame has several tissues that are "viscoelastic." The discs and ligaments of the spine are particularly susceptible to creep. Their shapes deform to relieve stress. Once deformed, it may take time for the structures to return to their normal shape. If too much deformation occurs, the changes may become permanent.

When placed in a sustained flexed posture like prolonged sitting or bending, the ligaments and annular rings are temporarily stretched to the point where they are less able to restrain the nucleus. Lifting, bending, or performing athletics after prolonged sitting is ill-advised. It is not uncommon for a disc herniation to occur when lifting luggage following a long drive or flight.

Prolonged bending, stooping, or even sitting stretches the ligaments and disc material that retains the nucleus from herniating. Like stretched out plastic wrap, the ligaments become slack, less able to prevent disc herniations. In time, usually a couple hours, the disc and ligaments regain their tautness after being removed from a stressful posture. For this reason it is not wise to perform strenuous activities after prolonged sitting or flexion.

Figure 18:1. Prolonged bending causes elastic over-stretching and deformation of the disc and other connective tissues. This is known as "creep."

Creep

Figures 18:2, 3, 4, 5, 6. Prolonged sitting, bending, and bike riding can result in stretching the discs and spinal ligaments leading to creep. It is wise to avoid athletic exertion or lifting after prolonged bending, sitting, or bike riding. Walking and arching your back after bending or sitting may also help prevent disc injuries.

After prolonged bending or sitting, avoid exertion or lifting. Perform standing lumbar extension exercises (chapter 22) to minimize the effects of viscoelastic creep.

Creep

Figure 18:7. Lifting luggage after prolonged driving or flying is a common cause of disc injuries. Do not lift immediately after prolonged sitting or bending, and never try to lift while flexed at the waist.

Figure 18:8. For athletes it would be unwise to perform strong exertions immediately after a prolonged bus or car ride or prolonged sitting on a bench.

19 Lifting and Load Bearing

Lifting

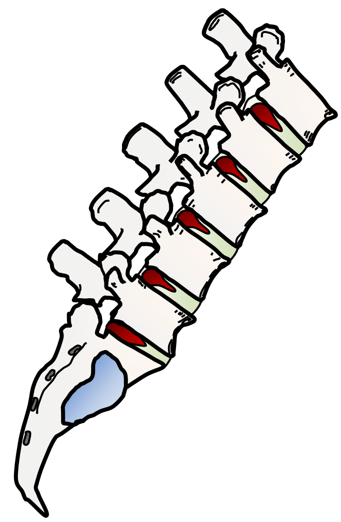
Lifting correctly is one of the most discussed activities in the conservative treatment of disc injuries. Usually the advice is simply to bend at the knees and not at your waist. However, this old-school guidance is not adequate. You can bend with your knees and still herniate a disc. There is more to safe lifting than simply bending at the knees.

Figure 19:1. Flexing the spine while lifting is provocative for those with disc herniations and injurious to those without herniations.

Maintaining a Safe Lumbar Arch

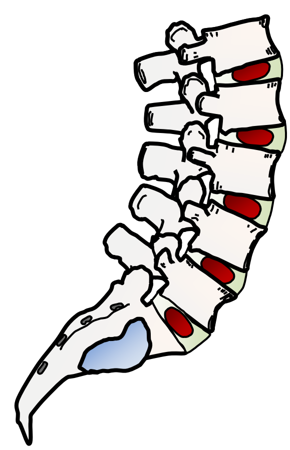
Proper lifting involves more than simply bending at the knees. This illustration shows the lifter bending his knees, but still curling his spine in a manner that could contribute to disc injury. Curling the spine, even with your knees bent, causes a dangerous migration of disc material back towards the spinal nerves.

3



Figures 19:2 and 19:3. Lifting with bent knees can still be injurious if the spine is curled (2). Curling the spine forward contributes to the movement of the internal nucleus toward a herniation.

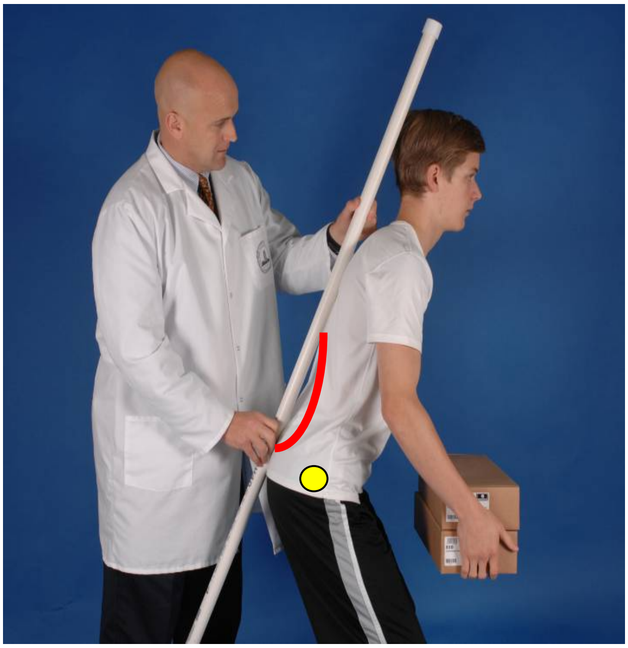
5



Figures 19:4 and 19:5. The safest way to lift involves keeping a comfortable neutral arch in your back while contracting or “stiffening” your abdominal muscles.

Maintaining a Safe Lumbar Arch

When lifting or bending, do not allow your lumbar spine to curl forward. Maintain a comfortable neutral arch in your lower back.



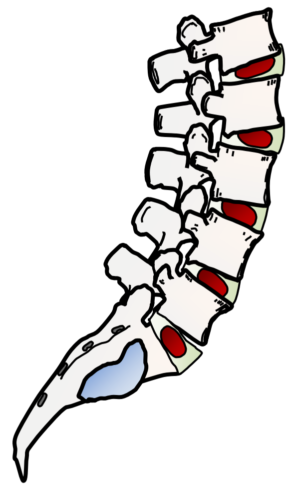


Figure 19:6

Figure 19:7

By maintaining a neutral arch it is possible to safely bend forward using the hips, not the spine. In these images (Figures 19:6 and 19:7) the pivot point of the hips is identified by the yellow dot. Using a pole for feedback, this lifter is trained to maintain an arched lumbar spine, even while bending.

Maintaining a Safe Lumbar Arch

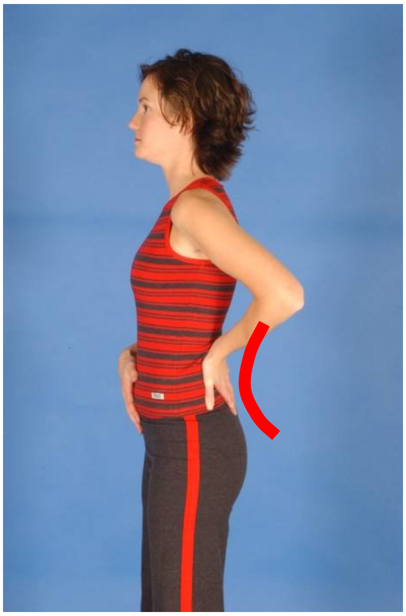


Figure 19:8. Maintaining a neutral arch (aka lordosis) is protective of the disc.

Figure 19:9. Curling the lumbar spine forward flexes the spine into a potentially damaging posture.

Figure 19:10. The doctor is using a rod placed against the subject's spine to reinforce this protective motion.

Differentiating spine motion from hip motion:

Spinal flexion occurs when the spine curls forward into a flexed posture.(Figure 19:9). This places increased pressure on the lumbar disc.

To protect the spine while bending, strive to maintain an arch in your lower back while pivoting at the hip. Figure 19:10 shows the subject bending at the hips while maintaining the arch in his lumbar spine. The doctor is using a rod placed against the subject's spine to reinforce this protective motion.

Maintaining a Safe Lumbar Arch

Figure 19:11. Good form for lifting begins by keeping the load close and the back arched.

Figure 19:12. Maintain good form throughout the lift.

Figure 19:13. Lifting from a sitting posture, especially with bending and twisting places a great deal of pressure on lumbar discs and should be avoided.

Key components of a safe lift:

•Bend with the knees.

•Keep the load close to your center of gravity.

•Keep your chest out.

•Bend at the hips, not at the spine

•Contract or "brace" your core muscles before and during the lift.

•If practical, straddle the load.

Mechanical Aids

Figures 19:14 and 19:15. Modern luggage allows for backpacks to be used as either a backpack or wheeled luggage. Avoid carrying heavy loads in a backpack, especially with only one strap.

Figures 19:16 and 19:17. Try to minimize or eliminate lifting whenever possible. Use mechanical aids to bear loads.

Maintaining a Safe Lumbar Arch

When possible, it is better to push heavy or large loads rather than to pull them.

Figure 19:18. Maintaining an arch and pushing is generally safer than pulling.

Figure 19:19. Curling your spine while pulling increases the risk of disc injury.

Activities of Daily Living

20

Activities of Daily Living

Activities of daily living (ADLs) are activities that we do on a regular basis as part of our daily life: driving, bathing, shaving, housework, yard work , dressing, and toileting. In healthcare, a great emphasis is placed on the importance of being able to perform these basic functions of normal living. This chapter is dedicated to helping anyone with a lumbar disc herniation adapt his or her life to allow healing to take place.

One of the key components to healing from a disc injury is to remove the cause of injury and the causes of irritation. In this chapter we will identify ways to protect the spine from further injury while participating in activities of daily living.

The prevailing concept in protecting the lumbar discs is based on maintaining a neutral arch of the spine in activities of daily living and avoiding flexion of the spine (bending forward).

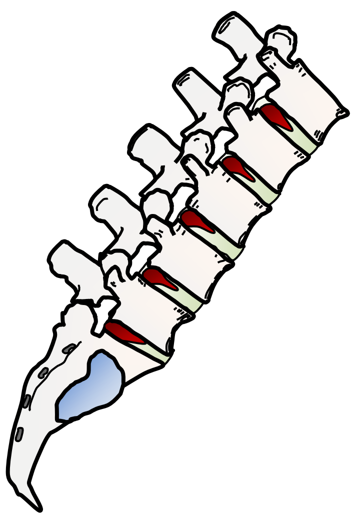


Figure 20:1. Bending the spine forward distorts the nucleus of the discs in a potentially injurious manner.

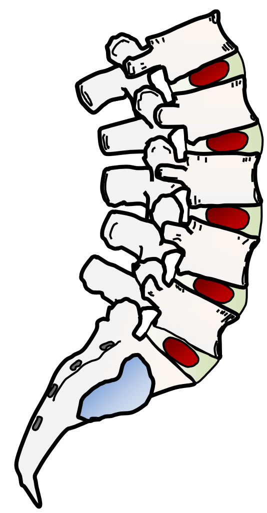


Figure 20:2. Maintaining a health lordosis (arch) is protective of the lumbar disc.

Accessing a Car's Trunk

Figure 20:3. Do not bend at the waist to access a car's trunk. This is especially dangerous after prolonged driving (due to creep).

Figure 20:4. When accessing the trunk of a car, avoid bending at the waist. Instead, place a foot on the bumper or use the "golfer's tilt" to minimize the risk of injury. Strive to maintain a neutral arch in the lower back.

Figure 20:5. The golfer's tilt allows a protective cantilever effect to protect the disc from flexion. In a golfer's tilt all motion occurs at the hip, not the spine.

Footstools

Figures 20:6 and 20:7. Utilize step stools or other aids to reduce spinal stress. Using a footstool will reduce precarious postures when trying to reach high places.

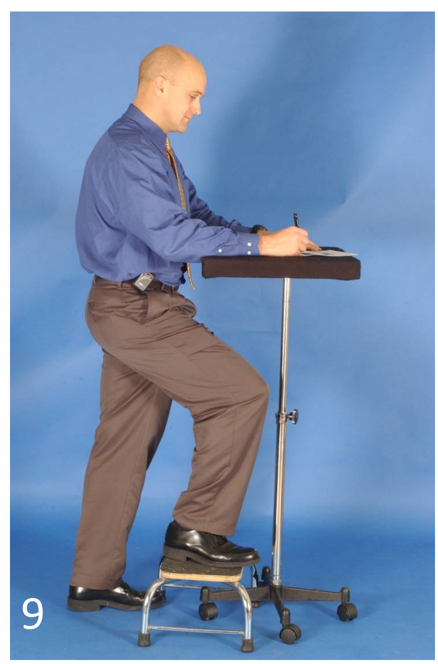


Figure 20:8 and 20:9. Placing one foot on a step stool can reduce the strain on the lower back. These step stools can ease pain associated with shaving, teeth brushing, ironing, public speaking, and doing household chores.

Yard Work

Figures 20:10 and 20:11. When shoveling, avoid bending at the waist (figure 7: 10) and extending the shovel away from your body. Keep the shovel close to you and constantly maintain an arch in your lower back (figure 7:11).

Figure 20:12. When gardening, do not bend at the waist.

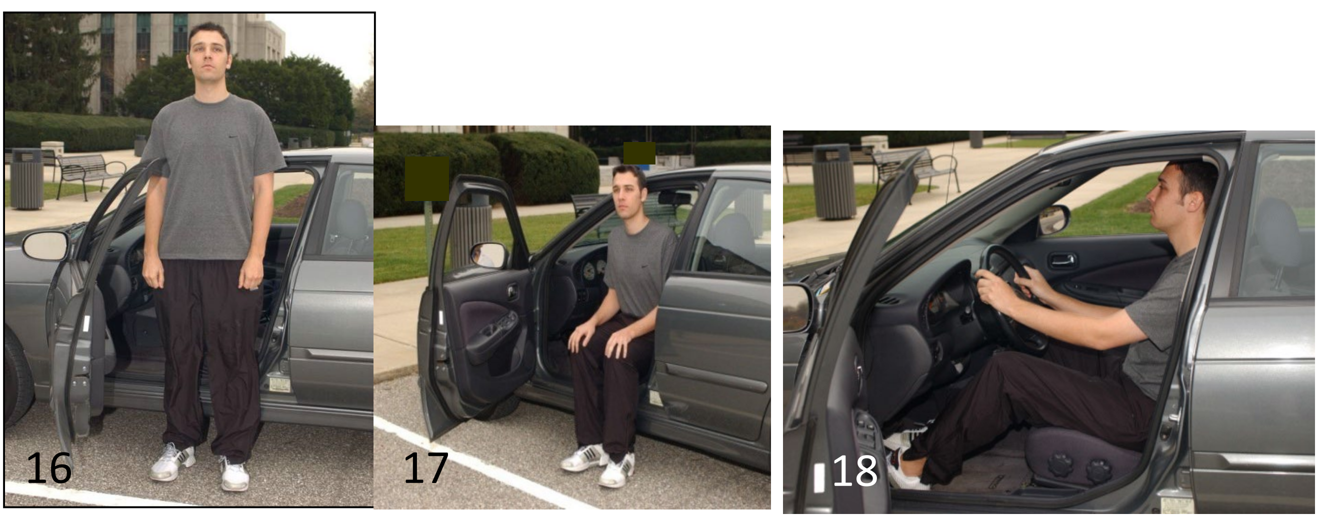
Figure 20:13. Kneel and maintain a natural arch in the lower back.

Figure 20:14. When raking, avoid bending and pulling movements. Stay more upright.

Safety notice: Even though we are addressing the safety of yard work, this does not mean that I advocate yard work in patients with disc herniations. Certainly I would recommend that patients with acute disc injuries or pain avoid all yard work. These recommendations are intended to prevent disc injuries or aggravations .

Entering and Exiting a Car

Figure 20:15. Do not step or stoop to enter a vehicle.



Figures 20:16, 20:17, and 20:18. Enter a vehicle by squatting and maintaining abdominal stiffness and a neutral arch in the lower back. Once sitting, "lock" the core in place and rotate into your driving position. A mildly reclined seat is usually the most comfortable position for a disc patient. However, adjust the seat to what you feel is the most comfortable.

Personal Hygiene

Bending over the sink to shave, wash your face, or brush your teeth can put tremendous pressure on the lumbar discs, especially for the first hour and a half after rising. Shaving in the shower helps to limit bending at the waist. An inexpensive mirror placed in the shower can help reduce disc irritation.

Also, remember that the first hour and a half in the morning is the most dangerous time to bend forward at the waist. Always limit bending at the waist, but especially early in the day.

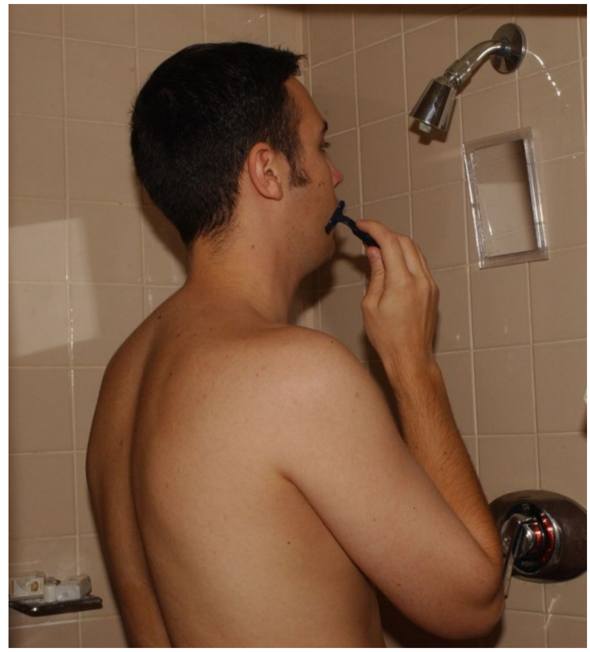


Figure 20:19. Shaving in the shower will protect the lumbar disc by eliminating the need to bend over the sink.

Figure 20:20. Utilizing a foot stool may also help to reduce pressure on the lower back.

You may avoid early morning flexion by also brushing your teeth in the shower. To prevent injury while shaving or brushing your teeth at the sink, use a foot stool for one leg and pivot at the hips. Use your free hand to provide additional support on the countertop.

Balancing Loads

.

Figures 20:21 and 20:22. Minimize and balance your loads. Even if you maintain an ideal posture and lift correctly, the weight you lift may contribute to the pressure within the disc and cause further herniation of a disc. If you do not need to lift during the healing period of your disc injury, do not lift.

Maintaining a Safe Lumbar Arch

20:23. Sitting in a flexed posture places increased pressure on the lumbar disc.

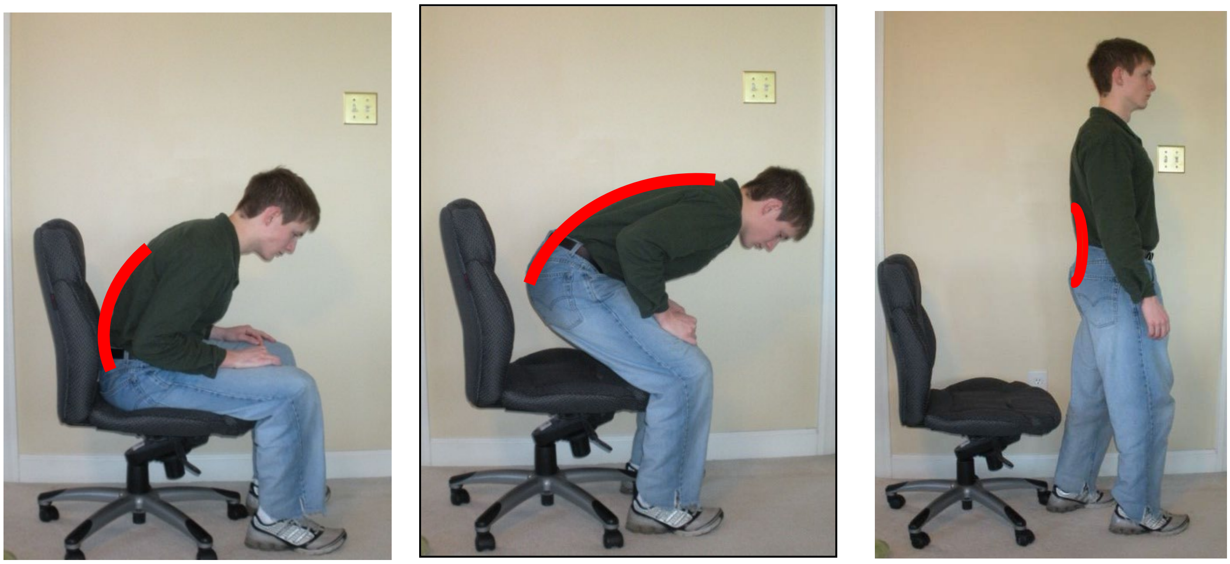
.

Figure 20:24. Using props, armrests, and desks for reading can help to minimize bending while sitting.

Maintaining a Safe Lumbar Arch

Figures 20:25 and 20:26. When swabbing, hold the mop close to your body, and avoid bending at the waist. Stiffen your core and move your pelvis and ribs together. Do not rotate by twisting the spine.

Rising from a Seated Position



Figures 20:27, 20:28, and 20:29. When rising from a seated position, avoid curling your spine forward. Rising in this manner can cause continual re-injury to the discs throughout the day.

Figures 20:30, 20:31, and 20:32. The preferred way to rise is to maintain a normal curve in your lower back, keep your chest out, and brace your abdominal muscles. Scoot to the edge of the chair so that your legs are under you and do most of the lifting. This one ADL (Activity of Daily Living) modification has been accountable for the reduction of symptoms in many chronic disc herniations.

Sitting

Sitting, as previously discussed, places a great deal of pressure on the discs of the lower back. Sitting with a slight recline (backward lean) reduces disc pressure for most people. Lumbar supports, adjustable arm rests, and foot stools are also beneficial for reducing pressure on discs. Experiment with different sitting positions until you find one that is most comfortable. Changing positions periodically is also a good idea for reducing discomfort associated with sitting.

Figure 20:33. Sitting with a slight recline**.**

Figure 20:34. An ergonomic footstool.

Lying Down

Figure 20:34. Comfortable sleeping positions vary. One position that may provide comfort for a time is lying with a cushion under the knees.

Figure 20:35. Another comfortable position is side-lying while straddling a body pillow or buttress.

Backpacks

.

Figures 20:36 and 20:37. When using a backpack, balance the load onto both shoulders.

Aerobic Exercise

Figure 20:38. People who are aerobically fit have less back pain than those who are not.

Aerobic Exercise

People who are aerobically fit heal from spinal conditions more quickly and more fully than those who are not aerobically fit. Brisk walking seems to be particularly beneficial for treating spinal pain. As your condition permits, walking and brisk walking should be re-introduced into your lifestyle.

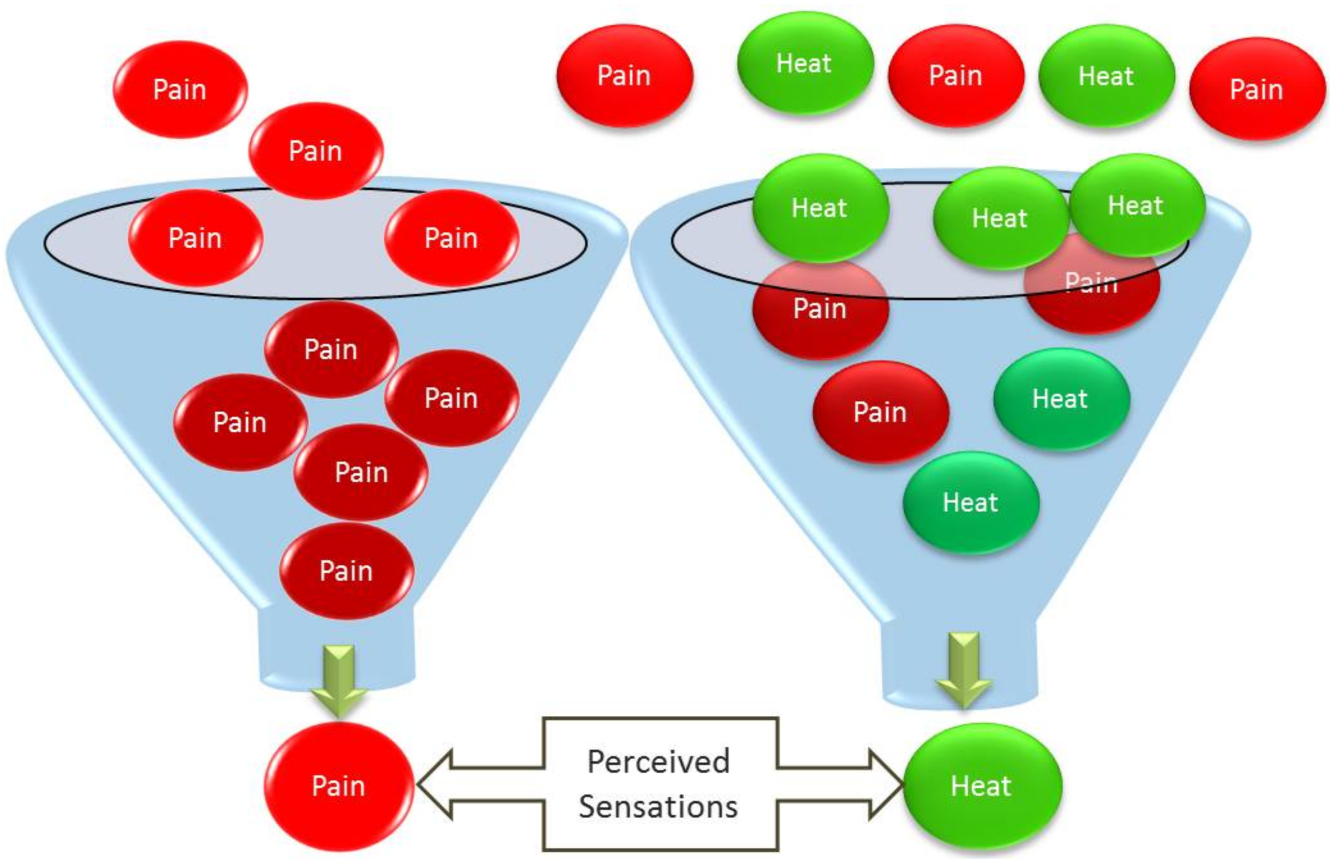
Perform aerobic exercise three to four times per week for 30 to 40 minutes under the supervision of your physician.

21

Physiological Factors in the Management of Disc Derangements

The Gate Theory of Pain

There are certain neurologic junctions that have the effect of bottlenecking afferent transmissions. At these bottlenecks certain perceptions compete for transmission. If pain is the predominate impulse, pain is perceived. If a competing sensation, for example heat, is applied to a region it may displace the perception of pain with the perception of heat. The gate theory proposes that only one impulse is allowed through the gate at a time and that overwhelming a region with a non-painful stimulation will help control the perception of pain.

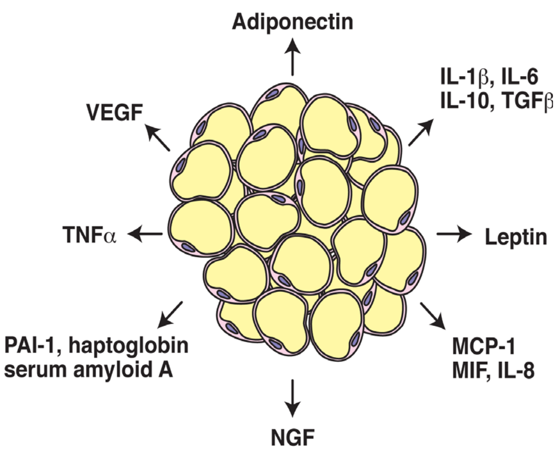


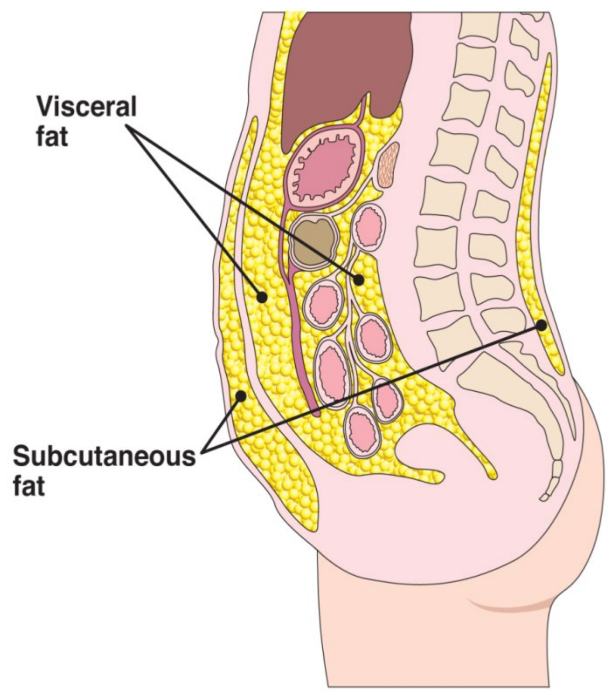
Applying the principles of the gate theory is simple. To reduce the effects of an irritant use a "counter-irritant." Choose a safe counter-irritant and apply it prudently.

1. Ice
2. Heat
3. Motion: walking, changing positions, rocking in a chair, exercising in the pool, etc.
4. Physical Therapy: modalities such as electrical muscle stimulation or ultrasound
5. Massage
6. Counter-irritants: analgesic rubs, creams, or patches

Central Obesity

Central obesity (belly fat) as been linked to the symptoms commonly associated with herniated discs. It has also has been linked to increased treatment complications. Central obesity plays a major role in creating systemic inflammation.





Bolgen-Cimen O, Aryncy-Yncel N, Karabiber M, Erdogan C. Role of obesity in low back pain related disability. *West Indian Med J*. 2007;56(3):252.

Djurasovic M, Bratcher KR, Glassman SD, Dimar JR, Carreon LY. The effect of obesity on clinical outcomes after lumbar fusion. Spine. (Phila Pa 1976).2008;33(16):1789-1792.

Heliövaara M. Body height, obesity, and risk of herniated lumbar intervertebral disc. Spine. [1987, 12(5):469-472].

Image used with permission form ACA News:
http://mydigimag.rrd.com/publication/?i=117689

Narcotic Addiction

Narcotics can help manage the pain associated with lumbar disc herniation, but in time the pain may persist even as the disc injury heals. The addiction of narcotics may recreate the pain associated with the drug to provoke the patient to obtain the narcotic.

Smoking

There is a statistical increase in the risk of lumbar (and cervical) disc herniation in smokers.

Fear Avoidance

Kinesiophobia has risen to being a predictor of disability, infirmity, and ill health in lumbar disc patients. The fear of motion actually contributes to the downward spiral of pain and disability.

Side Effects of Bed Rest

1. Muscle atrophy: 1.0 to 1.5% of muscle mass lost per day
2. Cardiopulmonary deconditioning (15% loss of aerobic capacity in 10 days)
3. Bone demineralization: hypercalcemia and hypercalcuria
4. Thromboembolism risk
5. Psycho-social side effects
6. Economical loss

3 Weeks of Bed Rest vs. 30 Years of Aging

The effects of 3 weeks of bed rest were more deleterious to these subjects than 30 years of normal aging.

An HS, Silveri CP, Simpson JM, File P, Simmons C, Simeone FA, Balderston RA. Comparison of smoking habits between patients with surgically confirmed herniated lumbar and cervical disc disease and controls. Journal of Spinal Disorders. [1994, 7(5):369-373].

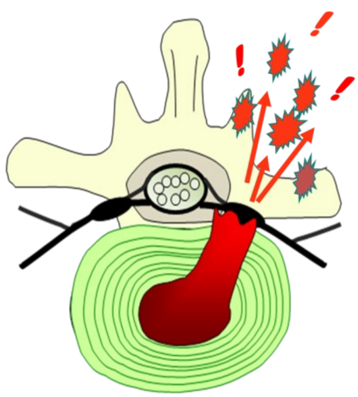
Battie MC, et al. " 1991 Volvo Award in clinical sciences. Smoking and lumbar intervertebral disc degeneration: an MRI study of identical twins." Spine 1991 ;16:1015-21.

Bigos, MD. Acute Low Back Problems in Adults. Clinical Practice Guidelines. December 1994. Potential Harms & Side Effects of Bed Rest (p.53).

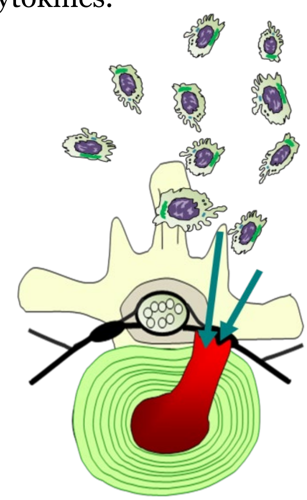
McGuire, MD, MHSc et al. A 30-Year Follow-Up of the Dallas Bed Rest and Training Study. Circulation 2001;104: 1350-1357.

Disc Reabsorption

- The nucleus produces inflammation when it escapes the disc and sets off a cascade of events.
- An inflammatory response occurs.
- Macrophages are attracted to the site.
- Matrix metalloproteinases are released from the macrophages.
- These enzymes degrade the herniated material.
- Macrophages consume the disc material and release cytokines.



The nucleus produces inflammation when it escapes the disc and sets off a cascade of events.



Macrophages are attracted to the inflammation and produce matrix metalloproteinase (enzymes that break down proteins).

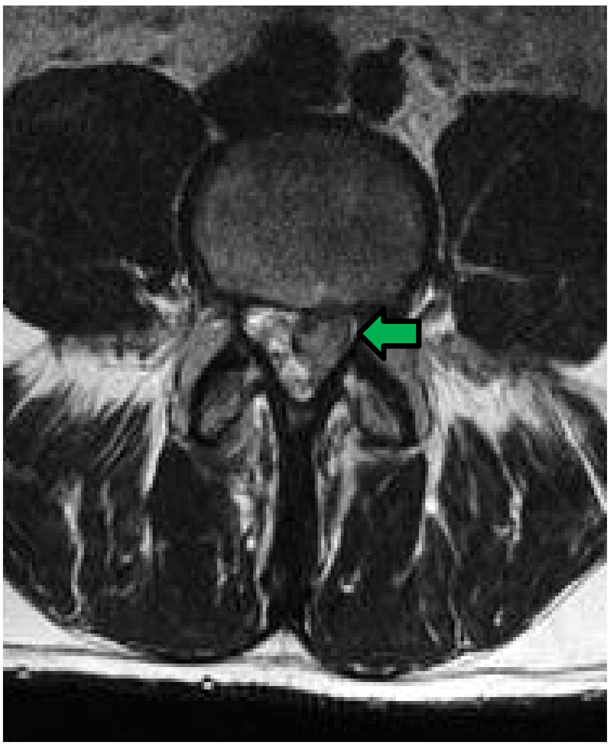
Disc size regression may be attributed to the macrophage infiltration of the herniated disc and subsequent release of matrix metalloproteinase -3 and MMP-7.

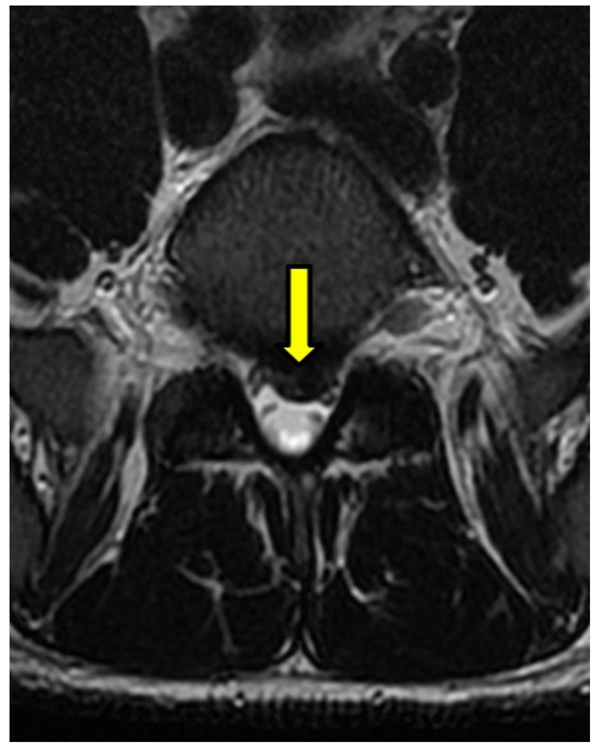
Doita M Kanatani,T, Ozaki T ,Matsui N, Kurosaka M, Yoshiya S. Influence of macrophage infiltration of herniated disc tissue on the production of matrix metalloproteinases leading to disc resorption. Spine: 15 July 2001 - Volume 26 - Issue 14 - pp 1522-152.

Welgus HG, Campbell EJ, Cury JD, Eisen AZ, Senior RM, Wilhelm SM, Goldberg GI. Neutral metalloproteinases produced by human mononuclear phagocytes. Enzyme profile, regulation, and expression during cellular development. J Clin Invest. 1990;86(5):1496–1502.

“Dry” Herniations are less likely to regress

Patients in whom the disc herniation has less hydration may have prolonged symptoms, but many improve with epidural steroid injections.





The green arrow points to a relatively well-hydrated disc. The yellow arrow points to a dark-colored disc which on a T2WI is indicative of reduced water content.

Buttermann GR. Lumbar disc herniation regression after successful epidural steroid injection. Journal of spinal disorders and techniques: December 2002 - Volume 15 - Issue 6 - pp 469-476.

Discogenic Pain Theory

- Normally only the outer margins of the disc and the vertebral endplate regions are innervated.
- Nerves and vessels can "grow" through fissures.
- The chemistry of the nucleus can trigger inflammation and an autoimmune response.
- A pain generating factory is created.

Freemont AJ, et al " Nerve growth factor expression and innervation of the painful intervertebral disc." J Pathol, 2002; 197:286 -292.

Freemont AJ, et al. "Nerve in-growth into the diseased intervertebral disc in chronic back pain. Lancet, 1997; 350:178 -81.

Palmgren T, et al. "Immunohistochemical demonstration of sensory and autonomic nerve terminals in herniated lumbar disc tissue." Spine. 1996; 21:1301-1306.

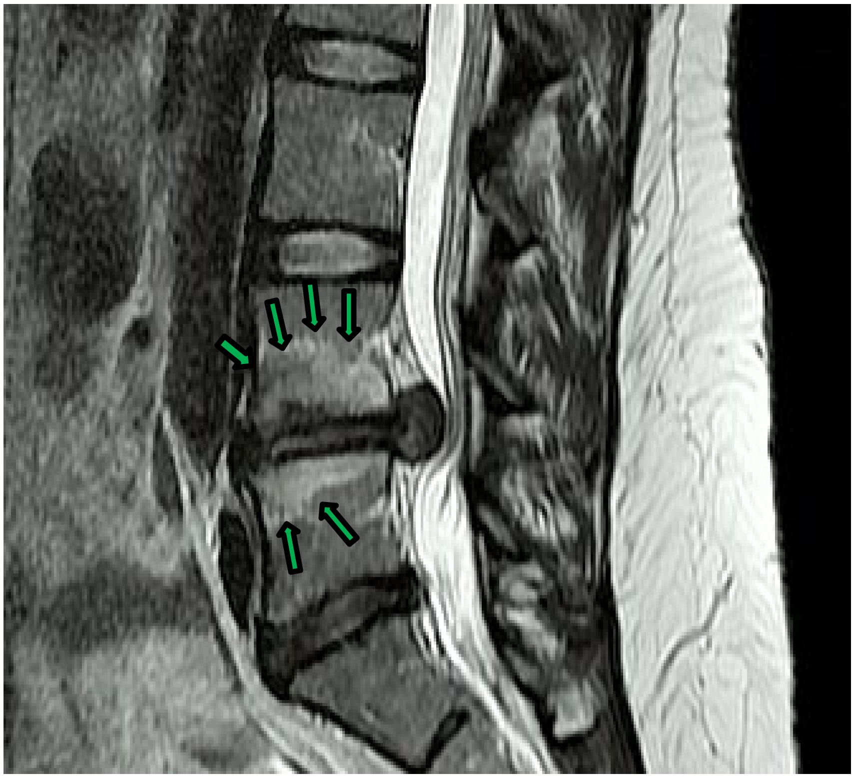
Coppes MH, et al. "Innervation of 'painful' lumbar discs." Spine. 1997; 22:2342-2349.

Pro-inflammatory cytokines in cerebrospinal fluid of patients with disc herniation and sciatica:

This study proposes the possibility of cytokine (IL-8) biochemical effects as well as the biomechanical effects of disc herniation in producing pain. Cytokines in the CSF can cause sensitization.

H. Brisby H, Olmarker K, Larsson K, Nutu M, Rydevik B. Proinflammatory cytokines in cerebrospinal fluid and serum in patients with disc herniation and sciatica. Eur Spine J (2002) 11:62–66.

Bony Edema



Vertebral body edema is a common finding on MR imagery, but it is frequently left absent from radiographic reports. This may be due to the radiologist considering this finding clinically irrelevant, or the more practical consideration that every finding on MR cannot be recorded and most practitioners do not want excessive details. Most practitioners want to know if there is a need for surgical referral or a referral to an oncologist: "Is there neurological defect? Is there a neoplasm?" Degenerative changes like bony edema may seem like unimportant background noise to the busy clinician. However, recent studies have found that that vertebral marrow edema is clinically significant and can be progressive.

Michael T. Modic, MD, identified and published his findings on vertebral bony marrow changes in the journal *Radiology* in 1988. Since that time these findings and his grading criteria have borne his name. Modic changes represent MR observations of vertebral marrow and endplate changes. These changes have been linked to trauma, disc disruption, and degeneration. More studies are currently underway to identify the clinical significance of this finding and to fully understand its progression.

Bony Edema (continued)

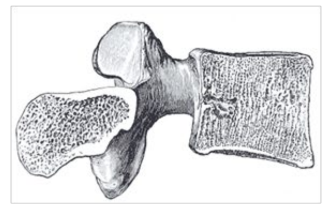
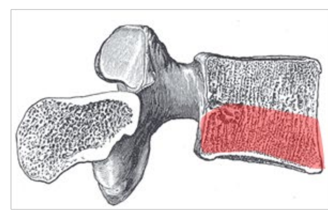
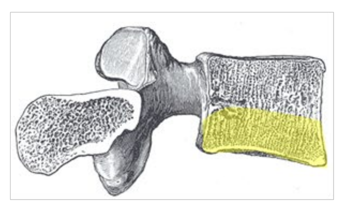
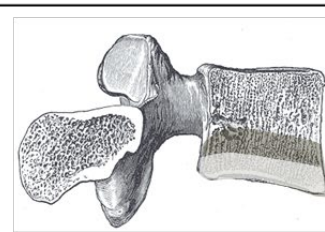
The vertebral body has a dense outer barrier of cortical bone which is particularly dense at the vertebral endplates. Within this tough outer shell lies the subcortical marrow cavity. This cancellous bone is less dense and is porous. It is normal for this porous bone to contain fatty marrow. The T1 and T2 weighted images will reflect the presence of normal fatty marrow with a supportive bony matrix. When edema is present in the marrow, it is characterized by an influx of water content: T1-weighted images show loss of signal (hypointense signal in the marrow), while T2-weighted images will demonstrate an increased (hyperintense) signal.

Modic MT, Steinberg PM, Ross JS, et al. Degenerative disc disease: Assessment of changes in vertebral body marrow with MR imaging. Radiology. 1988;166:193-9.

Modic MT, Ross JS. Lumbar degenerative disk disease. Radiology. 2007 Oct;245 (1): 43-61.

Bone Morphology and Modic Classifications

Evidence is emerging which indicates that there is a progressive nature to Modic changes. The bony edema of type I Modic changes may progress to type II, and type II may progress to type III.

Characteristics of Bone Morphology in Vertebral Bodies	
Normal bone is spongy and uniform in appearance. The vertebral endplates are a thin dense margin of bone.	 **Normal**
Bony edema has been connected with acute endplate or disc disruption. This edema is visible on MRI and is classified as a Type 1 Modic change. It has been associated with pain and inflammation.	 **Type 1 Modic Changes**
Type 2 Modic changes are indicative of yellow fatty infiltration into cortical bone following bony ischemia. Type 2 Modic changes may progress from type I Modic changes.	 **Type 2 Modic Changes**
Type 3 changes are categorized by sclerotic changes of subchondral bone and thickening of the endplates. In time, thickened endplates will reduce nutrient and fluid movement into adjoining discs. This will contribute to reduced fluid content within the adjoining disc and subsequent degenerative disc disease.	 **Type 3 Modic Changes**

Images adapted from Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

Type 1 Modic Characteristics

Bony edema extending into the spongy subcortical bone.

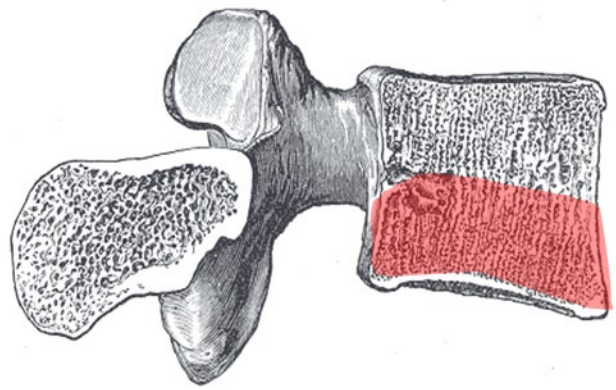
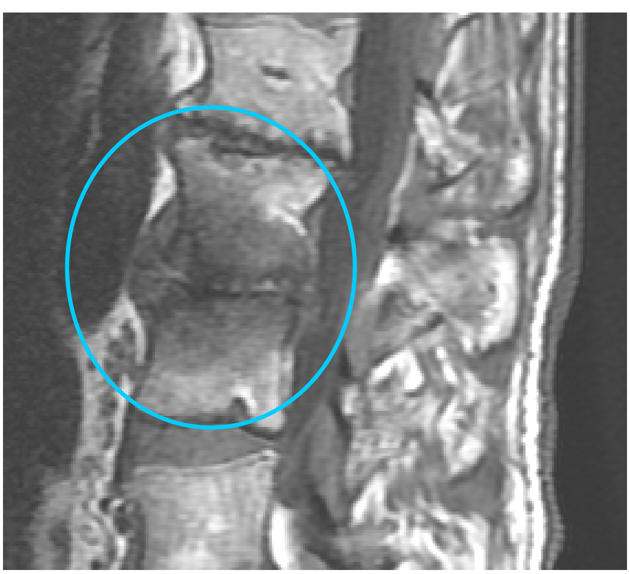
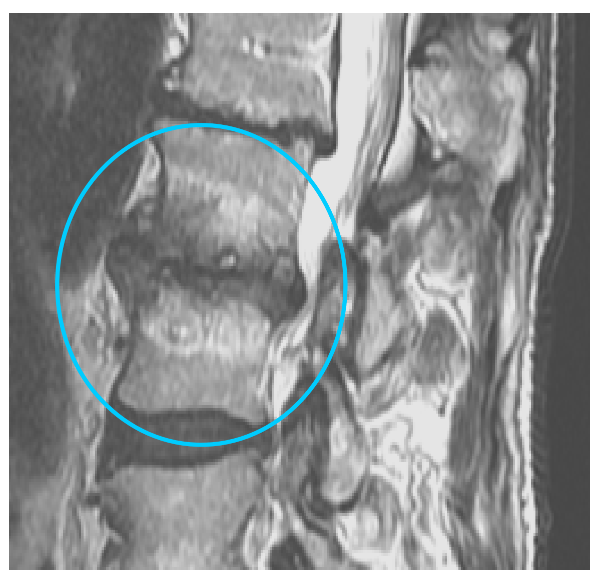


Image adapted from Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

The high water content of inflammation and edema: Type 1 changes are manifested as hypointense (dark) on T1 and hyperintense on T2 weighted images.





T1 weighted image

T2 weighted image

Type 2 Modic Characteristics

Fatty infiltration

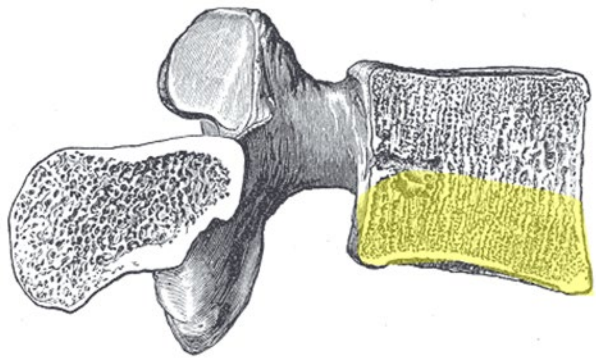
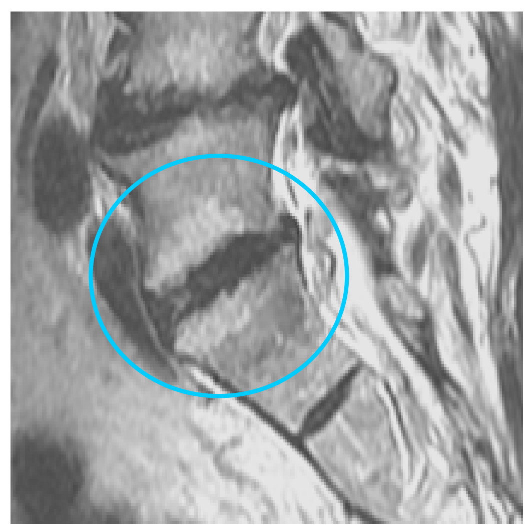


Image adapted from Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

On T1 images, the fatty infiltration of Type 2 Modic changes will appear hyperintense, and on T2 weighted images, they will appear hyperintense or isointense.

T1 weighted image



T2 weighted image

Type 3 Modic Characteristics

Sclerotic changes of the cortical bone and thickening of the vertebral endplates.

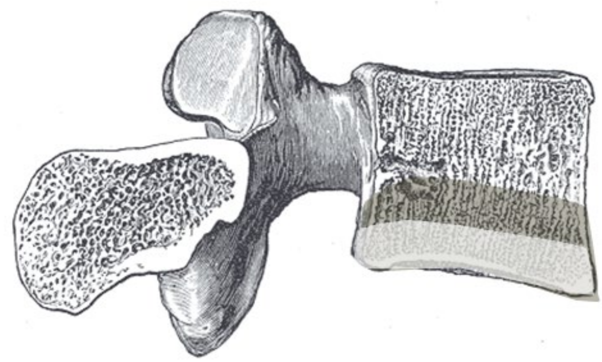
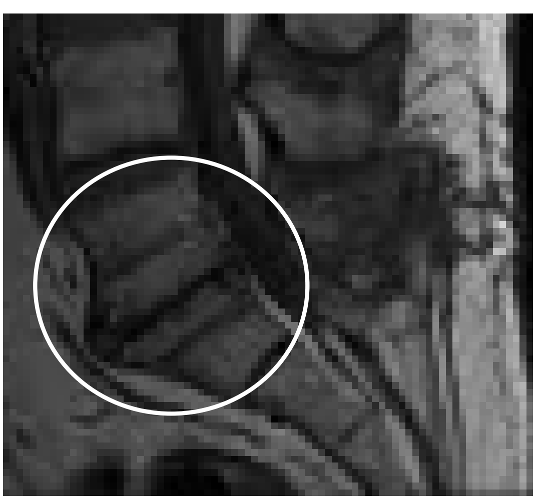
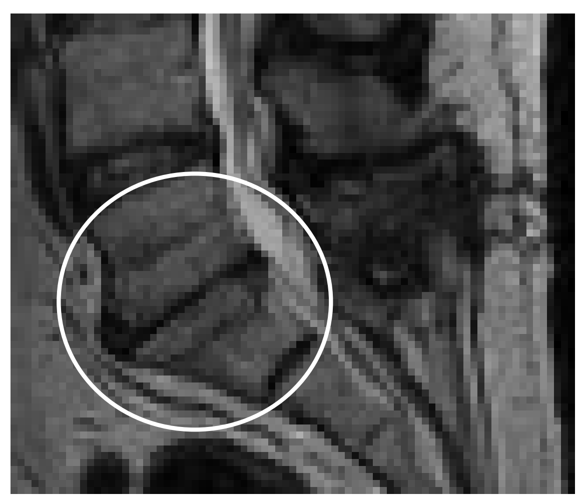


Image adapted from Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

T1 and T2 weighted MRI will manifest type 3 Modic changes with decreased signal or hypointense. These findings can typically be correlated with sclerosis on plain film x-ray. The images below demonstrate type 3 Modic changes in a patient with degenerative disc disease of L5-S1 following an old discectomy.



T1 weighted image

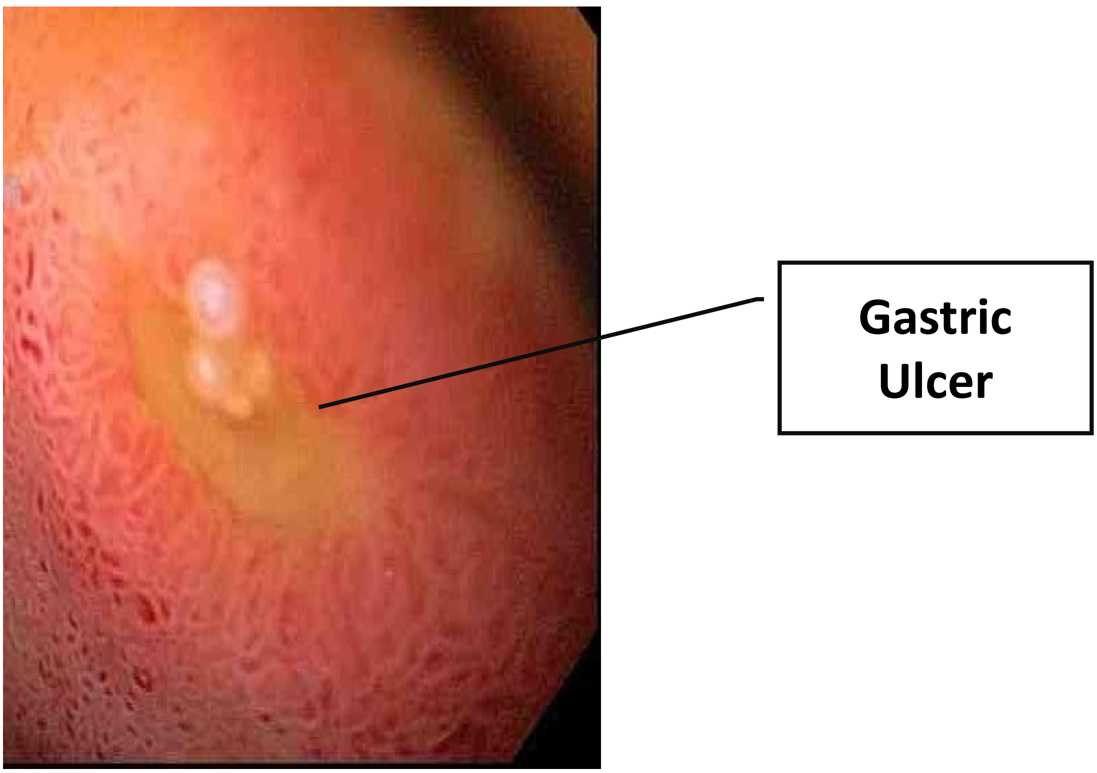


T2 weighted image

NSAIDs

NSAIDs Kill Almost as Many People as AIDS

In 1997 AIDS killed 16,685 people in the US (National Center for Health Statistics).
That year 16,500 people died from gastric bleeding from NSAIDs in the US (New England Journal of Medicine, June 17, 2000 news release).



NSAIDs: A Major Iatrogenic Problem:

"...the annual number of hospitalizations in the United States for serious gastrointestinal complications is estimated to be at least 103,000. At an estimated cost of $15,000 to $20,000 per hospitalization, the annual direct costs of such complications exceed $2 billion."

Wolfe, Michael M., et al, "Gastrointestinal toxicity of nonsteroidal anti-inflammatory Drugs." New Eng Jn of Med. Vol 340. No 24 (Jun 17, 1999).

NSAIDs

NSAIDs inhibit the production of GAG (glycosaminoglycan) and even the replication of chondrocytes.

Dekel, S., J. Falconer, & M.J. Francis, "The effect of anti-inflammatory drugs on glycosaminoglycan sulphation in pig cartilage." Prostaglandins Med. Vol 4. No 3 (Mar 1980).

de Vries, B.J., W.B. van den Berg, & L.B. van de Putte, "Salicylate-induced depletion of endogenous inorganic sulfate. Potential role in the suppression of sulfated glycosaminoglycan synthesis in murine articular cartilage," Arthritis Rheum. Vol 28. No 8 (Aug 1985).

Dingle JT. "The effect of NSAIDs on human articular cartilage glycosaminoglycan synthesis." Eur J Rheum Inflam. 1996;16:47-52.

Hugenberg, S.T., K.D. Brandt, & C.A. Cole, "Effect of sodium salicylate, aspirin, and ibuprofen on enzymes required by the chondrocyte for synthesis of chondroitin sulfate." J Rheumatol.Vol 20. No 12 (Dec 1993).

Yoo, J.U., R.S. Papay, & C.J. Malemud, "Suppression of proteoglycan synthesis in chondrocyte cultures derived from canine intervertebral disc." Spine. Vol 17. No 2 (Feb 1992).

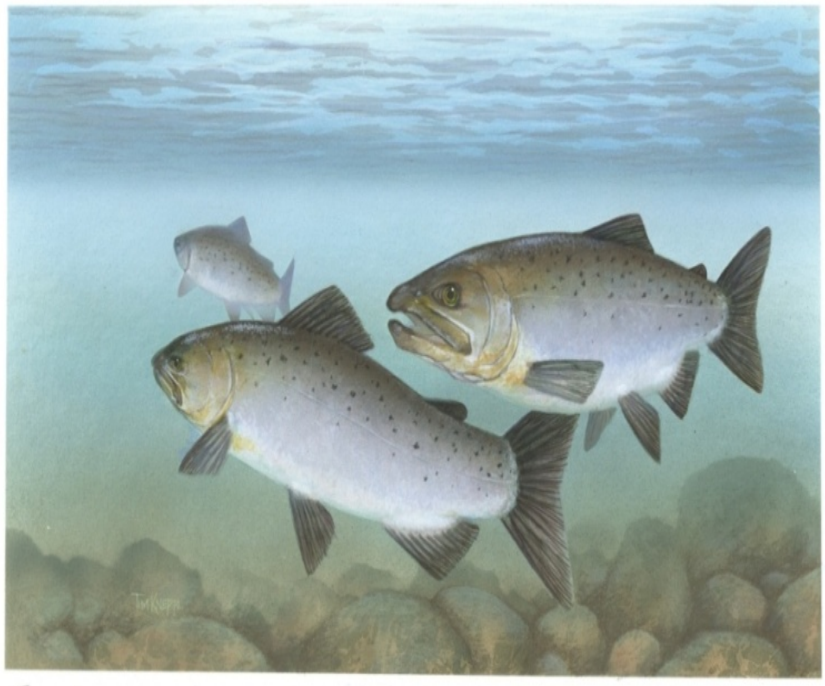
NSAIDs Inhibit Matrix Metalloproteinases

Matrix Metalloproteinases are the substances that help the body to reabsorb herniated disc material. It is conceivable that taking anti-inflammatory drugs could impede disc regression in patients with herniated discs.

Pan, M. R., and W. C. Hung. 2002. Nonsteroidal anti-inflammatory drugs inhibit matrix metalloproteinase-2 via suppression of the ERK/Sp1-mediated transcription. J. Biol. Chem. 277:32775-32780.

Hashizume M, Mihara M. Desirable effect of combination therapy with high molecular weight hyaluronate and NSAIDs on MMP production. Osteoarthritis Cartilage. 2009 Nov;17(11):1513-8. Epub 2009 May 5.

Omega 3 Oils: A Safe Alternative to NSAIDs?



For patients with non-surgical neck and back pain, these neurosurgeons found Omega-3 oils had an equivalent effect to NSAIDS.

Maroon JC, Bost JW. Omega-3 fatty acids (fish oil) as an anti-inflammatory: an alternative to nonsteroidal anti-inflammatory drugs for discogenic pain. Surgical Neurology. 65 (2006) 326– 331April 2006.

Vitamin D: A Safe Alternative to NSAIDs?

Findings showed that 83% of the study patients (n = 299) had an abnormally low level of vitamin D before treatment with vitamin D supplements. After treatment, clinical improvement in symptoms was seen in all the groups that had a low level of vitamin D and in 95% of all the patients (n = 341).

Al Faraj S, Al Mutairi K. Vitamin D deficiency and chronic low back pain in Saudi Arabia. Spine. 2003 Jan 15;28(2):177-9.

References

Al Faraj S, Al Mutairi K. Vitamin D deficiency and chronic low back pain in Saudi Arabia. *Spine*. 2003 Jan 15;28(2):177-9.

An HS, Silveri CP, Simpson JM, File P, Simmons C, Simeone FA, Balderston RA Comparison of smoking habits between patients with surgically confirmed herniated lumbar and cervical disc disease and controls. *Journal of Spinal Disorders* [1994, 7(5):369-373].

Apkarian AV, Sosa Y, Sonty S, et al. Chronic back pain is associated with decreased prefrontal and thalamic gray matter density. *The Journal of Neuroscience*, Nov. 17, 2004 24(46):10410-10475.

Autio RA, Karppinen J, Niinima¨ki J, Ojala R, Kurunlahti M, et al. Determinants of Spontaneous Resorption of
Intervertebral Disc Herniations. *Spine*, Volume 31, Number 11, pp 1247–1252.

Baliki MN, Geha PY, Apkarian AV, Chialvo DR. Beyond feeling: chronic pain hurts the brain, disrupting the default-mode network dynamics
The Journal of Neuroscience, 6 February 2008, 28(6): 1398-1403; doi: 10.1523/JNEUROSCI.4123-07.2008.

Battie MC, et al. " 1991 Volvo Award in clinical sciences. Smoking and lumbar intervertebral disc degeneration: an MRI study of identical twins." *Spine,* 1991; 16:1015 -21.

Bigos, MD. Acute low back problems in adults. *Clinical Practice Guidelines*. December 1994. Potential Harms & Side Effects of Bed Rest (p.53).

Bolgen-Cimen O, Aryncy-Yncel N, Karabiber M, Erdogan C. Role of obesity in low back pain related disability. *West Indian Med J*. 2007;56(3):252.

H. Brisby H, Olmarker K, Larsson K, Nutu M, Rydevik B. Proinflammatory cytokines in cerebrospinal fluid and serum in patients with disc herniation and sciatica. *Eur Spine J* (2002) 11 :62–66.

Buttermann GR. Lumbar disc herniation regression after successful epidural steroid injection. *Journal of Spinal Disorders & Techniques*, December 2002 - Volume 15 - Issue 6 - pp 469-476.

Coppes MH, et al. "Innervation of 'painful' lumbar discs." *Spine,* 1997; 22:2342-2349.

Dekel, S., J. Falconer, & M.J. Francis, “The effect of anti-inflammatory drugs on glycosaminoglycan sulphation in pig cartilage,” *Prostaglandins Med*, Vol 4, No 3 (Mar 1980).

de Vries, B.J., W.B. van den Berg, & L.B. van de Putte, “Salicylate-induced depletion of endogenous inorganic sulfate. Potential role in the suppression of sulfated glycosaminoglycan synthesis in murine articular cartilage,” *Arthritis Rheum*, Vol 28, No 8 (Aug 1985).

Dingle JT. The effect of NSAIDs on human articular cartilage glycosaminoglycan synthesis*. Eur J Rheum Inflam* 1996;16:47-52.

Djurasovic M, Bratcher KR, Glassman SD, Dimar JR, Carreon LY. The effect of obesity on clinical outcomes after lumbar fusion. *Spine* (Phila Pa 1976). 2008;33(16):1789-1792.

Doita M Kanatani,T, Ozaki T ,Matsui N, Kurosaka M, Yoshiya S. Influence of Macrophage Infiltration of Herniated Disc Tissue on the Production of Matrix Metalloproteinases Leading to Disc Resorption. *Spine*: 15 July 2001 - Volume 26 - Issue 14 - pp 1522-152.

Freemont AJ, et al " Nerve growth factor expression and innervation of the painful intervertebral disc." *J Pathol* 2002 ;197:286-292

Freemont AJ, Peacock TE, Goupille P, Hoyland JA, O'Brien J, Jayson MI.. Nerve in-growth into the diseased intervertebral disc in chronic back pain. Lancet, 1997 ;350:178 -81

Haro H, Shinomiya K, Murakami S, Spengler DM. Upregulated expression of matrilysis and neutrophil collagenase in human herniated discs. *J Spinal Disord* 1999;12:245–9.

Hashizume M, Mihara M.Desirable effect of combination therapy with high molecular weight hyaluronate and NSAIDs on MMP production. Osteoarthritis Cartilage. 2009 Nov;17(11):1513-8. Epub 2009 May 5.

Heliövaara M Body height, obesity, and risk of herniated lumbar intervertebral disc. *Spine* [1987, 12(5):469-472]

Henmi T, Sairyo K, Nakano S. Natural history of extruded lumbar intervertebral disc herniation. *J Med Invest* 2002;49: 40–3.

Hugenberg, S.T., K.D. Brandt, & C.A. Cole, “Effect of sodium salicylate, aspirin, and ibuprofen on enzymes required by the chondrocyte for synthesis of chondroitin sulfate,” *J Rheumatol*, Vol 20, No 12 (Dec 1993).

Ito T, Yamada M, Ikura F, Fukuda T, Hoshi SI, Kawaji Y, Uchiyama S, et al. Histologic evidence of absorption of sequestration-type herniated disc. *Spine* 1996;21:230–4.

Matsui, Y, Maeda M, Nakagami W, Iwata, H. The Involvement of Matrix Metalloproteinases and Inflammation in Lumbar Disc Herniation. *Spine*:
15 April 1998 - Volume 23 - Issue 8 - pp 863-868.

Maroon JC, Bost JW. Omega-3 Fatty acids (fish oil) as an anti-inflammatory: an alternative to nonsteroidal anti-inflammatory drugs for discogenic pain. *Surgical Neurology* 65 (2006) 326–331April 2006.

McGuire, MD, MHSc et al. A 30-Year Follow-Up of the Dallas Bed Rest and Training Study. Circulation 2001;104: 1350-1357.

Modic MT, Steinberg PM, Ross JS, et al. Degenerative disc disease: Assessment of changes in vertebral body marrow with MR imaging. *Radiology*, 1988;166:193-9.

Modic MT, Ross JS. Lumbar degenerative disk disease. *Radiology*. 2007 Oct;245 (1): 43-61.

Murphy DR, Hurwitz EL, McGovern EE. A nonsurgical approach to the management of patients with lumbar radiculopathy secondary to herniated disk: a prospective observational cohort study with follow-up. *J Manipulative Physiol Ther*. 2009 Nov-Dec;32(9):723-33.

Ozaki S, Muro T, Ito S & Mizushima M. Neovascularisation of the outermost area of herniated lumbar intervertebral discs. *J Orthop Sci* 1999;4:286-92.

Palmgren T, et al. " Imminohistochemical demonstration of sensory and autonomic nerve terminals in herniated lumbar disc tissue." *Spine* 1996; 21:1301-1306.

Pan, M. R., and W. C. Hung. 2002. Nonsteroidal anti-inflammatory drugs inhibit matrix metalloproteinase-2 via suppression of the ERK/Sp1-mediated transcription. *J. Biol. Chem*. 277:32775-32780.

Svensson GL, Lundberg M, Ostgaard HC, Wendt GK. High degree of kinesiophobia after lumbar disc herniation surgery: a cross-sectional study of 84 patients . *Acta Orthop*. 2011 Dec;82(6):732-6. Epub 2011 Nov 9.

Teplick JG, Haskin ME: Spontaneous regression of herniated nucleus pulposus. *AJR* 145: 371-375, 1985.

Virri J, Gronblad M, Seitsalo S, Habtemariam A, Kappa E & Karaharju E. Comparison of the prevalence of inflammatory cells in subtypes of disc herniations and associations with straight leg raising. *Spine* 2001;26:2311-5.

Welgus HG, Campbell EJ, Cury JD, Eisen AZ, Senior RM, Wilhelm SM, Goldberg GI. Neutral metalloproteinases produced by human mononuclear phagocytes. Enzyme profile, regulation, and expression during cellular development. *J Clin Invest*. 1990;86(5):1496–1502.

Wolfe, Michael M., et al, "Gastrointestinal Toxicity of Nonsteroidal Antiinfammatory Drugs" *New Eng Jn of Med* Vol 340, No 24 (Jun 17, 1999).

Yoo, J.U., R.S. Papay, & C.J. Malemud, "Suppression of proteoglycan synthesis in chondrocyte cultures derived from canine intervertebral disc," *Spine*, Vol 17, No 2 (Feb 1992).

Extension Exercises

22

Extension Exercises

Lumbar extension exercises are based on the concept that the nucleus of healthy discs migrate forward away from the spinal nerves when the lumbar spine is arched.

In the 1960s Robin McKenzie popularized a system of spinal rehabilitation that incorporated extension exercises as well as several other exercises. For this reason many erroneously refer to extension exercises as “McKenzie Exercises.” Robin McKenzie’s greatest contribution to spine care may be the promotion of patient involvement in their own treatment.

This chapter will provide a simplified overview of extension exercises.

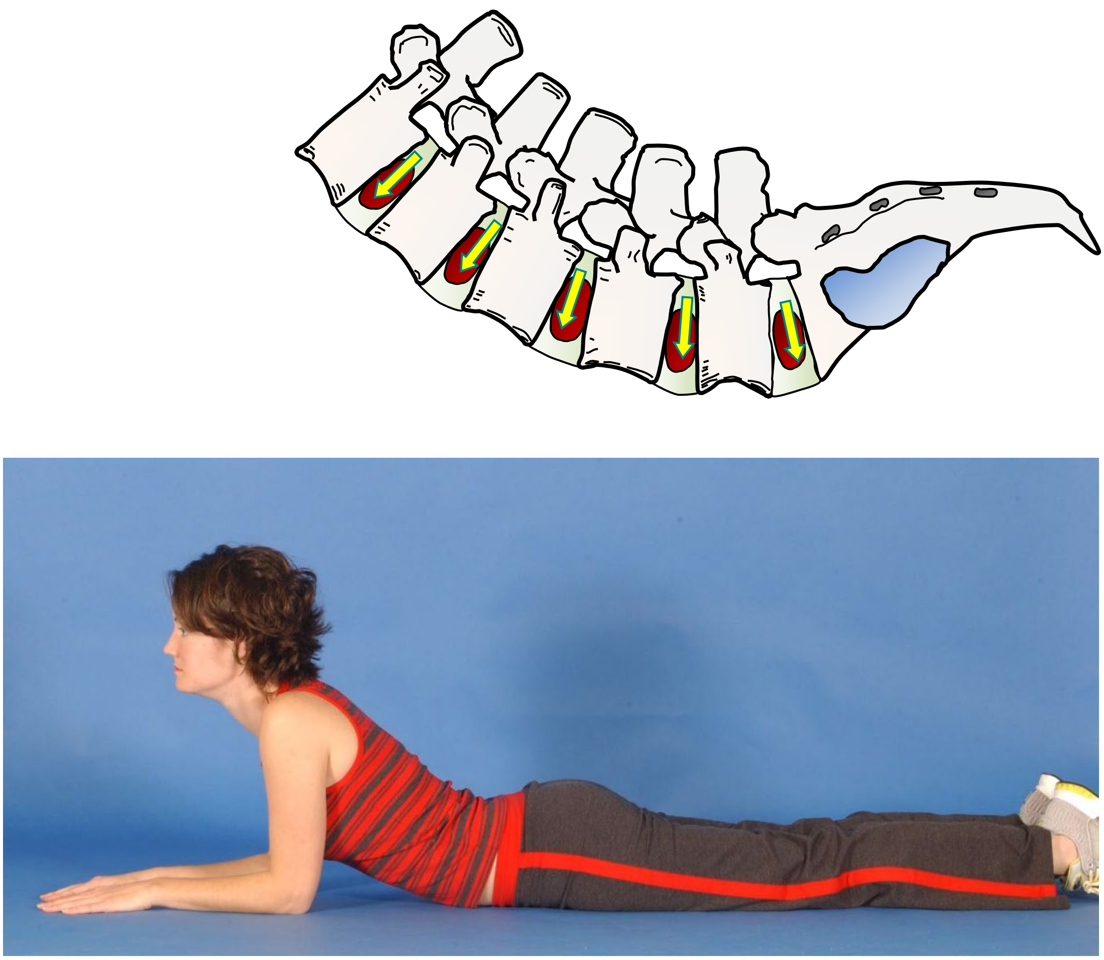


Figure 22:1. Lumbar extension exercise**.**

Centralization

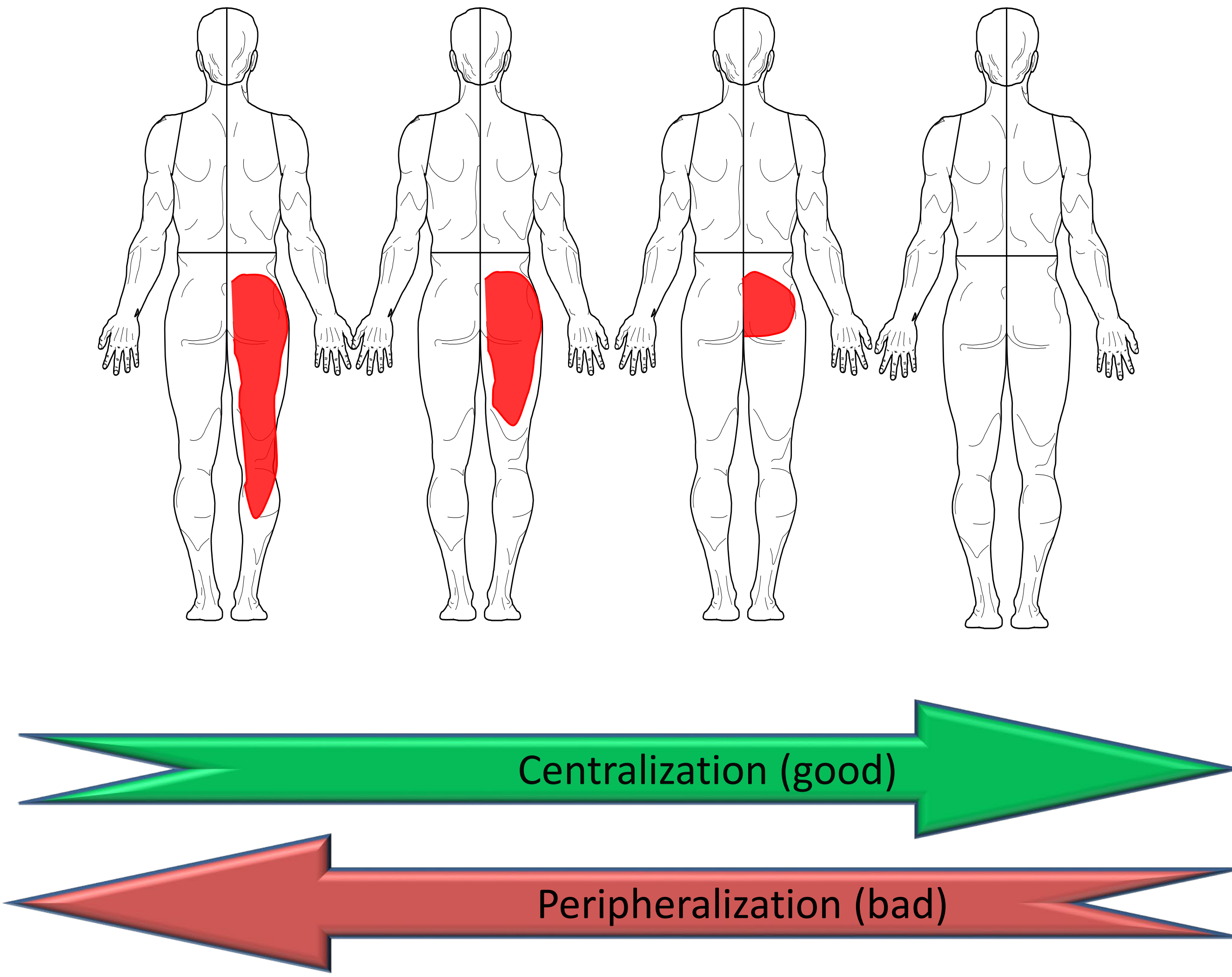


Figure 22:2. This schematic shows various distributions of leg pain in sciatica. Treatment that results in centralization (symptoms regressing to a more central location) is considered to be successful, while treatment that results in peripheralization (symptoms extending further down the leg) is not successful. If extension exercises cause peripheralization, discontinue them immediately. You may note a temporary mild increase in back pain with extensions. This is acceptable as long as the leg pain centralizes.

.

Extension Exercises

Figure 22:3. Lying in Extension: Begin by lying on your stomach. If you are not obese, this will put a slight arch in your lower back. Lie in this position for 5-10 minutes. If this is well-tolerated or if it reduces your symptoms, you may progress to the next step.

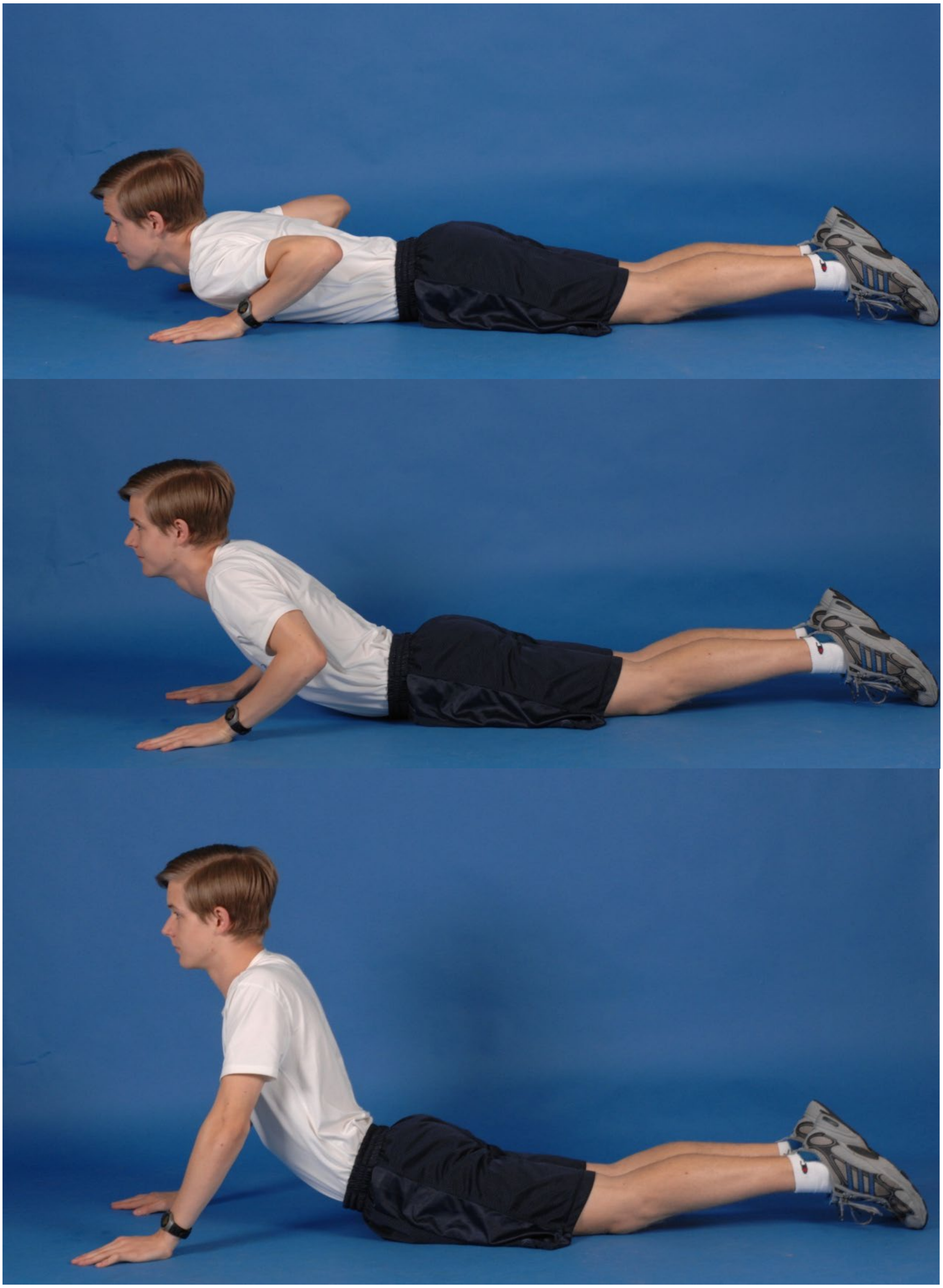
Figure 22:4. Elbow Extensions: Rest on your elbows for 30 seconds to 5 minutes, then lie down again.

Lying in Extension: Begin by lying on your stomach (figure 22:3). If you are not obese, this will put a slight arch in your lower back. Lie in this position for 5-10 minutes. If this is well tolerated or if it reduces your symptoms, you may progress to the next step. Rest on your elbows (figure 22:4) for 30 seconds to 5 minutes, then lie down again.

This may be repeated every hour until symptoms regress. You may reduce the frequency, duration of extension, or the number of repetitions to accommodate your tolerance of this exercise. Slowly return to the neutral position. Use slow, controlled, transitional movements. Rapidly straightening out may produce discomfort.

You may modify this exercise by using pillows placed under your chest to help prop you into position.

Extension Exercises



Figures 22:5, 6, and 7. Full Extensions: Progress to full extensions as you are able to tolerate this exercise. Hold the extended position for five seconds. Slowly lower your upper body. Repeat up to ten times.

Extension Exercises

If extension is painful or causes symptoms to expand further down your leg, stop them. You may modify extension exercises by laterally bending to one side or another while extending. If you are able to find a position that reduces your symptoms, continue. If not, discontinue attempts of extension exercises. While all disc patients should limit spinal flexion, not all patients should do extensions. Listen to your body.

Figure 22:8. Standing lumbar extensions: Place your elbows against a wall for support and as a spacer. Glide your pelvis toward the wall until a comfortable arch is produced. You may be able to touch the wall with your pelvis. Hold for 20 seconds and repeat.

Standing extensions may be performed throughout the day. They may be particularly beneficial after sitting or bending.

Extension Exercises

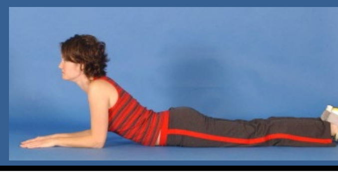
Timeline	Elbow Extensions 	Full Extensions 
Day One	Lie on stomach. If comfortable, attempt to rise to elbow extension for 30 seconds. If provocative, do not continue with extensions. If this position reduces pain and centralizes sciatica, perform every hour.	Do not attempt full extensions.
Early Stages of Healing (typically from week one to four)	Thirty seconds to two minutes every hour, depending your tolerance. Do not exceed your tolerance for these exercises. Discontinue if these increase the level of pain or cause peripheralization of symptoms down your leg.	After three days of elbow extensions with relief, attempt one set of full extensions. If these full extensions are beneficial in reducing pain and centralizing symptoms, you may begin to add two sets per day following a set of elbow extensions. Continue with one set at mid-day and another set in the evening.
Mid Stages of Healing (four weeks to three months)	Thirty seconds to five minutes, five times per day	If full extensions are well-tolerated, perform ten press-ups holding for five seconds in extension. Perform after elbow extensions throughout the day.
Late Stages of Healing, living pain free (when pain diminishes to occasional minimal pain)	Two minutes, twice a day and after periods of flexion.	

Figure 22:9

Extension Exercises are Not for Everyone

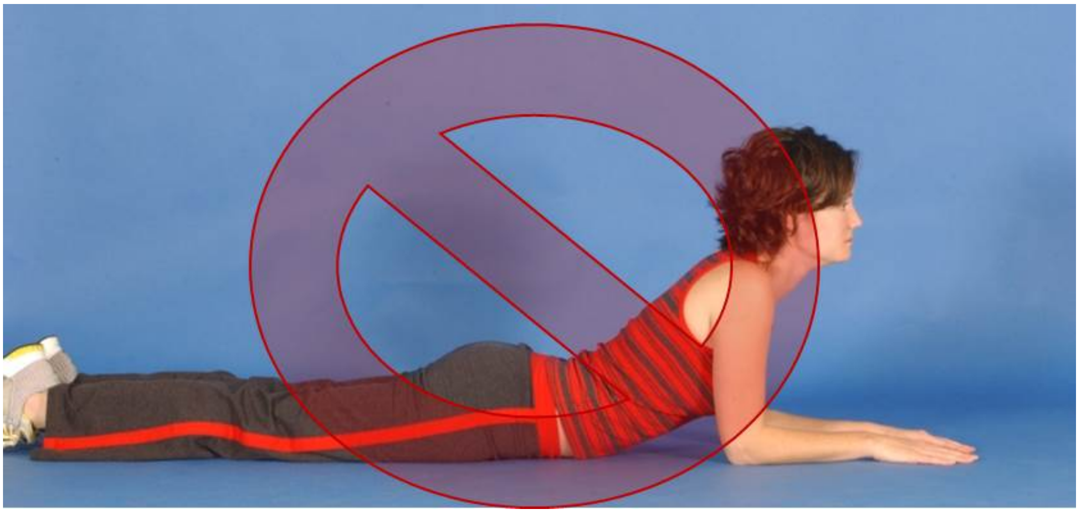


Figure 22:10. Certain conditions can be made worse with extension exercises. These include spondylolysis, spondylolisthesis, spondylosis, stenosis, facet disease, arthritis, or degenerative disc disease.

Pregnant women and anyone with recent spinal surgery should not perform these exercises. Pregnant women may perform standing extension exercises under the supervision of their physician if extension reduces the pain.

Additionally, avoid extension if peripheralization occurs (if extension causes a further progression of pain down the leg). Some people will not be able to tolerate extensions when they first rise in the morning. If extension is painful early in the morning, wait 1½ hours and attempt extension again. If extension exercises are still provocative, discontinue this line of exercise.

Figure 22:11. Some disc lesions are so large that that they are not able to benefit from extension exercises. Some conditions will even worsen with extensions. Moderation and physician supervision is advised for managing disc injuries.

Extension Exercises are Not for Everyone

Discontinue any exercise, activity, or treatment that causes peripheralization of symptoms.

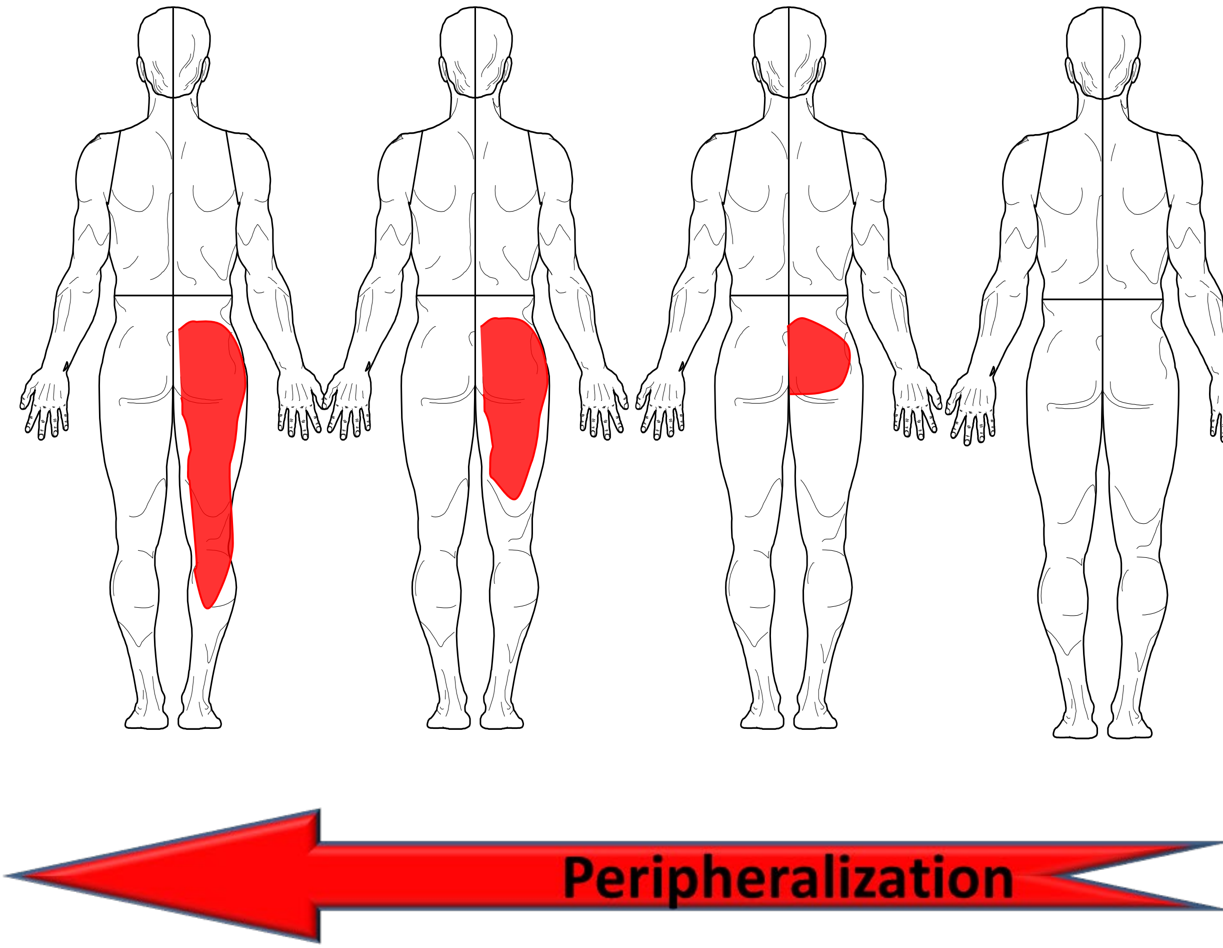


Figure 22:12

Extension Exercises are Not for Everyone

Special Cases

Not everyone with a disc herniation is a good candidate for extension exercises. The next couple pages will address some conditions which may become worse with extension exercises.

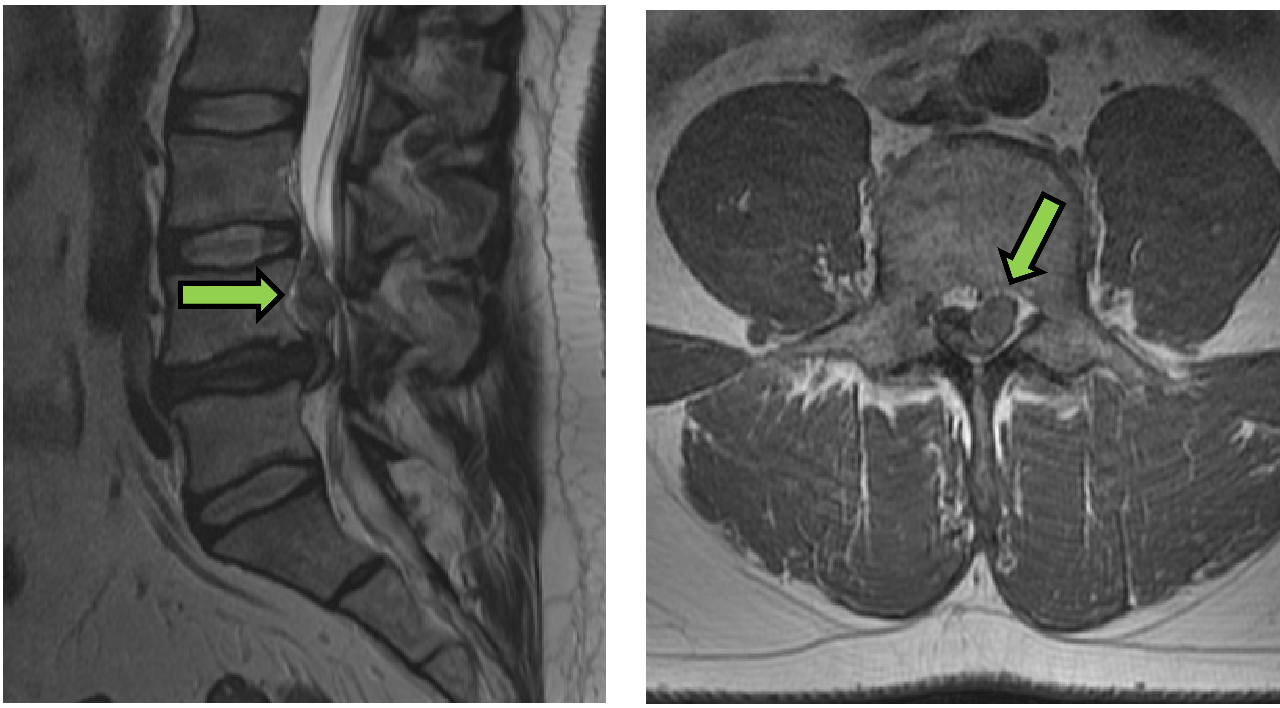


Figure 22: 13 and 14. Sequestered Fragments. Be particularly careful in monitoring extension exercises in patients with sequestered disc fragments.

Extension Exercises are Not for Everyone

Knife-Clasp Syndrome

A " knife-clasp syndrome" occurs when there is a spina bifida occulta of one vertebral segment coupled with an elongated spinous process of the segment above. This can allow for the spinous process to press into the gap left by the spina bifida occulta and produce pain.

Lumbar extension exercises could be provocative to patients with a knife-clasp syndrome.

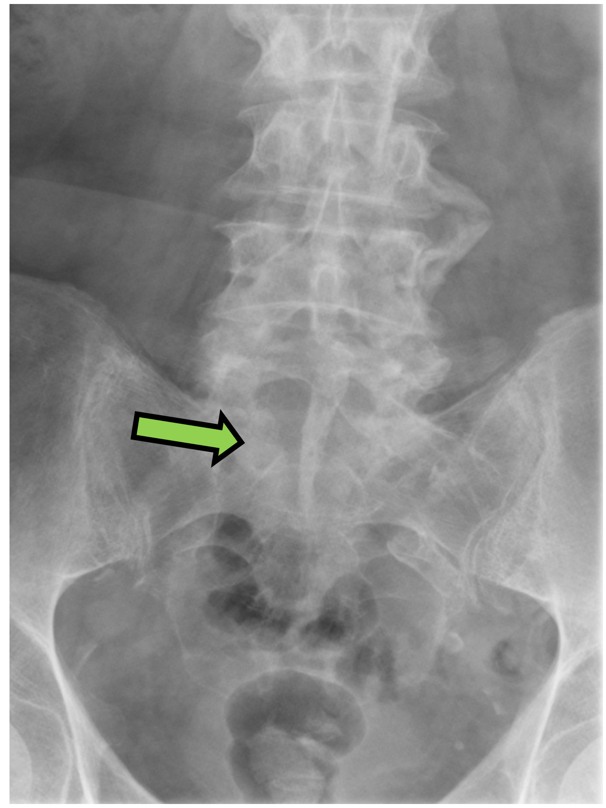


Figure 22: 15. In this plain film A-P radiograph of the lumbar spine, the green arrow points to an elongated spinous process that extends in a spina bifida occulta of the S1 and S2 segments of the sacrum.

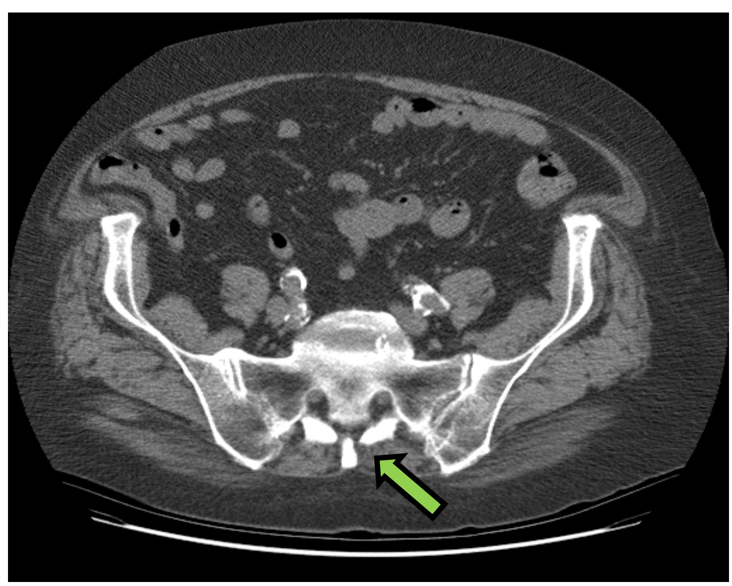
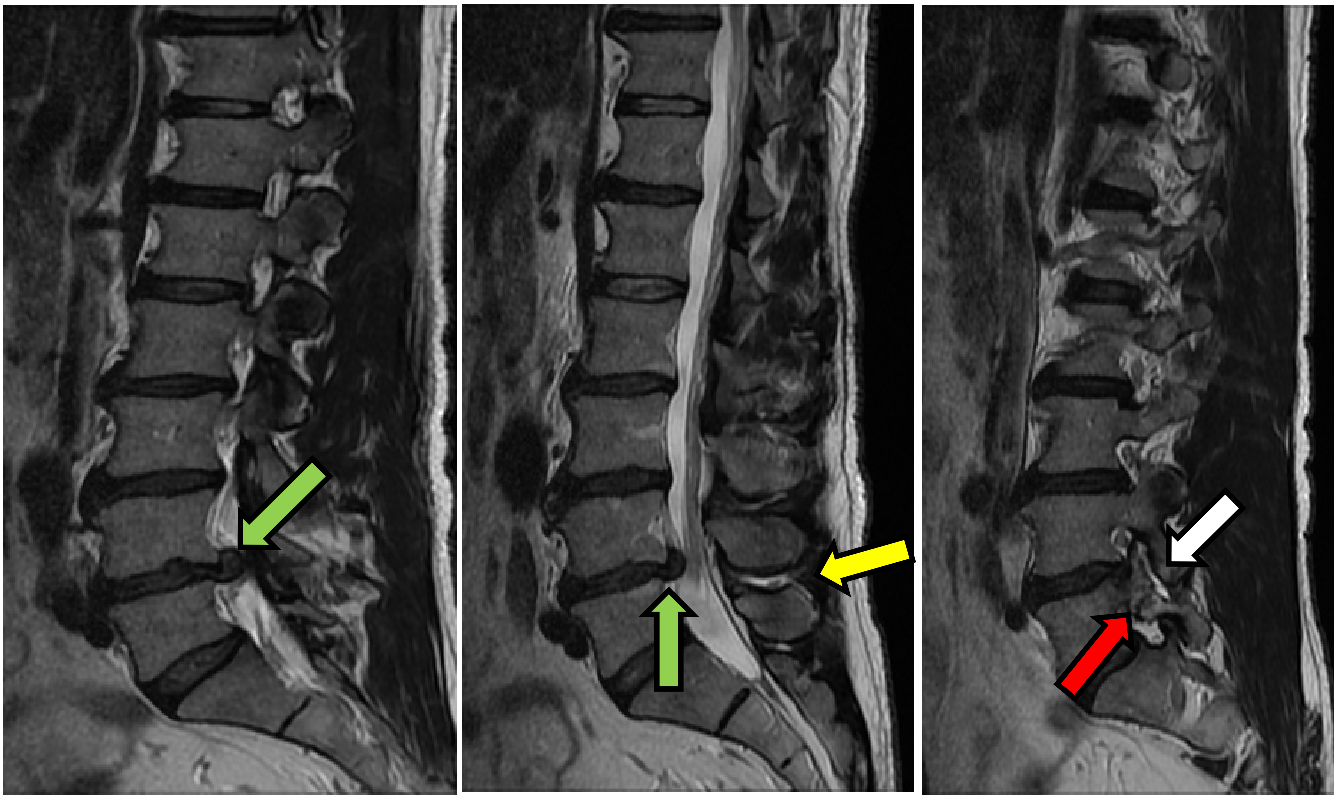


Figure 22: 16. In this axial CT image, the knife-clasp is clearly visible (green arrow).

Extension Exercises are Not for Everyone



Figures 22: 17. These sagittal T2 weighted MR images demonstrate three conditions that could be aggravated by lumbar extension exercises. The green arrows point to an L4-L5 disc extrusion which may or may not be helped by lumbar extension exercises. The yellow arrow points to interspinous process bursitis (Basstrup's disease) which would probably be aggravated by lumbar extension. The red arrow points to a pars interarticularis lysis, and the white arrow points to effusion of the L4-L5 zygapophyseal joint. Both of these conditions can also be provoked by lumbar extension exercises.

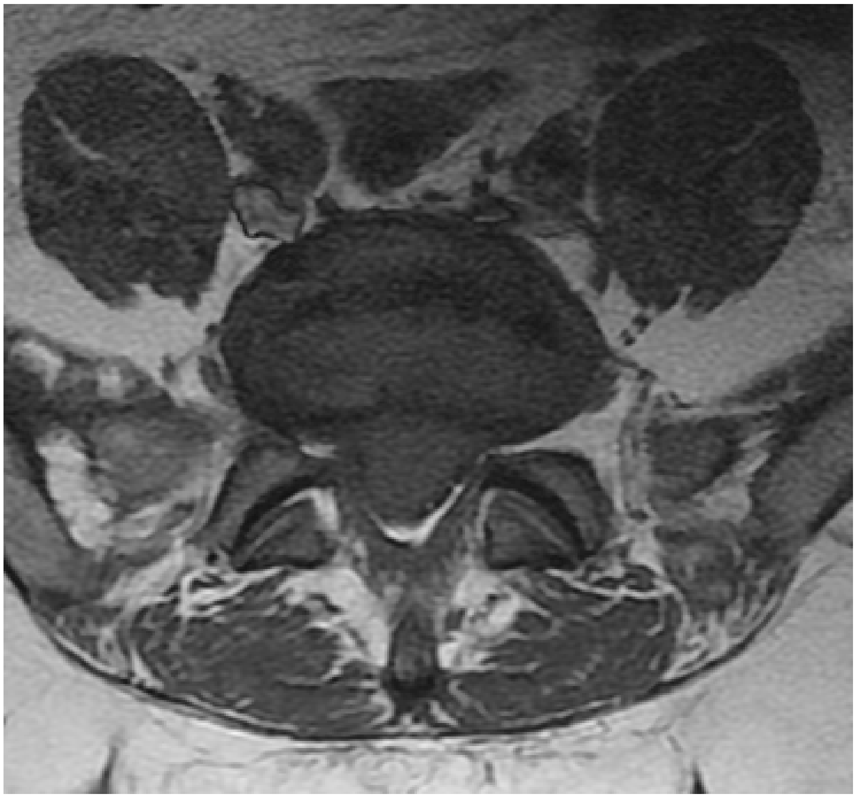


Figure 22:18 A severe herniation is visible in this axial T2W image.

Huge Disc Herniations

Lumbar extension exercises may be provocative to patients with very large disc herniations.

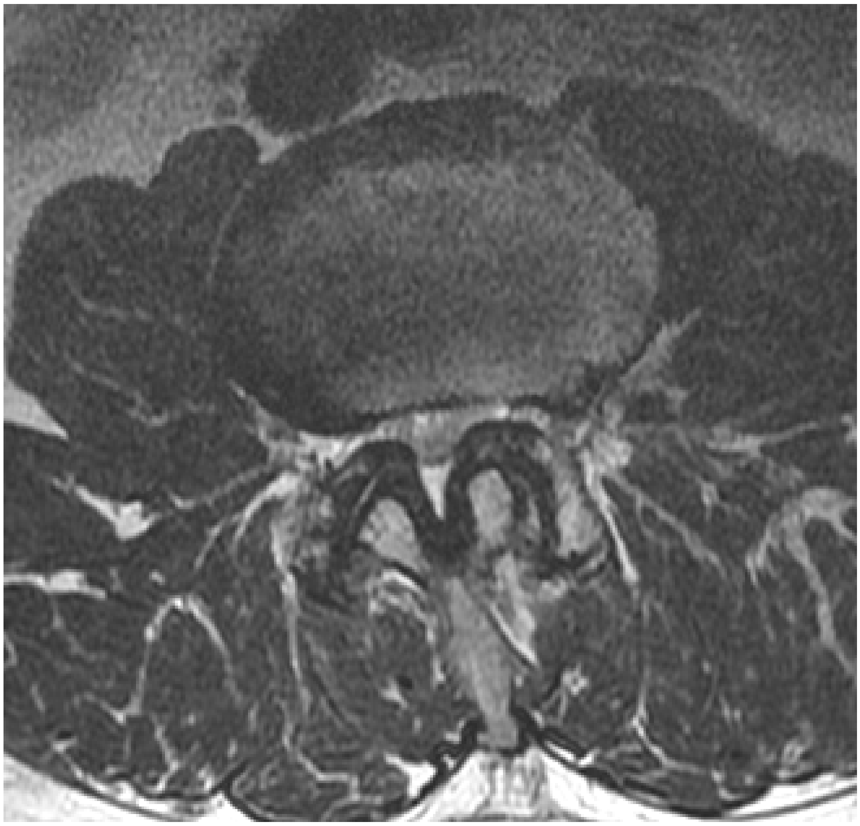


Figure 22: 19. A central canal stenosis is visible in this axial T2 weighted MRI.

Stenosis

Central canal stenosis and foraminal stenosis are worsened with lumbar extension.

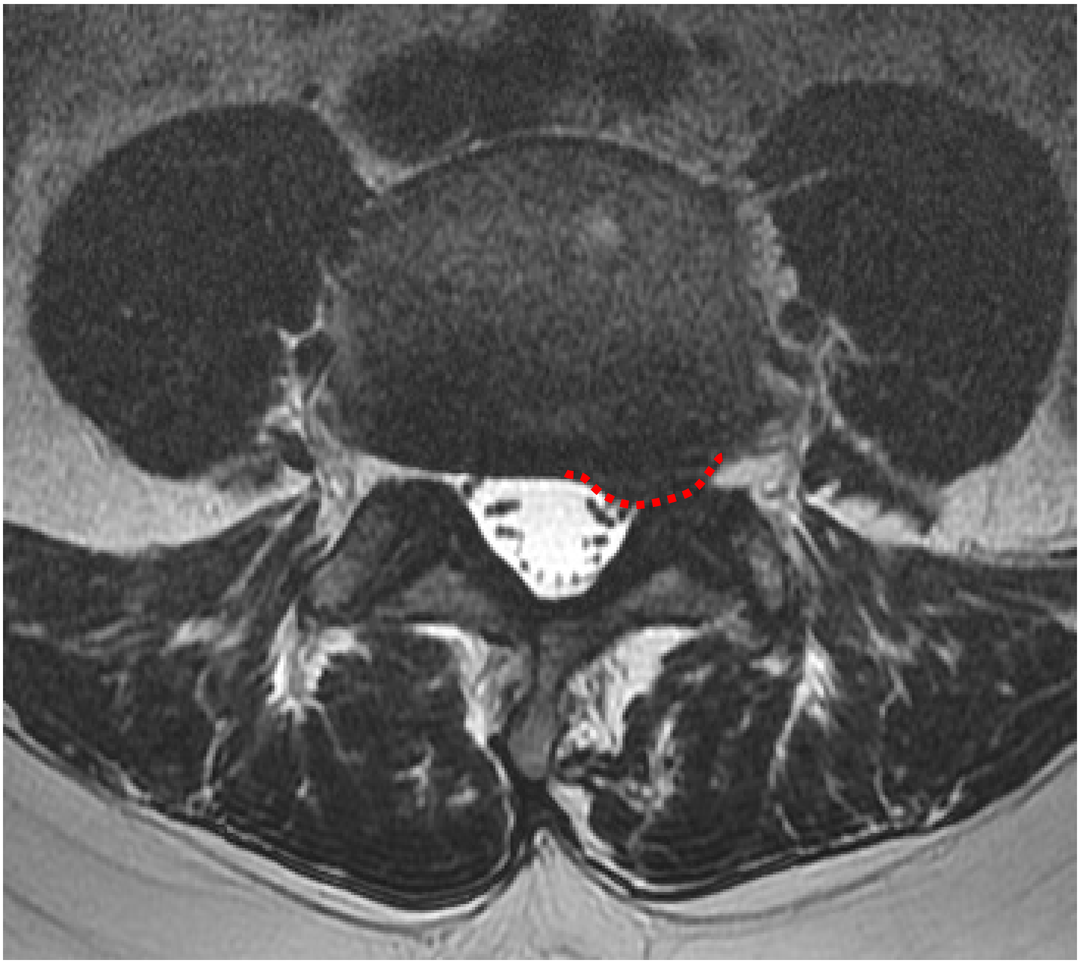


Figure 22: 20. A left-sided foraminal protrusion is visible in this axial T2 weighted MRI.

Foraminal herniations

Lumbar extension may place greater pressure on an exiting nerve root in patients with a foraminal herniation.

Extension Exercises are Not for Everyone: Spondylolisthesis

Figure 22: 21. An L5 spondylolisthesis is visible in this sagittal T2 weighted MRI.

Pars defects and spondylolisthesis

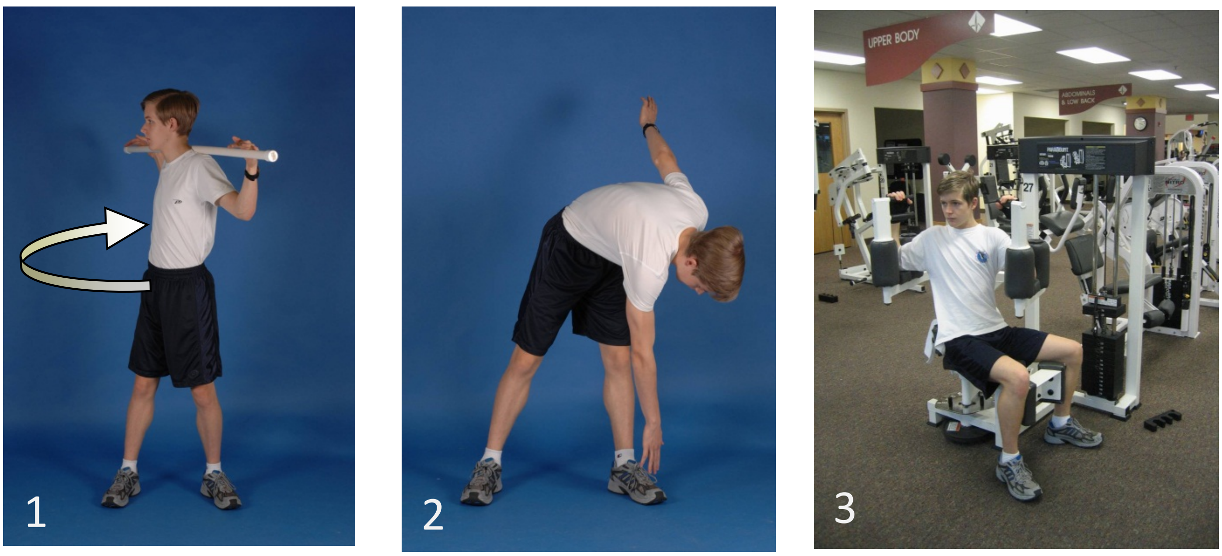
Spondylolysis and spondylolisthesis are almost always aggravated by lumbar extension.

23

Exercises to Avoid To Protect Your Disc

Exercises to Avoid

Certain exercises should always be avoided, especially if you have suffered from a disc injury. These hazardous exercises use excessive bending or twisting motions or bending and twisting while under load. This chapter identifies several common exercises that are hazardous to the lumbar discs. While there are hundreds of potentially risky exercises being performed on a daily basis in exercise classes, on DVDs, and proposed by well meaning trainers, we cannot expose them all. But once you get the sense of what to avoid, you should be able to apply this knowledge to your own fitness program.



Figures 23:1, 2, and 3. 1. Twisting with a stick. 2. Alternate toe touching. 3. Resisted twisting.

Twisting

Twisting exercises put excessive torsion stress on lumbar discs. Do not be tempted to stretch your spine with the broom stick twist (figure 23:1). There can only be limited benefit from this stretch, but there is a substantial risk for injury.

Bending and twisting or sitting and twisting combines (figure 23:2) two damaging motions to place the spine at greater risk. Toe touching and windmills should not be part of any exercise program.

Adding resistance to rotational exercises (figure 23:3) can increase the likelihood of injury. Avoid all twisting exercise machines, especially those that involve the use of weights or other resistance.

Twisting in athletics

The safest manner to transfer energy in athletics or manual work is to stiffen the muscles of the abdominal wall to limit spinal motion and to pivot from the hips. The main power of athletic rotation should come from the muscles of the hip, particularly the gluteal muscles.

Exercises to Avoid

Forward Bending ***(Spinal Flexion)***

Figures 23:4, 5, and 6. Forward bending.

Double knee to chest stretches (figure 23:4) may feel good for certain spinal conditions, but typically should be avoided due to the pressure placed on the lumbar discs.

Toe touching (Figures 23:5 and 23:6) with a curled spine does more damage than good. In spite of many practitioners prescriptions for hamstring stretches, research does not strongly link hamstring tightness with back pain. Patients and doctors often mistake the nerve tension caused by a herniated disc for tight hamstrings and mistakenly try to stretch it out. This can cause a worsening of the condition.

This common stretch exerts tremendous pressure on the lumbar discs. The ability to flex is not an indicator of spinal health or fitness. Some research has shown that people with more flexible spines were actually at greater risk for back injury.

Alternate (Safe) Hamstring Stretches

Figure 23:7. Hamstrings can be safely stretched while maintaining an arch in the lower back.

Caution

Stretching the hamstring muscles can tug on an irritated sciatic nerve. Many people mistake sciatic nerve tension, caused by a herniated lumbar disc, with tight hamstrings. Trying to stretch the hamstrings can be provocative to an irritated nerve. Do not attempt to stretch out leg tightness if you are suffering from an acutely herniated disc.

Do not mistake the author's description of safe alternative exercises as a recommendation for treatment of an acute disc herniation.

Figure 23:8. Hamstrings can be safely stretched while maintaining an arch in the lower back.

The hamstring muscles can be safely stretched by maintaining an arch in the lower back and raising the chest while slowly bending until a comfortable hamstring stretch is felt. Stretch one leg at a time by putting the heel of the foot on an elevated surface.

Another safe alternative hamstring stretch involves lying on your back with a strap, towel, or cord looped over your foot. Gently stretch one leg at a time while maintaining a comfortable arch in your lower back.

Hold these stretches for 30 seconds, twice per leg.

Leg Press

.

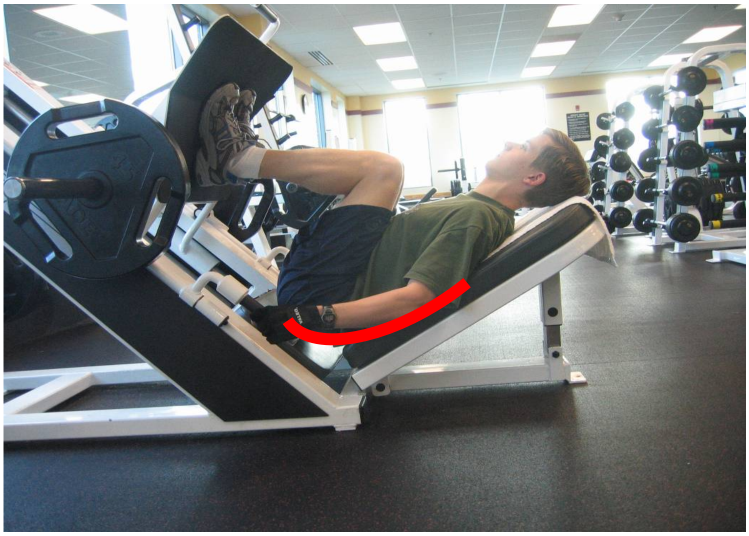


Figure 23:9. Two-legged leg presses cause the spine to flex into a dangerous position. Note the amount of lumbar flexion which occurs when the legs are fully bent.

Figure 23:10. Alternative exercise. Switching to a one-legged leg press will reduce the disc pressure for those who feel compelled to include this exercise. In addition, having a lumbar support will help prevent injuries.

Ironically many weight lifters switch to leg presses from squats in an attempt to spare their lumbar spine from injury. This exercise allows the person to use extremely large amounts of weight while flexing the spine into a dangerous position.

Caution

An alternate method of performing leg presses is offered for those who are not suffering from the effects of a herniated disc, but would like a safe alternative to standard leg presses.
If you have an acute lumbar disc herniation do not even perform the alternative version of leg presses.

Exercises to Avoid

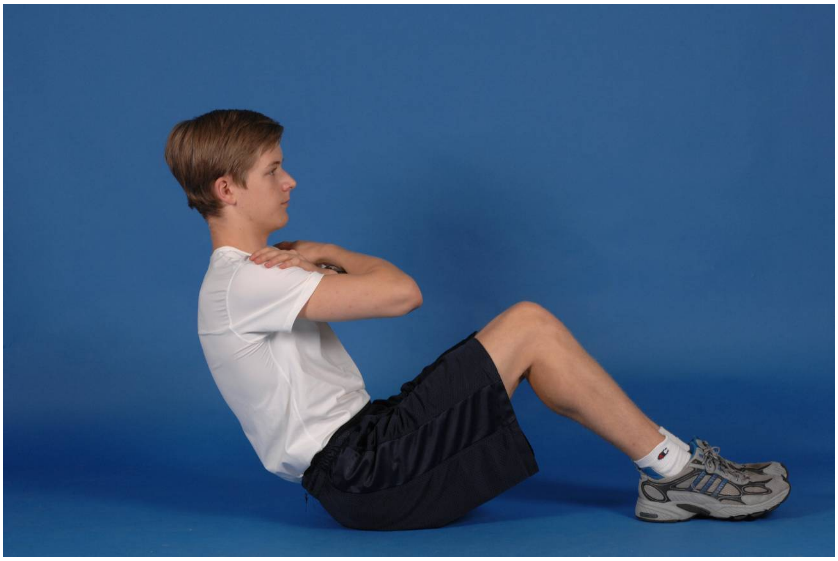


Figure 23:11. The sit-up and even the crunch are exercises that repeatedly flex the spine in a disc damaging manner. These exercises should be avoided if possible.

Figure 23:12. Incorporating a twist into the sit-up combines two damaging motions and offers little additional training benefit.

Exercises to Avoid

Figure 23:13. Bending and lifting.

Bending over with a curved spine is always an unwise maneuver, but lifting weights while bent over is especially risky. This motion places a tremendous amount of pressure on the disc and can contribute to debilitating injuries. Do not perform straight-leg dead lifts and bent rowing.

Figure 23:14. Lifting with a flexed spine or while sitting is a common source of disc injuries.

Weights

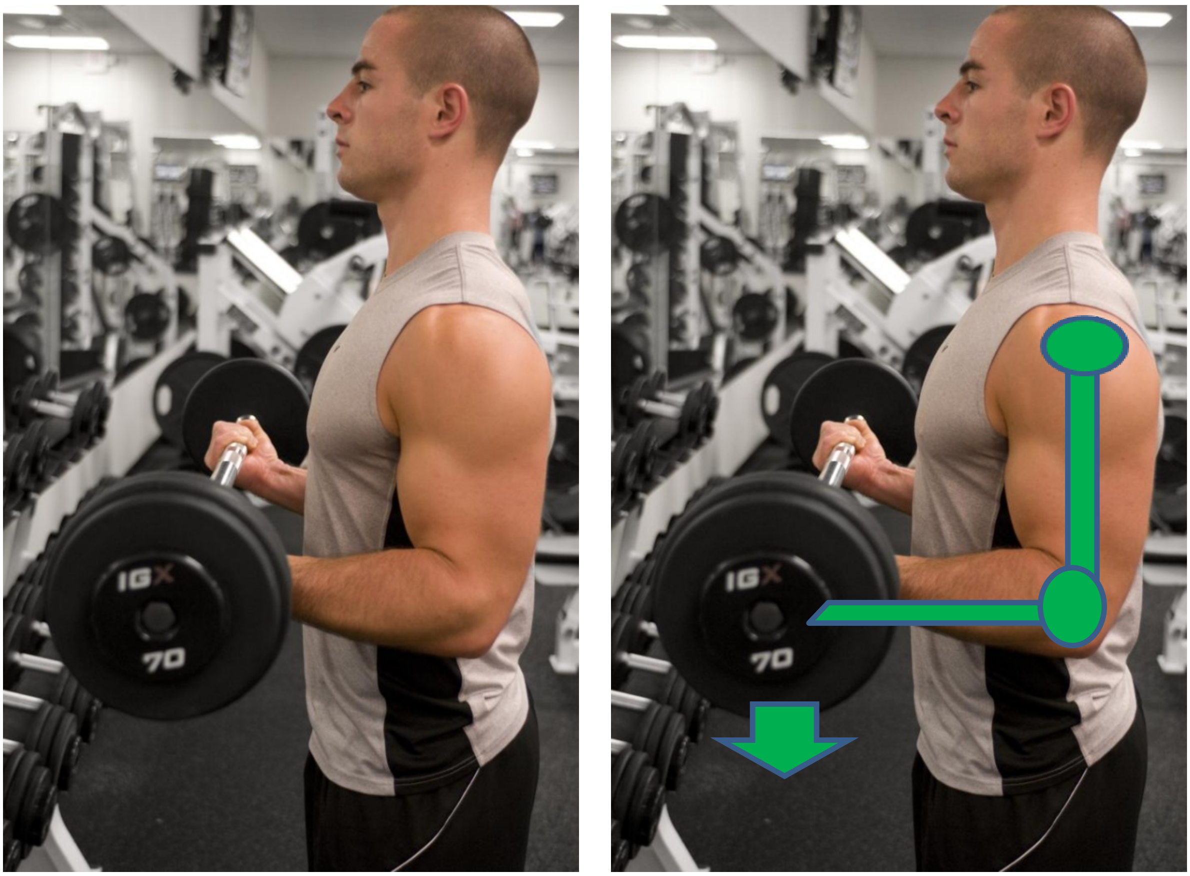


Image courtesy of the Center for Disease Control and Amanda Mills

Exercises which hold weight away from the body will not only put axial pressure on the spine, but will tend to pull the trunk forward creating even greater forces on the lumbar disc. While recovering from a disc injury, this type of exercise should be avoided.

Recreation

Bicycles and exercise bikes usually require truncal flexion, and truncal flexion can provoke a herniated disc. These exercises should be avoided while healing from a disc derangement.

Recreational activities that require truncal flexion such as kayaking and canoeing should be avoided while recovering from a lumbar disc herniation.

Image courtesy of the Center for Disease Control and Amanda Mills

Strengthening the Core

24

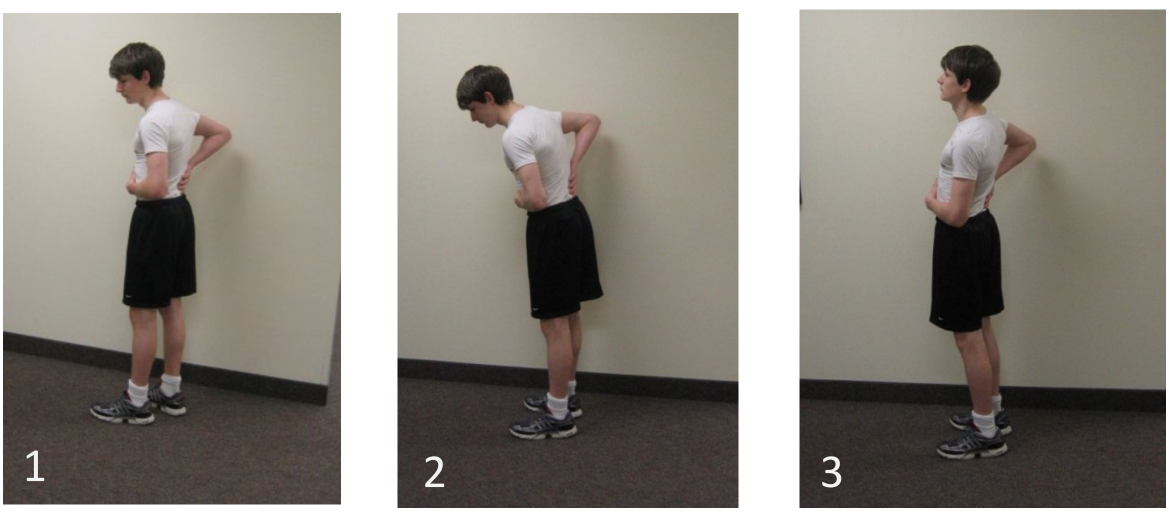
Activating the Core

Following a spinal injury, particularly an injury to the disc, certain spinal stabilizing muscles begin to weaken or deactivate. When these muscles lose their ability to protect the spine from further injury, a downward spiral of injury → weakness → fear → activity avoidance-weakness → re-injury occurs.

To prevent this downward spiral from occurring, it is advisable to begin core stabilizing exercises as early as they can be tolerated after an injury. This line of exercises is based on the ability to contract the corset of muscles comprising the "core."

Before beginning this exercise program it is important to understand there is a fine line between beneficial therapy and injurious overexertion. This program is a phased approach to spinal stabilization. Be patient. It will take months to realize the benefits of these stabilization exercises. Of course if these exercises increase your pain, discontinue them immediately.

The research and writings of Stuart McGill, PhD, has provided the world with much of our knowledge of spinal rehabilitation. For physicians interested in understanding the science behind these exercises, I recommend his writings.



Figures 24:1, 2, and 3. Activating the core muscles.

To learn how to activate these muscles, place the fingertips of one hand on the spinal muscles just to the side of the bony protuberances found at the midline of the spine (figure 24:1). The other hand should be positioned on the abdominal muscles. Bend forward at the waist until you feel the muscles of your lower back contract (figure 24:2). Note how this feels, then arch your spine until the spinal muscles relax under your fingers (figure 24:3). While maintaining this position, stiffen your abdominal muscles until you feel your spinal muscles contract, like they did when you bent over at the waist. Note how this feels with both hands. Practice isolating these muscles.

If bracing in this manner aggravates your condition, reduce the degree of abdominal contraction. If even mild contraction produces pain, discontinue and seek advice from your doctor.

Core Strengthening Exercises

Once you have learned to activate the muscles of the core, you may be able to perform simple exercises to coax these muscles into action. Begin by gently stiffening your muscles, about 5-10% of maximum contraction, and going for a walk. Try to maintain the contraction for 5-10 minutes of walking. Gradually increase the amount of time that you walk while stiffening your core muscles.

In the early weeks of a disc herniation, walking and co-contraction of your core may be the primary exercises of rehabilitation.

To activate the key muscles of the core, three exercise components should be present:

1. A stiffening of the abdominal muscles
2. An involvement of the arms and legs
3. A balance component to the exercise

Walking with co-contraction of the core accomplishes all three of these components of muscle training. This will be the foundational rehabilitation exercise in the early portion of healing.

Stiffening is good for developing the protective muscles of the core, but it does have the potential for increasing the pressure in the disc. For this reason, spinal stabilization exercises should be gradually introduced. Start with walking, and then add additional exercises in a progressive manner. More rigorous exercises (planking and side planking) may not be added until well into the healing process. It is better to perform core stabilization exercises in moderation every day, than to perform long rigorous workouts. Walking can be performed every day, while the floor exercises should be done 4-6 times per week.

The Bird Dog

Figure 24:4 . Alternate arm and leg raising, *the Bird Dog.*

Alternating Arm and Leg Raising (The Bird Dog)
From the quad stance and while contracting the core muscles tense (tightening them in a comfortable contraction and stiffening these muscles while maintaining a "neutral spine"), lift one leg and the opposite arm to parallel with the ground. Hold the arm and leg in this position for eight seconds. As strength and fitness improves it is preferable to add more repetitions of this exercise rather than holding the arm and leg up for longer periods of time. Be mindful to maintain proper technique. Avoid hiking the hip, twisting, or curling the spine.

Caution

Before continuing I would like to interject a word of caution. The next three exercises have the potential to aggravate a disc injury if performed too early in your recovery or on the wrong individual. Consult your physician before beginning this or any exercise program.

These exercises may take months to initiate if at all. Do not perform the bridge, the side bridge, or the curl-up if these aggravate your symptoms or cause peripheralization. Gradually introduce these exercises, starting with the bird dog. The bird dog may be introduced 6-8 weeks following the initial disc injury. The other exercises should be added later.

Curl-Ups

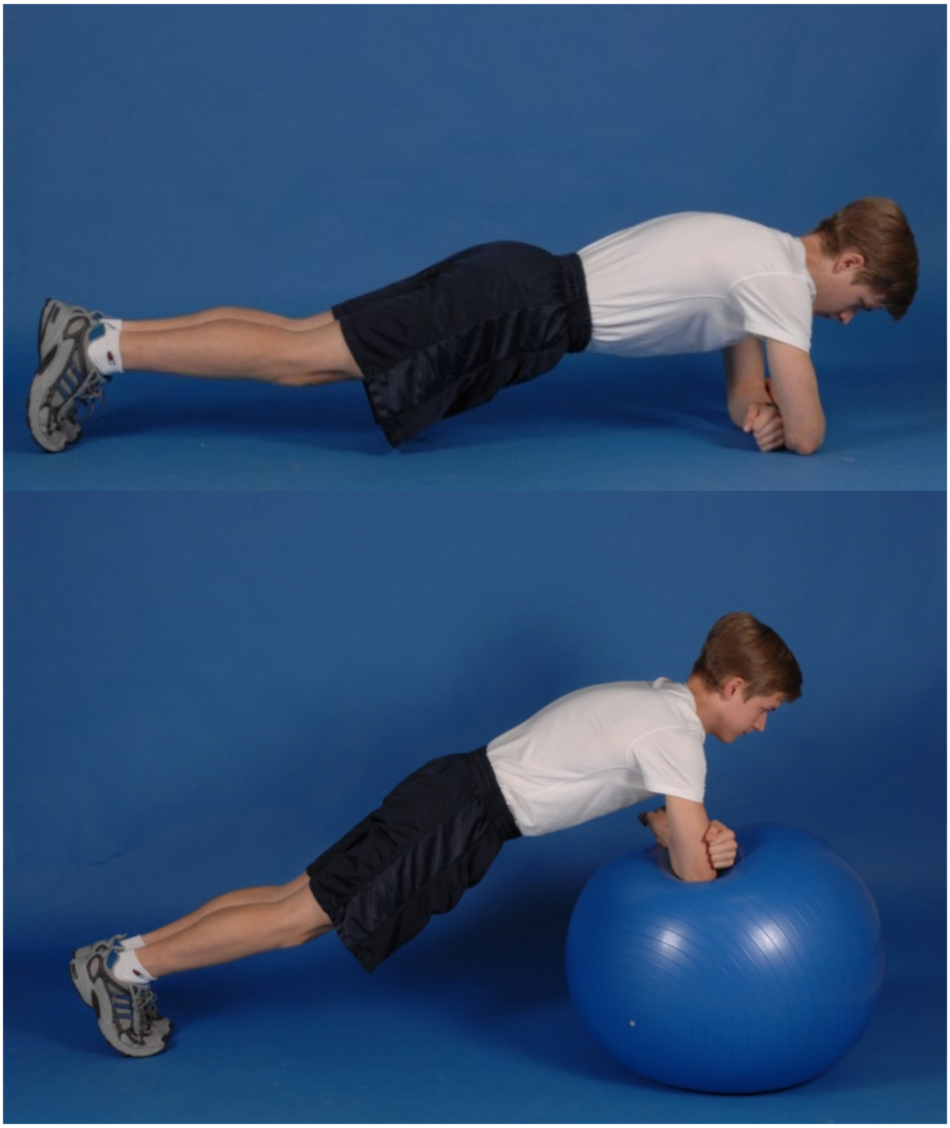
Figure 24:5. Curl-ups.

Curl-ups

This exercise is intended to work the abdominal muscles while protecting the lumbar discs. The key to this exercise is the isolation of the abdominal muscles while avoiding spinal flexion. Lay on your back with your arm or a folded towel under your lower back. One knee is bent, while the other is straight. The exercise is performed by stiffening the core and then curling the upper back off the floor a few inches while maintaining the neutral spinal curve of the lower back. Avoid jutting the neck or head forward while performing this exercise.

Hold contractions for up to 8 seconds. Build muscular endurance by gradually increasing the number of repetitions. Alternate which leg is bent at the midpoint of repetitions.

Planking



Figures 24:6 and 24:7. Planking and advanced planking.

Planking

Planking involves stiffening your body into a plank while supporting yourself on the balls of your feet and your elbows. Concentrate on stiffing the back and abdominal muscles while maintaining a stiff posture.

An easier version would involve starting on your knees or using a countertop while standing. An advanced version of this exercise (Figure 24.7) would include placing the elbows or the feet on an exercise ball. This could be added in more athletic individuals months after symptoms have resolved.

Hold contractions for up to 8 seconds. Build muscular endurance by gradually increasing the number of repetitions.

Side Bridges

Figure 24:8. Side-bridge on knees.

Side Bridges
Form a bridge with your body with your elbow supporting your upper body and your knees supporting your lower body. Stiffen your stomach and back muscles and strive to keep your spine straight. Hold contractions for up to 8 seconds. Build muscular endurance by gradually increasing the number of repetitions. This exercise should be performed on both sides.

An easier version of this exercise would involve leaning against a countertop.

Figure 24:9. Advanced side-bridge.

A higher level of intensity for this exercise can be obtained by bridging from the elbow to the feet. The top foot should be in front of the bottom foot.

Combining Core Stabilizers

Combining side bridges and planking can add intensity to your core stabilization program. Start in a side plank and hold for eight seconds. Next, transition to a plank for eight seconds and then to a side plank on the other side. Stiffen your core so that your ribs, pelvis, and trunk move as one unit. Do not allow your torso to sag, twist, or bend.

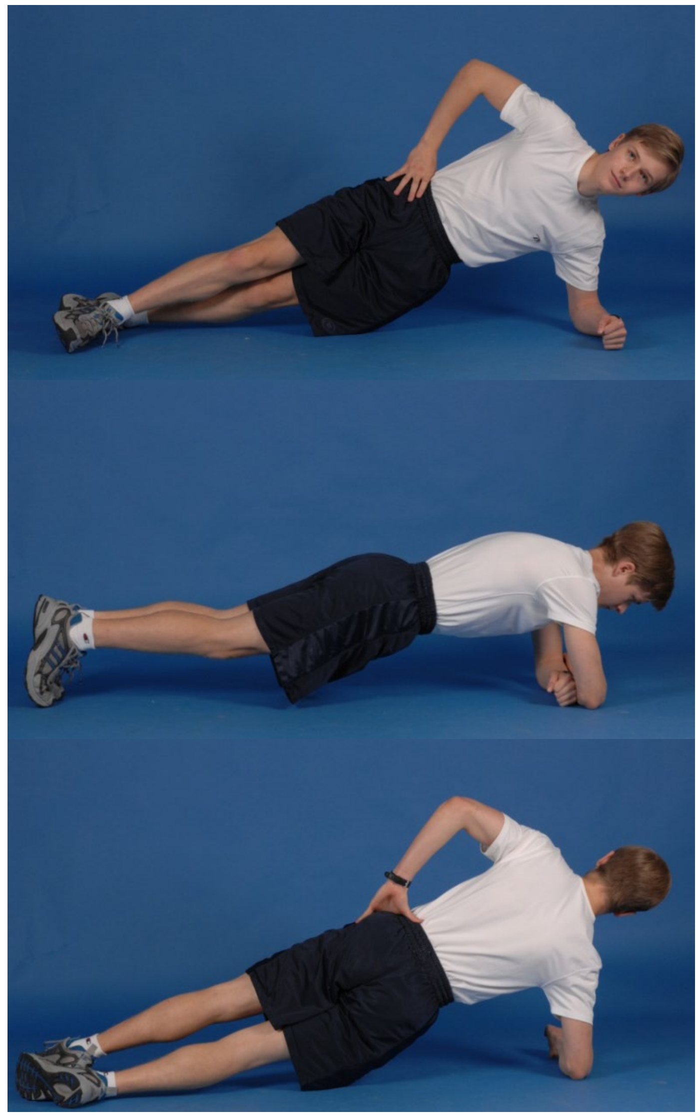


Figure 24:10. Combining core exercises.

Cable Core Exercises

Cable exercises for engaging the core stabilizers

There are innumerable variations of cable exercises that can be used to activate the muscles of the core. The main concept is that the spine should not move during these exercises. The muscles of the core should inhibit motion, but transfer force. While stiffening the core muscles, use arm, shoulder, and hip motions to move a cable with resistance.

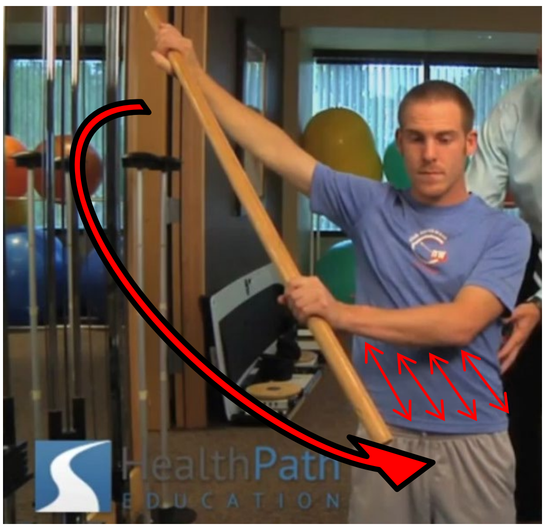



Figure 24:11 and 12. Kneeling cross-body cable presses.   While maintaining stiffness of the abdominal muscles, the patient moves the bar across the body moving only the arms and shoulders. Start with a light weight that will not provoke the patient's injury.

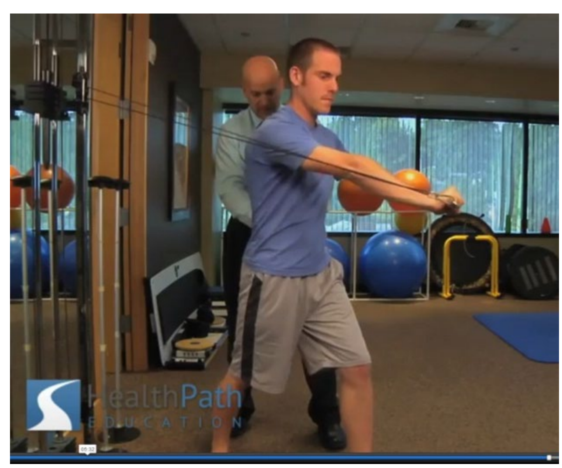



Figure 24:13 and 14. Standing cross-body cable presses.   While maintaining stiffness of the abdominal muscles, the patient moves the bar across the body moving only the arms and shoulders.

Gradual Integration of Core Stiffening Exercises

These exercises should be introduced in a graduated and integrated manner. Phase 1 should be implemented as soon as one is able to tolerate these exercises. Phase 2 should be introduced after the acute pain diminishes and leg pain begins to regress. Phase 3 exercises are introduced when the disc symptoms can be controlled with posture, motion, and position changes. These exercises may be implemented in conjunction with extension exercises.

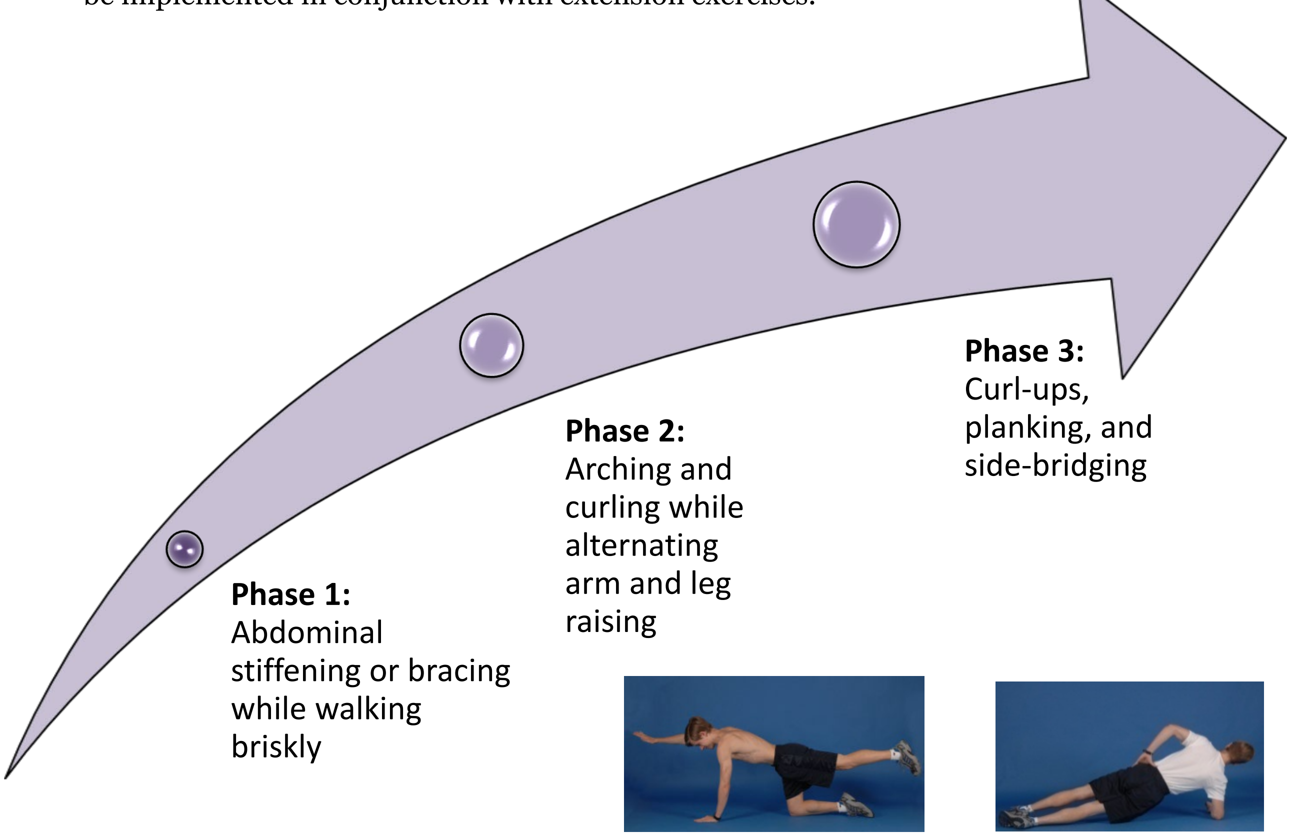


Figure 24:15. Slowly progress through the stages of core stabilization by gradually phasing in exercises.

Sample Timeline for Disc Healing

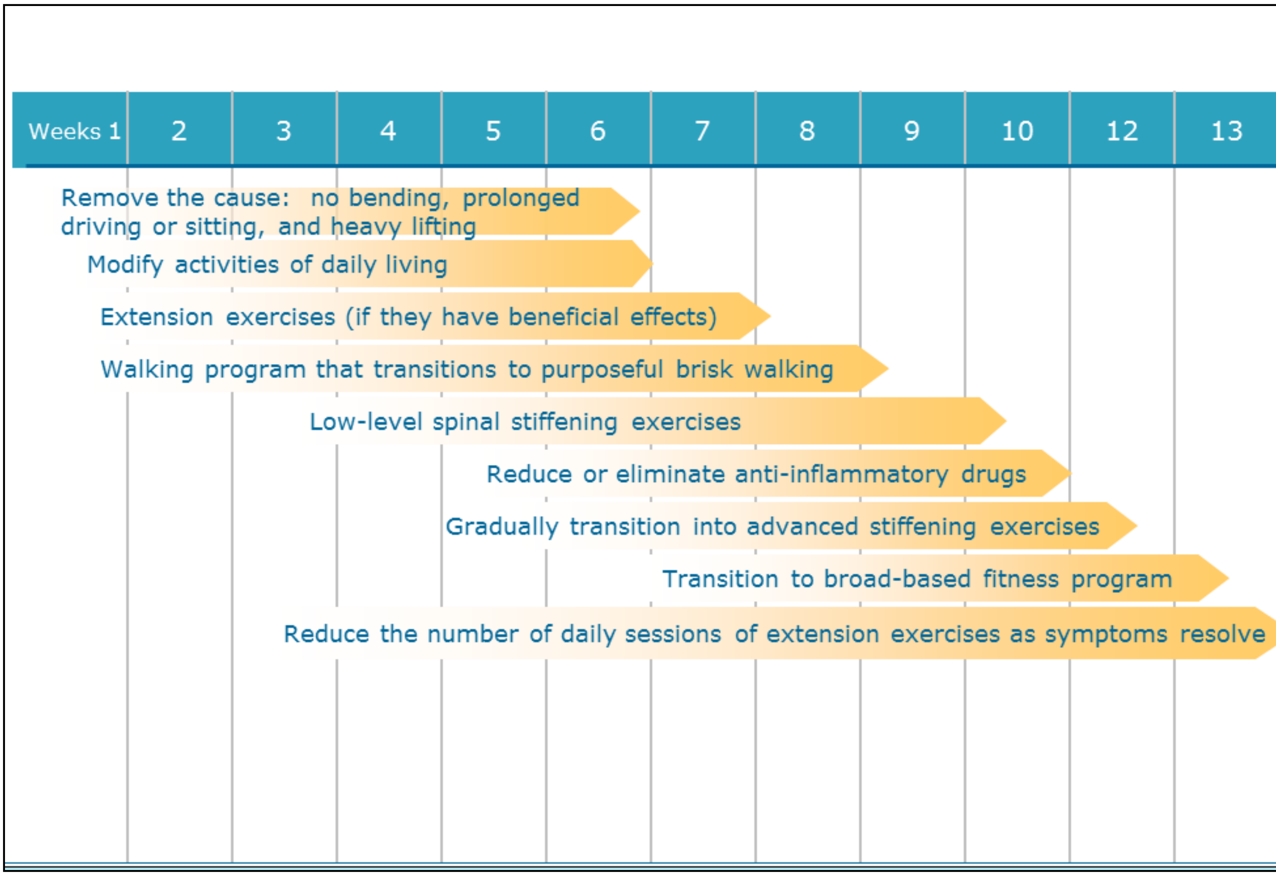
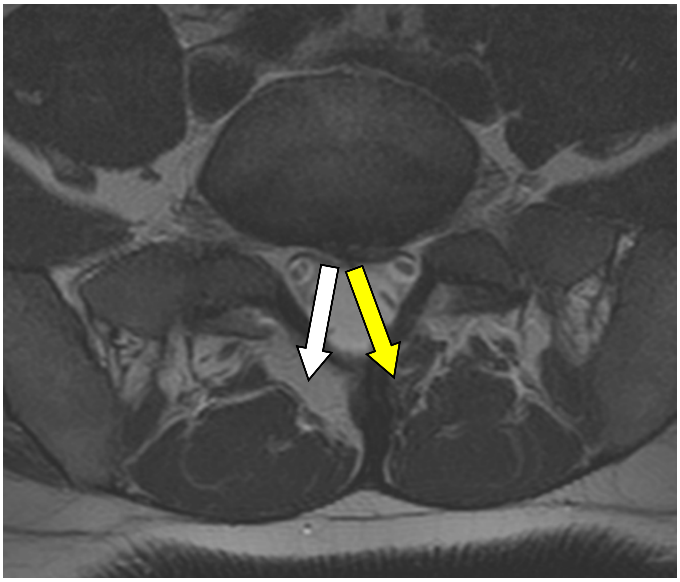
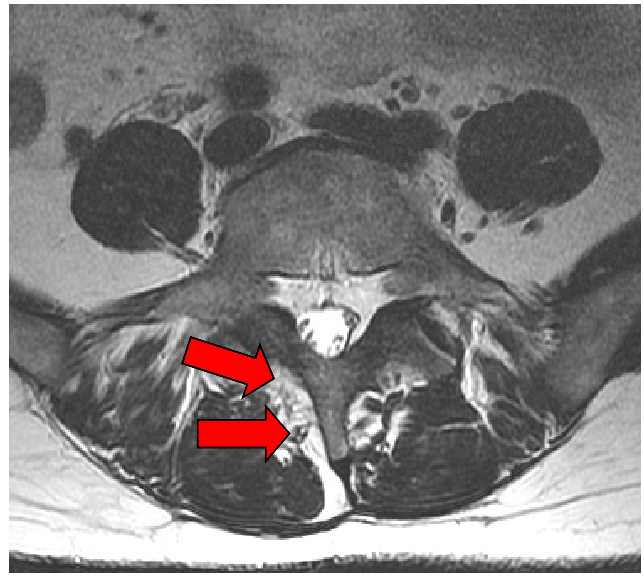


Figure 24:16. Sample timeline of recovery.

Rehabilitation of the spine following a lumbar herniation is a very individual process. Some patients may take many months before they can tolerate core stabilization exercises. Some patients do remarkably well with just a walking program of rehabilitation. It is important to proceed at a safe pace and not to rush the process. Work with your physician, chiropractor, or therapist to progress at a safe pace. The goal is to restore normal function and to transition to a broad-based fitness program that will promote strength and aerobic fitness. This may take three to six months and at times longer. Sometimes there are permanent restrictions that inhibit a full return to a broad-base program of fitness.

Multifidus Atrophy Following Injury

Manipulation Improves Recruitment of Multifidus Muscles

Koppenhaver SL, et al. Association between changes in abdominal and lumbar multifidus muscle thickness and clinical improvement after spinal manipulation. *JOSPT,* 2011;41(6):389-99.

Fritz JM, et al. Preliminary investigation of the mechanisms underlying the effects of manipulation: exploration of a multivariate model including spinal stiffness, multifidus recruitment, and clinical findings. *Spine*, 2011;36(21):1772–1781.

Tunnell J. Needle EMG response of lumbar multifidus to manipulation in the presence of clinical instability. J Man Manip Ther. 2009; 17(1): E19–E24.

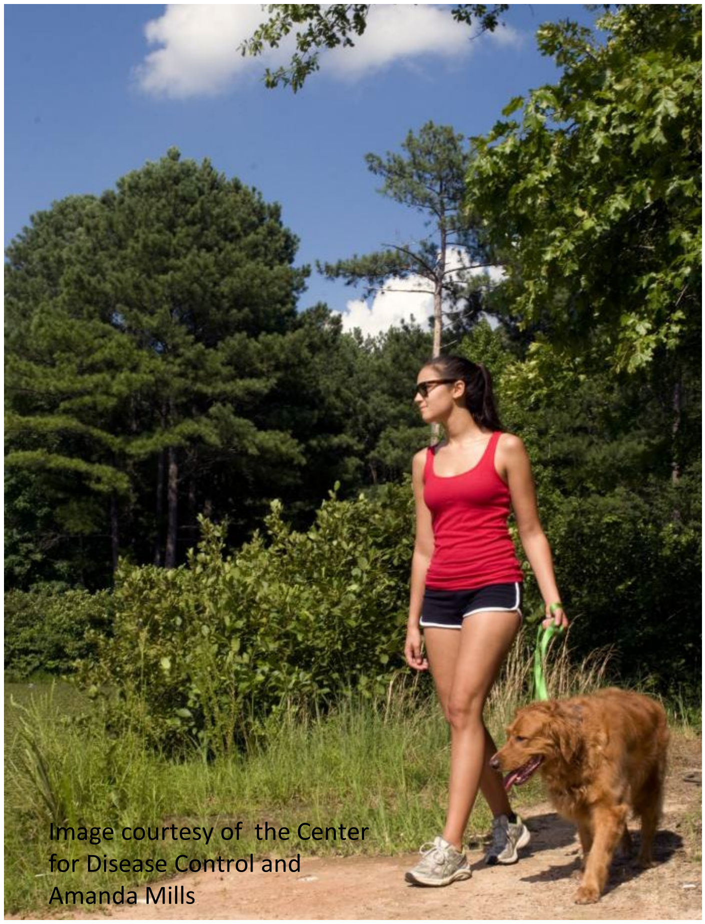


Image courtesy of the Center for Disease Control and Amanda Mills

Walking with co-contraction of the core accomplishes all three of these components of muscle training. This is the foundational rehabilitation exercise in the early portion of healing.

References

Aultman, C.D., Scannell, J., and McGill, S.M. (2005) Predicting the direction of nucleus tracking in porcine spine motion segments subjected to repetitive flexion and simultaneous lateral bend. Clinical Biomechanics, 20:126-129.

Axler, C., and McGill, S.M. (1997) Low back loads over a variety of abdominal exercises: Searching for the safest abdominal challenge. Medicine and Science in Sports and Exercise, 29(6):804-811.

Bogduk N. *Clinical Anatomy of the Lumbar Spine and Sacrum, 3rd Edition*. Churchill Livingstone, Edinburgh, 2001.

Brennan, G.P.; Fritz, J.M.; Hunter, S.J.; Thackeray, A; Delitto, A; Erhard, R.E.: Identifying subgroups of patients with acute/sub acute “non-specific” low back pain. *Spine*; 2006; 31:623-631

Callaghan, J.P., Gunning, J.L., and McGill, S.M. (1998) Relationship between lumbar spine load and muscle activity during extensor exercises. Physical Therapy, 78(1): 8-18.

Callaghan, J.P., and McGill, S.M. (2001) Intervertebral disc herniation: Studies on a porcine model exposed to highly repetitive flexion/extension motion with compressive force. Clinical Biomechanics, 16(1): 28-37.

Cook G. *Movement*. On Target Publications, Santa Cruz, California, 2010

D'Sylva, J, Miller J, Gross A, et al. Manual therapy with & without physical medicine modalities for neck pain: a systematic review. *Manual Therapy,* October 2010;15(5):415-33.

Fritz JM, et al. Preliminary investigation of the mechanisms underlying the effects of manipulation: exploration of a multivariate model including spinal stiffness, multifidus recruitment, and clinical findings. *Spine*, 2011;36(21):1772–1781.

Gill N, Teyhen D, Lee I. Improved co-contraction of the transversus abdominis immediately following spinal manipulation. *Man Ther*, 2007 Aug;12(3):280-5.

Hicks, G.E., Fritz, J.M., Delitto, A., and McGill, S.M. (2005) Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. Archives of Physical Medicine and Rehabilitation, 86(9): 1753-1762.

Hodges P, et al. Rapid atrophy of the lumbar multifidus follows experimental disc or nerve root injury. *Spine,* 2006;31:2926-33.

Kang, Y.-M., PhD et. al. Electrophysiologic evidence for an intersegmental reflex pathway between lumbar paraspinal tissues. Spine 2002; 27: E56-63.

Kavcic, N., Grenier, S.G., and McGill, S.M. (2004a) Determining tissue loads and spine stability while performing commonly prescribed stabilization exercises. Spine, 29(11): 1254-1265.

Kavcic, N., Grenier, S., and McGill, S. (2004b) Determining the stabilizing role of individual torso muscles during rehabilitation exercises. Spine, 29(11):1254-1265.

Koppenhaver SL, et al. Association between changes in abdominal and lumbar multifidus muscle thickness and clinical improvement after spinal manipulation. *JOSPT,* 2011;41(6):389-99.

Koumantakis GA, Watson, PJ, Oldham, JA, Trunk muscle stabilization training plus general exercise versus general exercise only: Randomized controlled trial with patients with recurrent low back pain. Physical Therapy, 85(3):209-225.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. JMPT 2001; 24: 596-602.

Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). Spine 1995; 20: 2513-21.

MacDonald D, Moseley GL, Hodges PW. Why do some patients keep hurting their back? Evidence of ongoing back muscle dysfunction during remission from recurrent back pain. *Pain*, 2009;142:183-188.

Marshall LW and McGill SM. (2010) The role of axial torque in disc herniation. Clinical Biomechanics, 25(1):6-9.

Marshall PP, Murphy BD. The effect of sacroiliac joint manipulation on feed-forward activation times of the deep abdominal musculature. *J Manipulative Physiol Ther,* 2006;29:196-202.

McGill, S.M. Invited Paper. (1998) Low back exercises: Evidence for improving exercise regimens. Physical Therapy, 78(7): 754-765.

McGill, S.M. (2007) Low back disorders: Evidence based prevention and rehabilitation, Second Edition, Human Kinetics Publishers, Champaign, IL, U.S.A.

McGill, S.M., (2007) (DVD) The Ultimate Back: Assessment and therapeutic exercise, www.backfitpro.com12

McGill, S.M., Grenier, S., Bluhm, M., Preuss, R., Brown, S., and Russell, C. (2003) Previous history of LBP with work loss is related to lingering effects in biomechanical physiological, personal, and psychosocial characteristics. Ergonomics, 46(7): 731-746.

McGill, S.M. (2009) Ultimate back fitness and performance – Fourth Edition, Backfitpro Inc., Waterloo, Canada, (www.backfitpro.com).

McGill, S.M., Karpowicz, A. (2009) Exercises for spine stabilization: Motion/Motor patterns, stability progressions and clinical technique. Archives of Physical Medicine and Rehabilitation, 90: 118-126.

McGill SM, Norman RW, Sharratt MT. The effect of an abdominal belt on trunk muscle activity and intra-abdominal pressure during squat lifts. *Ergonomics*, 1990 Feb;33(2):147-60.

McKenzie RA. The Lumbar Spine. Mechanical diagnosis and therapy. Waikanae: Spinal Publications; 1981.

Parks, K.A., Crichton, K.S. Goldford, R.J. and McGill, S.M. (2003) On the validity of ratings of impairment for low back disorders. Spine, 28(4):380-384.

Richardson C, et al. *Therapeutic Exercise for Lumbopelvic Stabilization. A Motor Control Approach for the Treatment and Prevention of Low Back Pain*. Edinburgh: Churchill Livingstone, 2004:59-73.

Sanchez-Zuriaga D, et al. Is activation of the back muscles impaired by creep or muscle fatigue? *Spine,* 2010;35(5):517–525.

Tampier, C., Drake, J., Callaghan, J., McGill, S.M. (2007) Progressive disc herniation: An investigation of the mechanism using radiologic, histochemical and microscopic dissection techniques. Spine, 32(25): 2869-2874.

Tunnell J. Needle EMG Response of Lumbar Multifidus to Manipulation in the Presence of Clinical Instability J Man Manip Ther. 2009; 17(1): E19–E24

Vera-Garcia FJ, Elvira JL, Brown SH, McGill SM. Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. *J Electromyogr Kinesiol,* 2006 Sep 20;17(5):556-67.

Wallwork T, Stanton W, Freke M, et al. The effect of chronic low back pain on size and contraction of the lumbar multifidus muscle. *Man Ther*, 2008 Nov 20.

Nutritional Considerations

25

Nutritional Considerations

Figure 25:1. Vegetables, fruits, and other whole foods can reduce inflammation naturally.

While many doctors and authors point to carrying excess body weight as a source of back pain, there is more than just the weight to worry about. Where the weight is carried is every important. Fat that is located around the organs in the belly is physiologically different than fat found in other parts of the body. It acts like an endocrine organ, releasing various chemicals and compounds. Several of these compounds are markedly pro-inflammatory.

While there is much that we do not know about weight gain and back pain, what is supported by science is the fact that inflammation is produced by excessive body fat, in particular excessive belly fat. This inflammation contributes to heart disease, Alzheimer's disease, diabetes, and various pain syndromes. Just ten years ago medicine was ignorant of the many pro-inflammatory effects of excessive fat. It was believed that fatty acids were stored in adipose (fat) cells and that the fatty acids were released for fuel when needed. We now know that in addition to releasing fatty acids, adipose cells also release several pro-inflammatory chemicals. The more fat you have, the more pro-inflammatory chemicals are produced. Conceivably, these chemicals can magnify the painful effects of a disc injury.

The antidote to these pro-inflammatory chemicals may be the anti-inflammatory effect of exercise and weight loss. Maintaining lower body fat and larger muscles will contribute to reducing chronic inflammation.

Physiology of Adipose

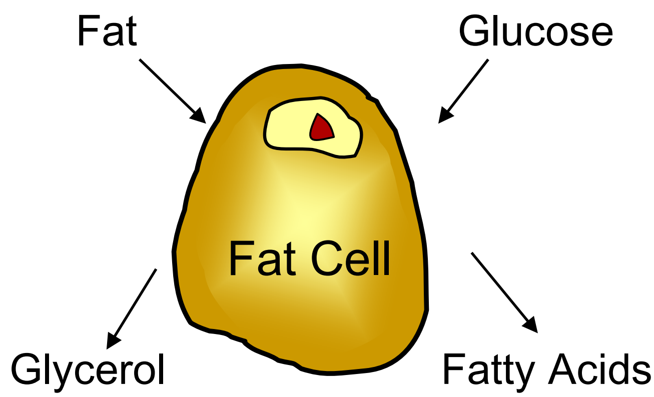


Figure 25:2. The physiology of a regular fat cell.

Until recently, fat cells were thought to be simply storage sites for fat. Fat and a small amount of glucose would enter the cells, and glycerol and fatty acids would be secreted. Now, however, we know that many chemicals, some inflammatory by nature, are released from [belly] fat cells.

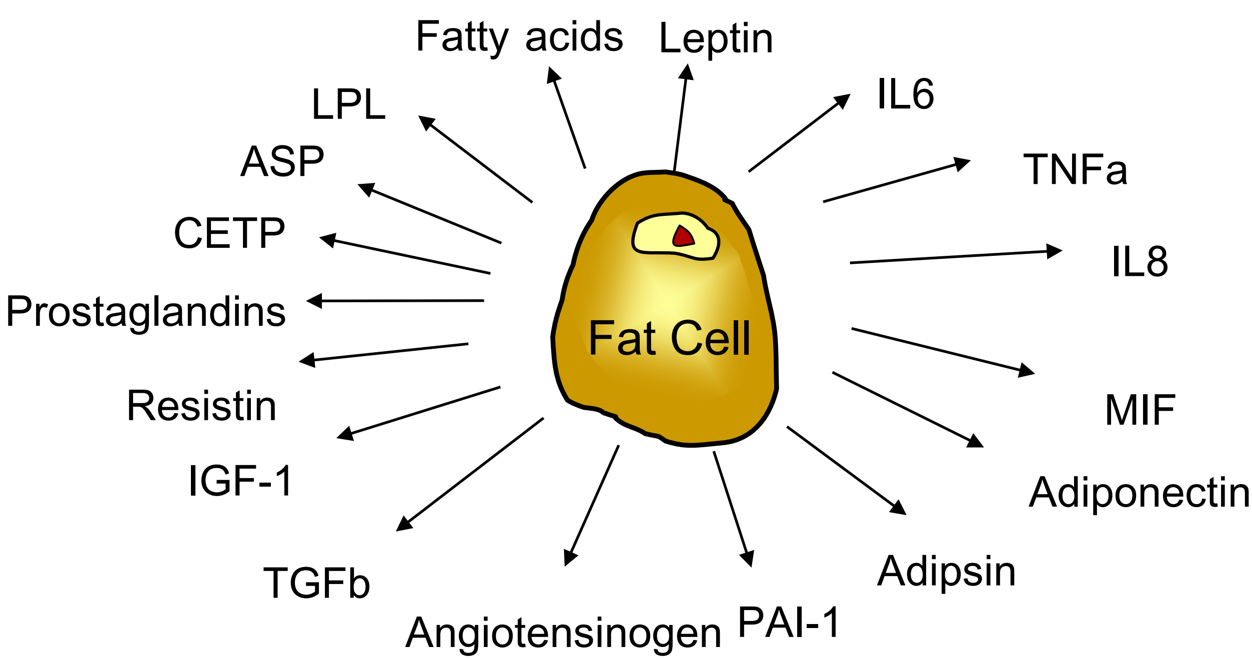


Figure 25:3. The physiology of a belly fat cell.

Fat cells release several substances such as hormones and chemical mediators. Most of these chemicals produce or contribute to inflammation and pain. Bloated (hypertrophic) belly fat cells weep these chemicals into the body, contributing to pain and ill health. Excessive body fat produces inflammation. Reducing body fat will have a global effect on reducing inflammation.

Foods That Reduce Inflammation

Spices with Anti-Inflammatory Properties	Foods that Reduce Inflammation
• Ginger • Turmeric • Black Pepper • Cinnamon • Rosemary • Basil • Cardamom • Chives • Cilantro • Cloves • Garlic • Parsley • Curry	• Olive oil • Fruit (particularly berries, cherries & grapes) • Vegetables • Nuts (walnuts in particular) • Fish (especially wild salmon, mackerel, herring, and sardines) • Flax seed • Pumpkin seeds • Sunflower seeds • Range-fed meat • Green tea • Avocados and avocado oil • Cocoa (light on the sugar) • Beans • Dark chocolate (in moderation)
Sprinkling these spices on your meals may have a beneficial effect on inflammatory conditions like disc injuries.	All these foods have beneficial anti-inflammatory properties.

Figure 25:4. Certain foods and spices can aid in reducing inflammation.

Certain foods produce inflammation, while other foods and spices reduce inflammation. Research has shown that certain spices have the ability to reduce pain and inflammation.

Foods that Promote Inflammation

Indeed not all foods have an anti-inflammatory effect. Certain foods have the effect of increasing pain and inflammation. Avoid or eliminate foods that produce inflammation and disease.

Inflammatory Foods
• Fried foods including French fries and potato chips • Cured meat • Corn products including popcorn • Corn-fed meat • Animal fats and fatty meats • Sugar • Breads (especially croissants, doughnuts & other pastries) • Pastas • Saturated fats, trans fats, and shortening • Sodas • High fat granola • Chinese food • Rice • Tortillas • High-fat dairy products like cheese and ice cream • Excessive alcohol These foods should be restricted or eliminated.

Figure 25:5. This table is a partial list of foods that are inflammatory in their effect.

Vitamin D

A study in Saudi Arabia uncovered some interesting information about Vitamin D and inflammation. This research project studied patients who had lower back pain without a known cause. It was found that many of the participants had abnormally low levels of vitamin D. When vitamin D was supplemented to their diet, a majority of these back pain sufferers were relieved of their pain. This study, along with others, point to the inflammation-reducing properties of vitamin D supplementation.

Notes: Vitamin D is produced naturally by exposing skin to the sun. In Saudi Arabia the extremely high temperatures, intensity of sunlight, and cultural preferences encourage the population to cover their skin with clothes and avoid sun exposure. These factors combine to inhibit the natural production of vitamin D in this population. In excessive doses, vitamin D may become toxic.

Vitamin D Deficiency and Chronic Low Back Pain in Saudi Arabia

Saud Al Faraj, MD, and Khalaf Al Mutairi, MD

SPINE Volume 28, Number 2, pp 177–179

©2003, Lippincott Williams & Wilkins, Inc.

For additional information about Vitamin D access this link:
http://www.nlm.nih.gov/medlineplus/druginfo/natural/patient-vitamind.html

Omega-3 Fish Oils

Studies of patients with joint pain, including non-surgical back pain,* have shown that supplementing their diet with omega-3 fatty acids yielded a reduction in pain and a decreased need to take NSAIDs (non-steroidal anti-inflammation drugs).

One particular back pain study conducted by neurosurgeons is particularly encouraging. For the study's first two weeks, patients daily dose totaled 2.4 grams of omega-3 fatty acids (eicosapentaenoic acid, EPA, and decosahexaenoic acid, DHA) found in fish oil supplements. After that, patients were to cut that dose in half and taper off their NSAIDs over the next one or two weeks. The results were very favorable. Most experienced reduction or elimination of pain. Of the participants, 59% discontinued taking other medications. At the end of the study, 88% of the participants said that they would continue taking Omega-3 EFAs.

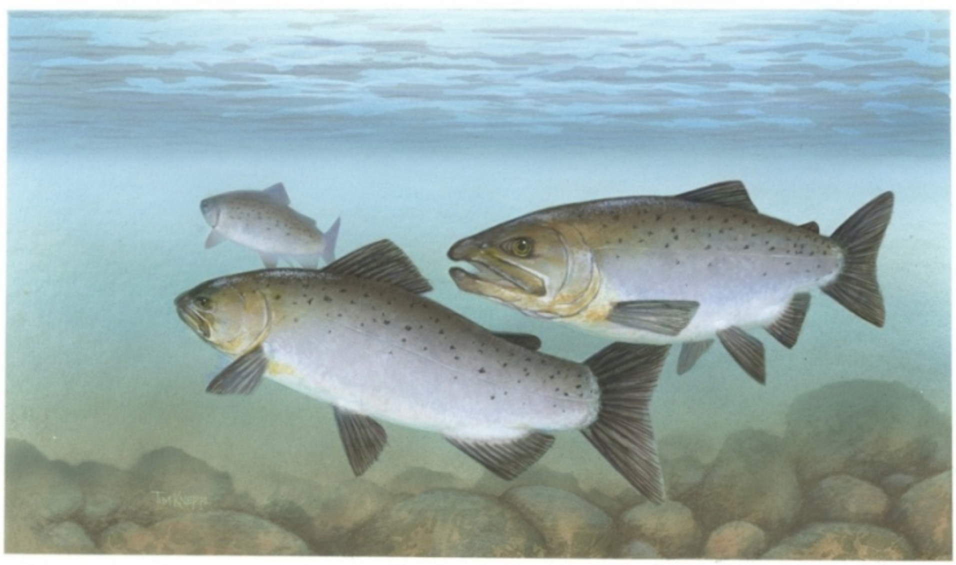


Figure 25:6. Omega-3 oils from fish have strong anti-inflammatory properties.

"Our study adds to the numerous previously published studies showing the health benefits of omega-three EFAs which include blood clot prevention, pain reduction, immune system boosting, and healthy blood vessel dilation," Maroon says in the news release.

Seek a pharmaceutical–grade fish oil supplement to avoid contaminants such as mercury.

* Maroon J., Bost J. Omega-3 Fatty acids (fish oil) as an anti-inflammatory: an alternative to nonsteroidal anti-inflammatory drugs for discogenic pain. Surgical Neurology 65 (2006) 326– 331. April 2006.

Additional information on the use of Omega-3 oils may be found in this link: http://www.nlm.nih.gov/medlineplus/druginfo/natural/patient-fishoil.html

Glucosamine Sulfate

Glucosamine sulfate and chondroitin sulfate are natural compounds found in healthy cartilage and in fluid within the joints. There is evidence that supplementing a diet with these compounds will help reduce the pain and possibly prevent degeneration of cartilage associated with arthritis.

Unfortunately, to date there is no evidence that glucosamine sulfate or chondroitin speeds the healing of herniated or degenerated discs. You may take glucosamine and chondroitin for arthritis prevention and pain, but do not expect a degenerated disc to grow back or for the symptoms of a lumbar herniation to abate.

Note: In clinically controlled studies (higher quality studies) *sulfated* forms of glucosamine seem to be effective, while *non-sulfated* forms lack strong evidence for effectiveness in treating arthritis, particularly arthritis of the knee.

For more information on glucosamine, check this link:
http://www.nlm.nih.gov/medlineplus/druginfo/natural/patient-glucosamine.html

Nutritional Strategies

Maintaining a diet that is high in foods that reduce inflammation, while minimizing the intake of inflammation-producing foods is a good strategy to promote healing. Certainly eating a diet that is rich in vegetables, spices, vitamin D, and omega-3 fish oils will boost health and healing and reduce global inflammation. Avoiding grains, sugars, excessive alcohol, fried foods, and soft drinks will help decrease inflammation. Maintaining a lower fat to lean tissue ratio will promote overall health. Building bigger muscles and reducing the belly fat around your organs will yield benefits not only for your spine, but also in all aspects of your health and well-being.

Figure 25:7. Vegetables and fruits reduce inflammation naturally.

26

Chiropractic Management of Herniated Discs

Chiropractic Management of Herniated Discs

Chiropractic is a profession, not a modality. Chiropractors can employ many different treatment and management protocols which can be appropriate for many conditions. At times chiropractic adjustments, exercise, distraction, modalities, and lifestyle advice would be the most appropriate treatment. However, there will be other times when manipulation, exercise, and manual treatment will be inappropriate and the best treatment will be watchful waiting or simply removing the patient from the cause of injury. There will be other times when a timely referral to another provider is the most appropriate treatment.

Spinal manipulation, the chiropractic adjustment, is safe to implement in most cases of lumbar disc herniation. Below is listed a group of studies and a case series that supports the use of the chiropractic adjustment in treating lumbar disc herniation. The master clinician should strive to ascertain which cases are appropriate and which cases are not appropriate to treat with chiropractic adjustments. The master clinician should also be able attenuate the treatment to be appropriate for each individual patient and case.

Safety of Treating Lumbar Herniations with Manipulation

BenEliyahu DJ. MRI and clinical followup study of 27 patients receiving chiropractic care for cervical and lumbar disc herniation. *JMPT* 1996;19(9):597-606.

Cassidy JD, Thiel HW, Kirkaldy-Wills WH. Side posture manipulation for lumbar intervertebral disk herniation. *J Manip Physiol Ther* 1993;16:97-103. David Cassidy,DC, Kirkaldy Willis, MD, University of Saskatchewan, 1985.

Lisi AJ, O'Neill CW, Lindsey, Cooperstein R, Cooperstein, E, Zucherman JF. Measurement of in vivo lumbar intervertebral disc pressure during spinal manipulation: a feasibility study. *Journal of applied biomechanics*, 2006; 22:234-239.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. *JMPT* 2001; 24: 596-602.

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 Journal.* Mar-Apr 2006;6(2):131-137.

Safety Concerns: Adjusting Disc Herniations

Treating disc herniations requires discernment, discretion, knowledge, and skill. There is not one treatment program that will fit every patient's needs. We will need to monitor patient response, adapt, and modify treatments to maximize outcomes.

Some of the particular concerns in treating disc patients include:

Progression of Neurological Signs and Symptoms

If neurological signs progress under treatment, discontinue or modify treatment. Refer to a medical spine specialist as needed. Motor weakness and bowel and bladder symptoms are particularly worrisome signs and should be referred with due haste.

Huge Herniations

Huge herniations are prone to aggravation with manual treatments. Proceed with caution in treating patients with large herniated discs. Sometimes all that we can offer for patients with large herniations is to take away the cause of their herniation.

Conjoined Nerve Roots

Conjoined nerve roots can be damaged more easily than normal nerve roots, even in the presence of a relatively small disc derangement.

Peripheralization

If symptoms peripheralize, stop or modify treatment.

Sequestered Fragments

The response of sequestered disc fragments to manual treatment is difficult to predict. Some do well and some do poorly. In cases of sequestered fragments, sometimes watchful waiting is a prudent path.

Provocation

If the patient is in more pain with treatment, perhaps the treatment is not appropriate at this time.

Applying Centralization Concept to Chiropractic Care

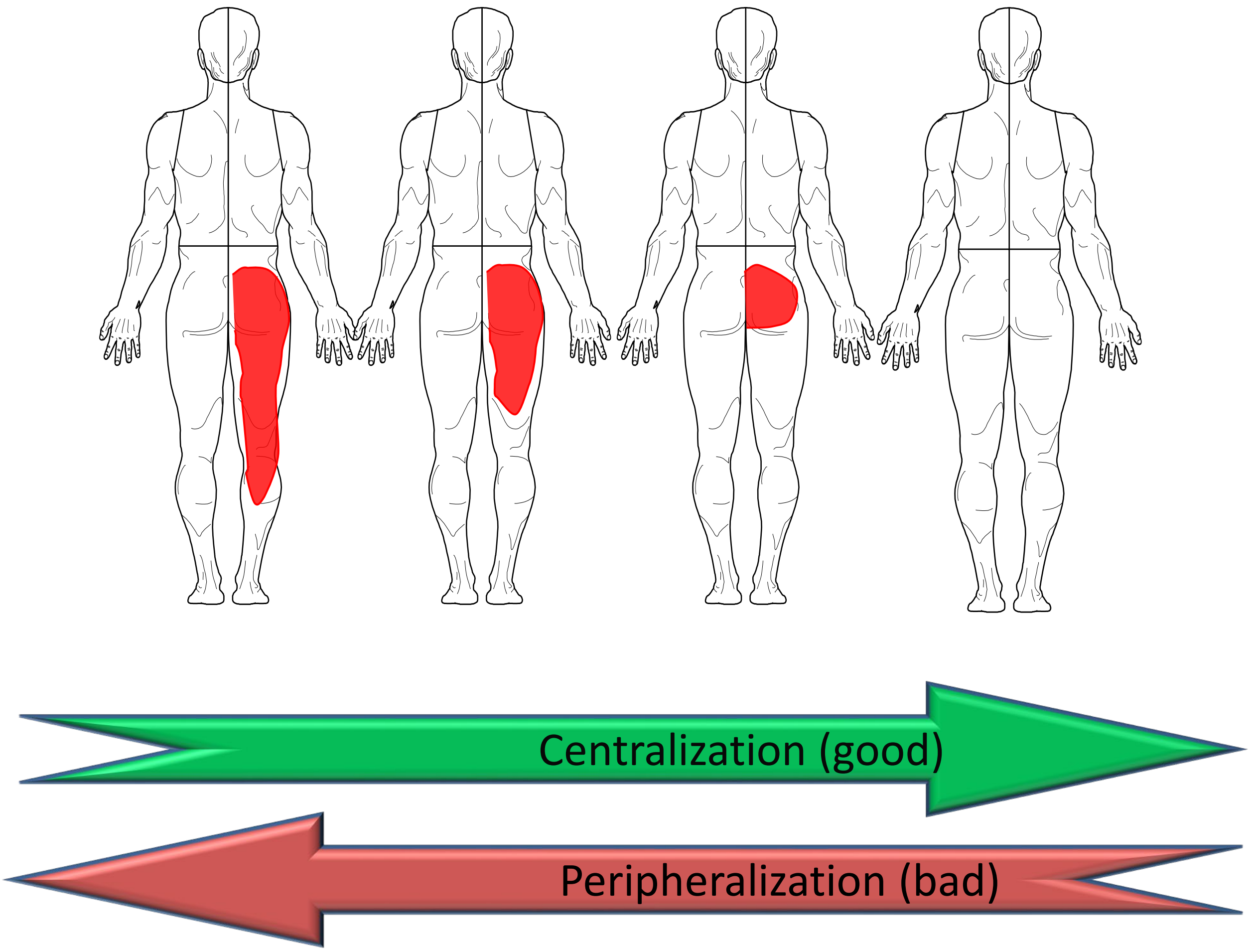


Figure 26:1. This schematic shows various distributions of leg pain in sciatica. Treatment that results in centralization (symptoms regressing to a more central location) is considered to be successful, while treatment that results in peripheralization (symptoms extending further down the leg) is not successful. If extension exercises cause peripheralization, discontinue them immediately. You may note a temporary mild increase in back pain with extension. This is acceptable as long as the leg pain centralizes.

.

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. *JMPT* 2001; 24: 596-602.

McKenzie RA. The Lumbar Spine. Mechanical diagnosis and therapy. Waikanae: *Spinal Publications*; 1981.

Motion Table Techniques

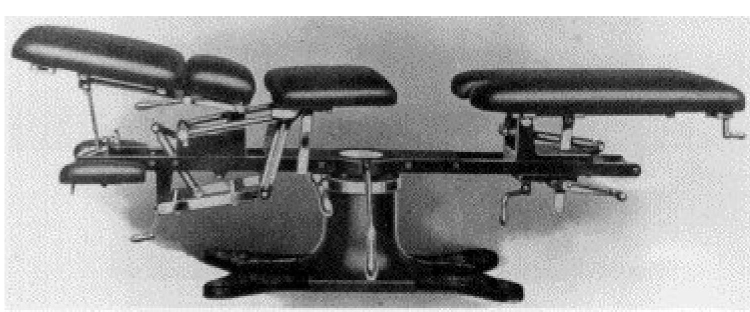
Flexion distraction techniques have been around for over a century. In 1909 an osteopath by the name of Dr. McManus began manufacturing flexion-distraction tables. Subsequent innovations in this technology has been on going, and now there is a wide selection of prone-distraction tables and motorized continuous motion tables that have a variety of features. The term prone-distraction is preferred versus flexion-distraction. Lumbar flexion has the increased likelihood to cause disc injury, so a table with the ability to extend or maintain a neutral curve is preferred to a flexion-distraction table. The features that reduce lumbar flexion in a prone distraction table are a lowering abdominal section and the ability to have the lower section move into extension.

Recommended features in an prone-distraction table:

- The ability to place the lumbar spine into extension by lowering the abdominal section or to raise the abdominal section for flexion-distraction
- Passive continuous motion feature (motorized table motion) with adjustments for timing of treatment
- The ability to laterally flex the spine

Other beneficial options for a prone-distraction table:

- Long-axis distraction feature
- Drop pieces
- The ability to set degree of motion (lower body motion)
- The ability to flex the spine by raising the abdominal section above the horizontal plane (for foraminal herniations, stenosis, and facet disease).



McManus table patented in 1909

Table with Abdomen Section Raised

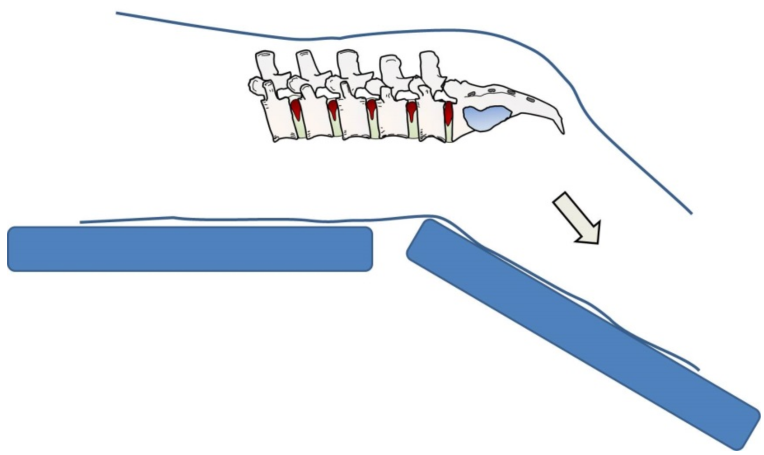


Figure 26:2 Flexion-traction of the lumbar spine separates the posterior elements of the lumbar spine which may be palliative for patients with stenosis, facet pain, ligamentum flavum hypertrophy, or foraminal herniations. Flexion promotes posterior migration of the nucleus pulposa and may worsen a disc derangement.

Table with Abdomen Section Lowered

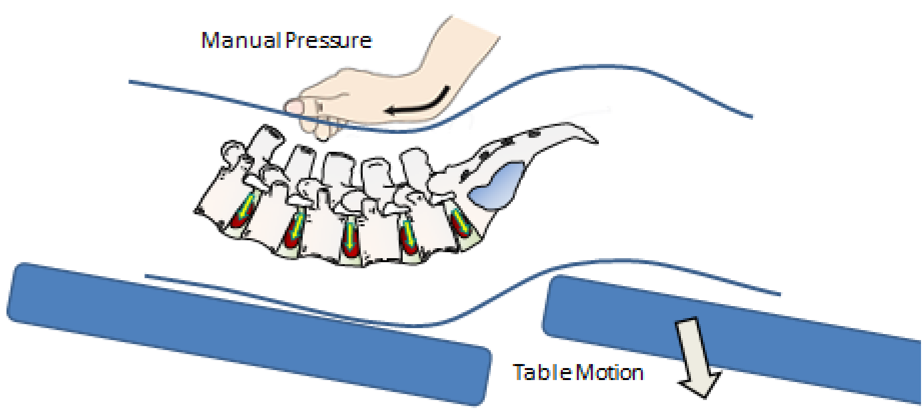


Figure 26:3 Prone-distraction with the thoracic/abdominal section lowered, promotes an anterior migration of the nucleus pulposa with table motion.

Table with Abdominal Section Raised

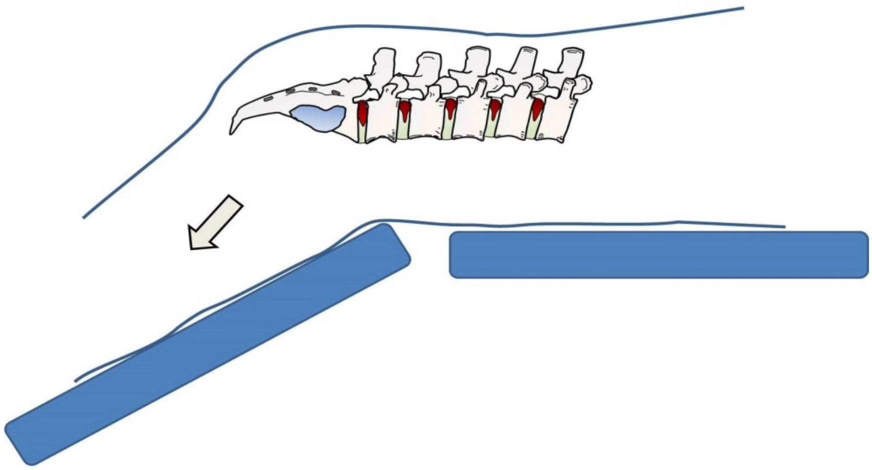


Figure 26:4 Schematic of flexion-distraction with the thoracic/abdominal section raised.

Figure 26:5 Photo of flexion-distraction with the thoracic/abdominal section raised.

Table with Abdomen Section Lowered

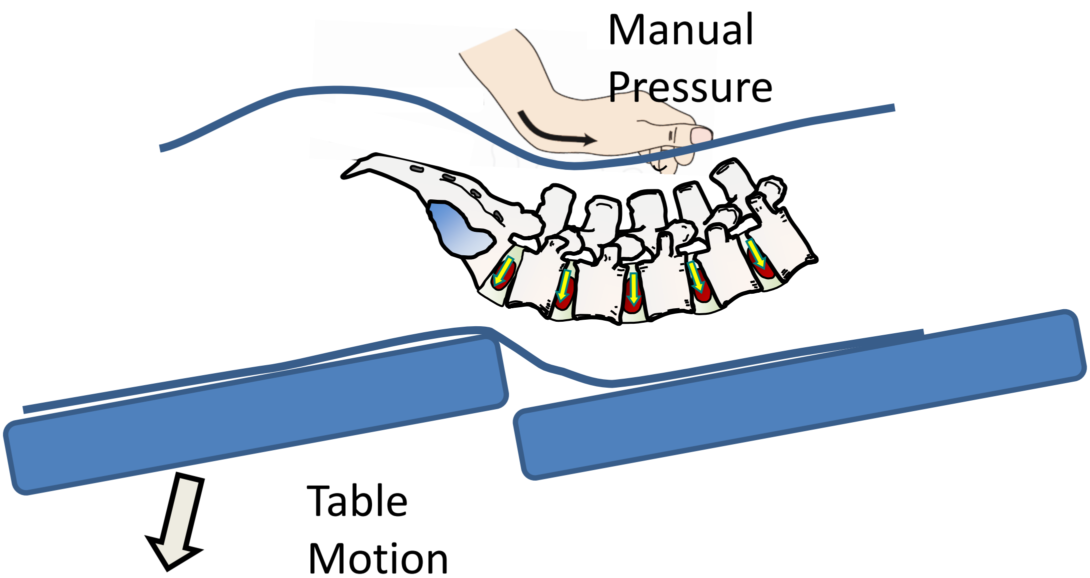


Figure 26:6 Schematic of flexion-distraction with the thoracic/abdominal section lowered and the doctor providing gentle manual over-pressure.

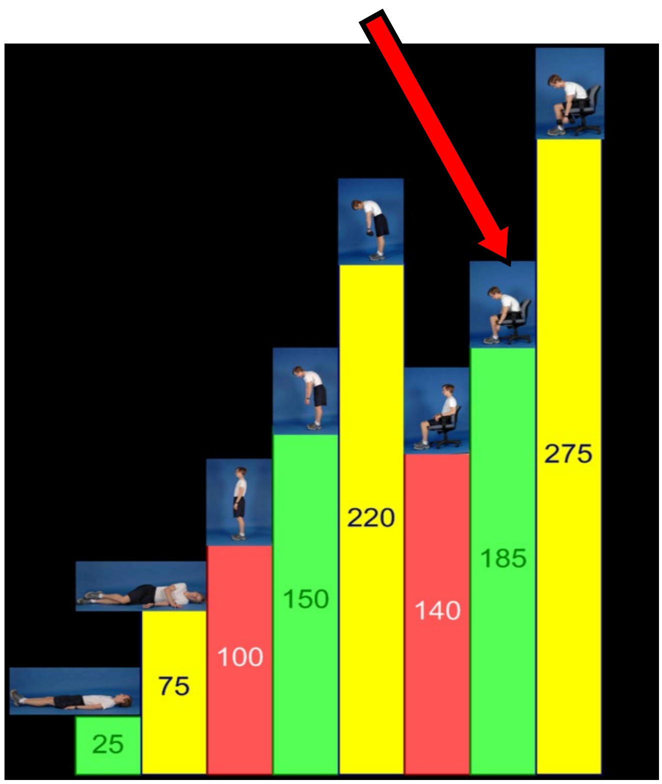
Figure 26:7 Photo of flexion-distraction with the thoracic/abdominal section lowered and the doctor providing gentle manual over-pressure.

Figure 26:8 Warning: Do not use extreme or end-range motion of the prone-distraction table. Too much leg flexion is provocative.

Figure 26:9 Some lumbar disc patients will respond best to leg section extension.

Disc Pressures During Side Posture Manipulations

"The peak pressures measured during the manipulation positioning and thrust were similar to pressures previously measured for sitting unsupported and sitting flexed, respectively. These data do not support the hypotheses that manipulation can reduce a herniation by decreasing intradiscal pressure or cause a herniation by raising pressure to failure levels."



Lisi AJ, O'Neill CW, Lindsey, Cooperstein R, Cooperstein E, Zucherman JF. Measurement of in vivo lumbar intervertebral disc pressure during spinal manipulation: a feasibility study. Journal of applied biomechanics. 2006; 22:234-239.

Nachemson A. Disc pressure measurements. Spine. 1981;6:93–7.

Provocation Testing

- Use pre-manipulative oscillations to test for provocation of symptoms.
- Incrementally increased pressures are used to test the patient's tolerance and bias.
- If the patient is tolerant of provocation testing, a manipulation may be employed. If not, use lower force techniques.

Place the patient in the position of treatment. Before treating with a thrusting adjustment, apply gentle oscillations in the direction of intended line of drive. If the patient tolerates the oscillations well, an adjustment may be administered. If the oscillations increase the patient's pain or causes a peripheralization of symptoms, then try performing the oscillations in different directions, lines of drive, and locations until a well-tolerated line of drive is identified. The patient may even need to be positioned on the opposite side. If no position can be found that is well-tolerated, then a high-velocity treatment should not be attempted until a later time.

Figures 26:10 and 11. The side posture adjustment for the disc patient: limit spinal rotation and spinal flexion, thrust is low amplitude and in a palliative line of drive. The pelvis is supported on the pelvic section and the lumbar spine is over the lowered thoracic/abdominal section (blue arrow). The line of drive is dictated by the patient's preference, but is generally posterior-anterior, and lateral to medial.

Biomechanical "Blocking"

Figure 26:12 Using firmly padded wedges (yellow arrow) positioned under the pelvis can provide relief form disc herniations with minimal force. In this photo the doctor is using a brief period of gentle over-pressure to maximize results.

The use of padded wedges placed under the pelvis was initially developed by the founder of Sacro-Occipital Technique (SOT); Major DeJarnette, DC. While SOT is commonly associated with the use of padded wedges (blocks), we will not be using the protocols taught in SOT as we learn biomechanical blocking. This course recommends the use of symptom provocation – placation and centralization-peripheralization to determine the placement of these wedges and if the wedges should be used at all. Our protocol essentially uses this simple guideline: place the wedges (blocks) under the pelvis in a manner that maximally reduces and centralizes the symptoms. There are several block placements that are possible. Cross pelvis blocking will torsion the pelvis and affect the position of the pelvis, sacroiliacs, and lumbo-sacral junction.

Typically blocking is used when the patient cannot tolerate the motion of a prone-distraction table and or manual adjusting. This low-force technique can be used with therapeutic modalities.

Dosage tolerance varies from patient to patient. Some patients will find blocking initially comfortable, but provocative with extended sessions. Treatment time varies from three to twelve minutes. Start with a short session to determine the patient's tolerance. In subsequent treatments of patients with a positive response to treatment the doctor may place his/her hands over the portions of the pelvis not supported by the blocks (figure 26:12) and provide gentle over-pressure.

Prone Biomechanical "Blocking"

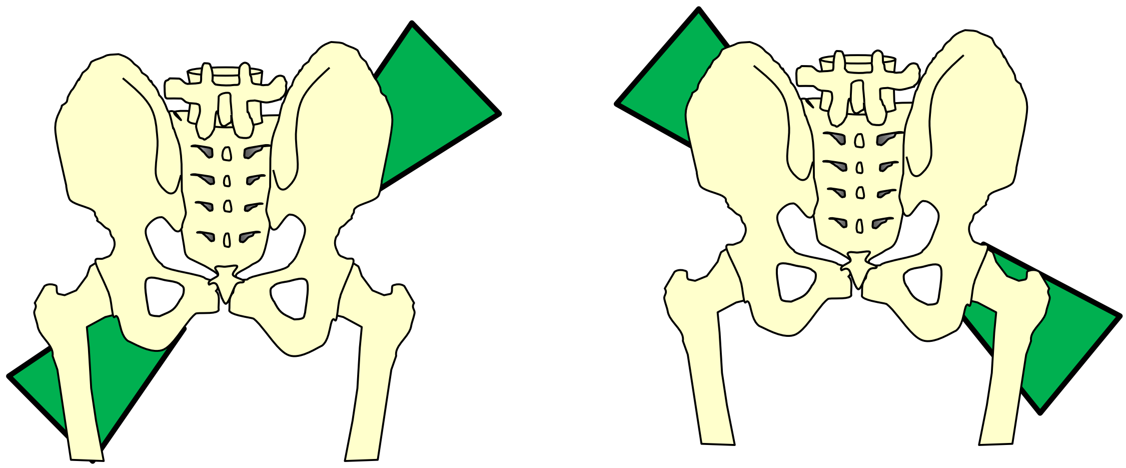


Figure 26:13. Diagonal across pelvic blocking options.

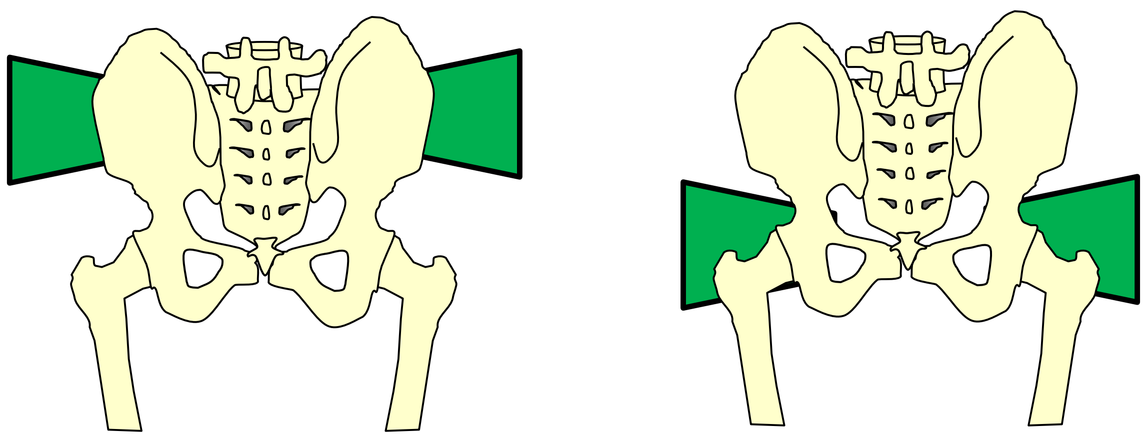


Figure 26:14. Sagittal across pelvic blocking options: bilateral ASIS blocking, and bilateral lower anterior pelvis blocking.

Supine Biomechanical "Blocking"

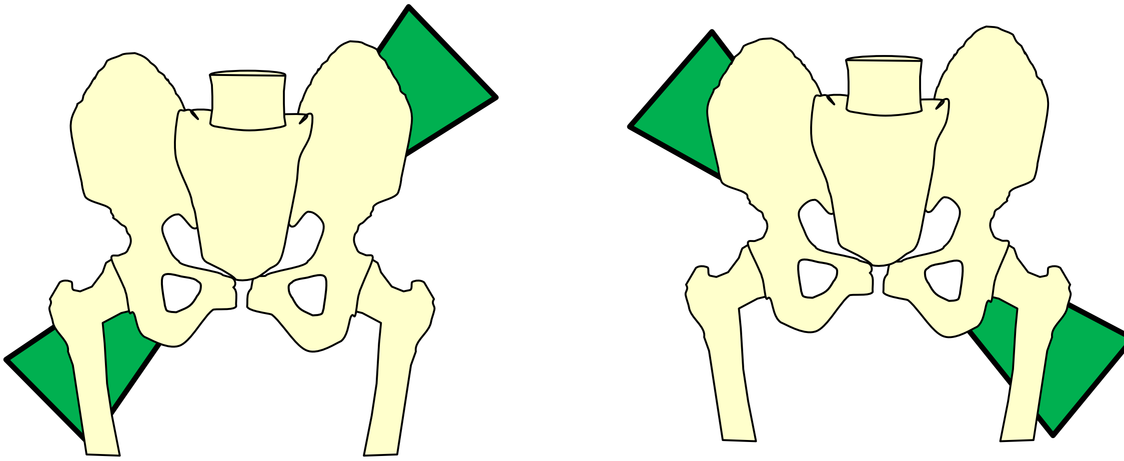


Figure 26:15. Diagonal across pelvic blocking options for treating the supine patient.

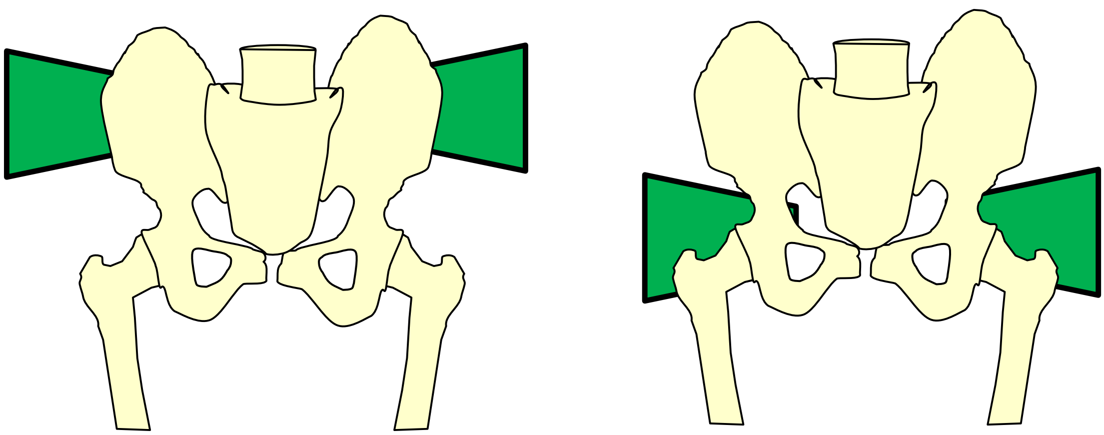


Figure 26:16. Sagittal across pelvic blocking options for the supine patient: bilateral PSIS blocking and bilateral lower anterior pelvis blocking.

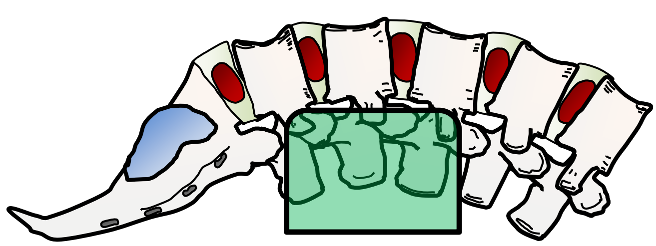


Figure 26:17. Supine lumbar blocking. One block is inserted to support the lumbar lordosis from each side.

Maximizing Patient Comfort

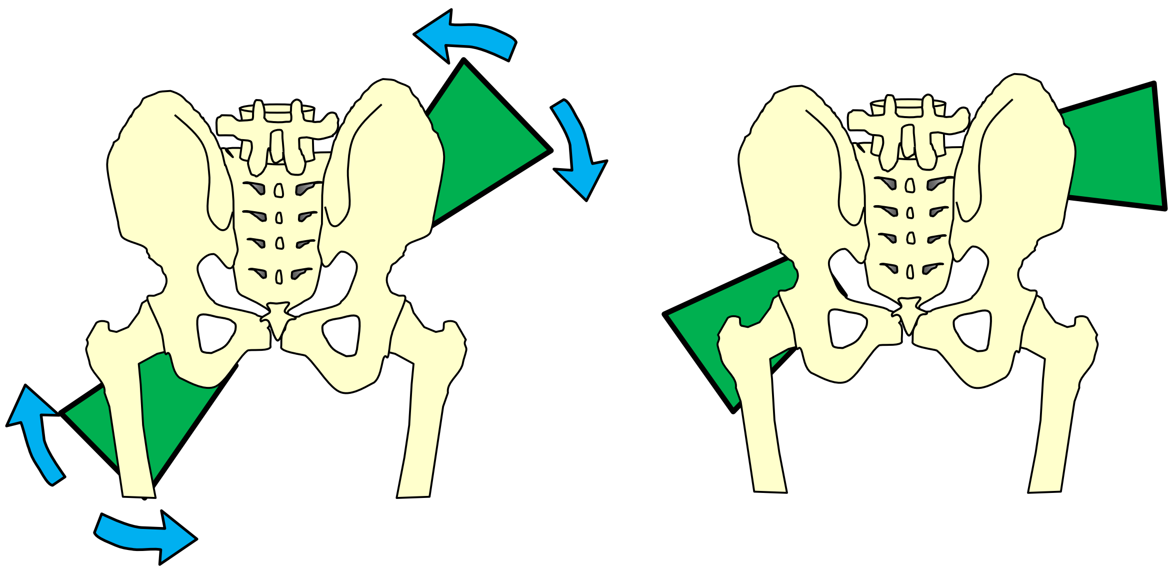


Figure 26:18. When placing the blocks, feel free to rotate the blocks to a position of maximal comfort.

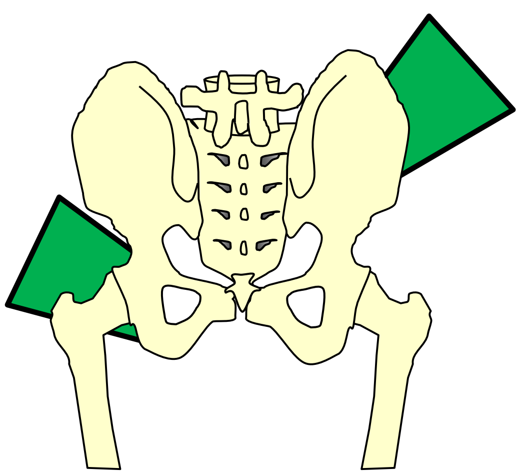


Figure 26:19. Variation in block diagonal block placement.

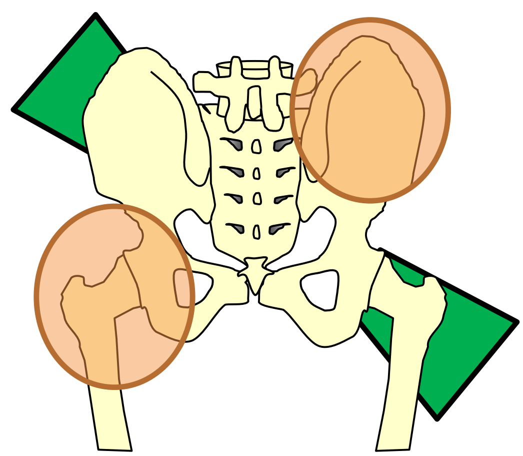
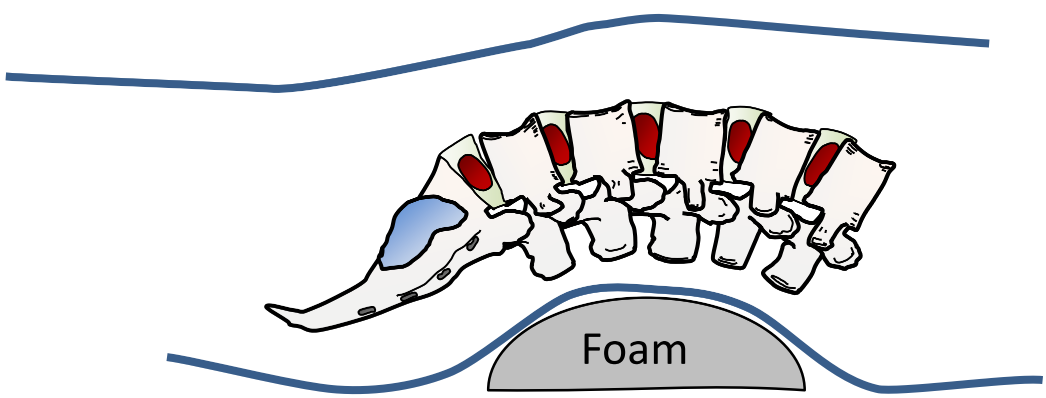


Figure 26:20. Hand placement for over-pressure (orange circles). The hands are placed over the portions of the pelvis not supported by the blocks.

Postural Molding

Figure 26:21 Postural molding is a technique that utilizes a fulcrum to affect the soft tissues of the spine. This technique employs ligamentous and discal creep to reduce symptoms and alter the spinal curves.



Postural molding has its roots in biophysics. By placing a rounded high-density foam fulcrum under the lumbar spine, a lordosis and anterior migration of the nucleus pulposa is encouraged. As in all treatments, only proceed with this treatment if it placates the symptoms. This treatment is akin to lumbar extension exercises, but may be more focused on the restoration of lordosis in restricted segments. Initial treatment time should be less than three minutes. If this treatment is well-tolerated, it can be used up to 20 minutes per session, two sessions per day. Individualize treatment times and foam size for each patient. As with all treatments, more is not necessarily better. Some patients will find that a rolled towel or blanket placed under the lumbar spine is sufficient.

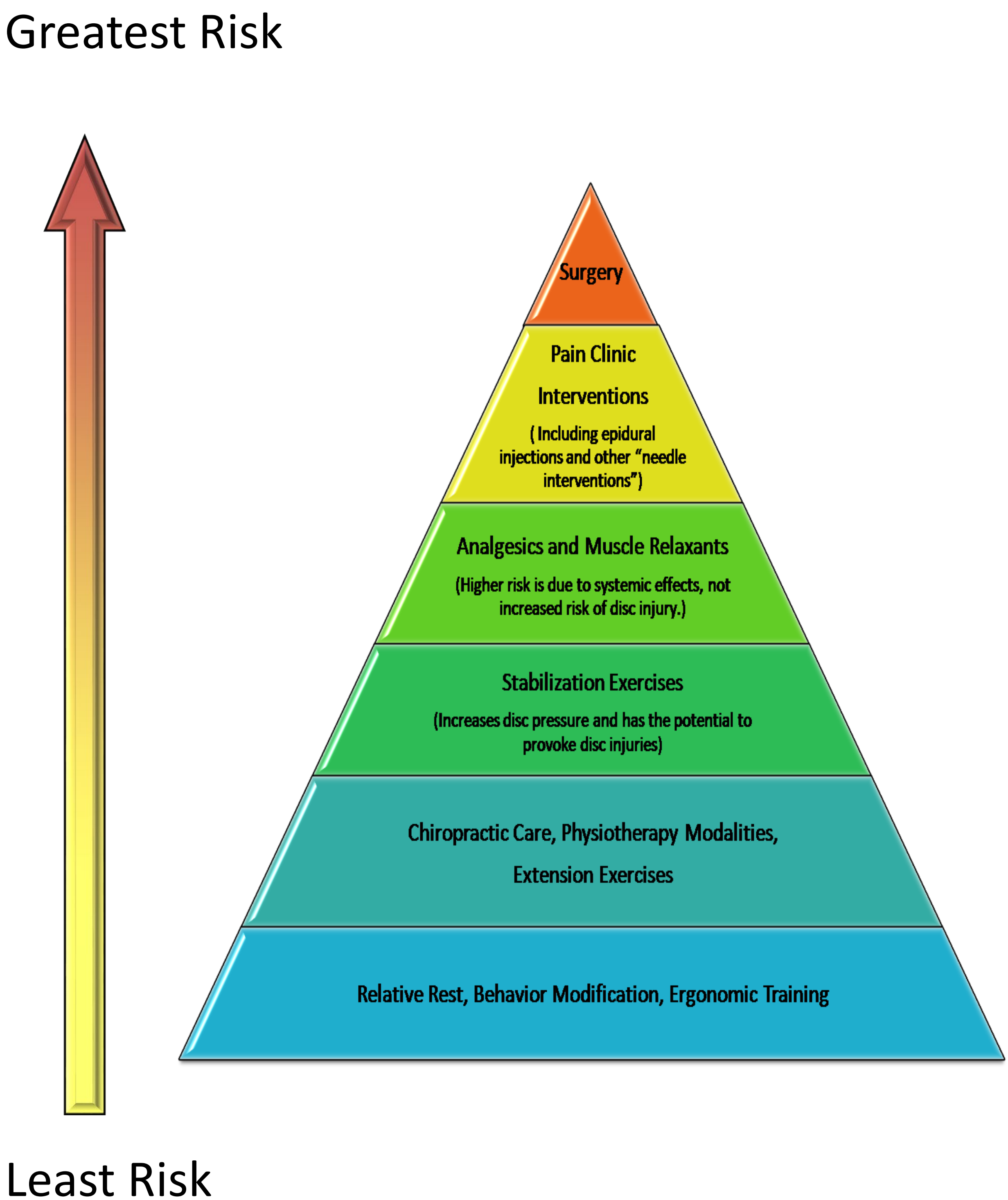
Managing a Non-Surgical Lumbar Disc Herniation	
Management Categories	**Action**
Posture	•Avoid spinal flexion or twisting. •Try to maintain a comfortable arch in the lower back. •Avoid prolonged sitting. •Be careful for the first 1 ½ hours after getting out of bed and for 30 minutes after prolonged sitting.
Exercise	•Avoid any exercise that has forward bending. Do not perform toe-touches, sit-ups, or any other flexion exercise. •Perform extension exercises if they reduce pain. •Gradually implement spinal stabilization exercises. •Pursue an aerobic exercise that does not hurt.
Pain Relief	•Apply hot or cold packs for 20 minutes at a time. •Analgesics may be used early in treatment for inflammation and pain relief, but should be tapered off as soon as possible. • Use chiropractic manipulation if pain is relieved by it. •Physical therapy modalities (ice, heat, ultrasound, electrical muscle stimulation, etc.) may be used for pain relief.
Activity	•Avoid prolonged bed rest. Never remain in bed for longer than three days. •Use relative rest instead of total rest. Stay active, but avoid provocative activities.

Summary of Disc Herniation Management

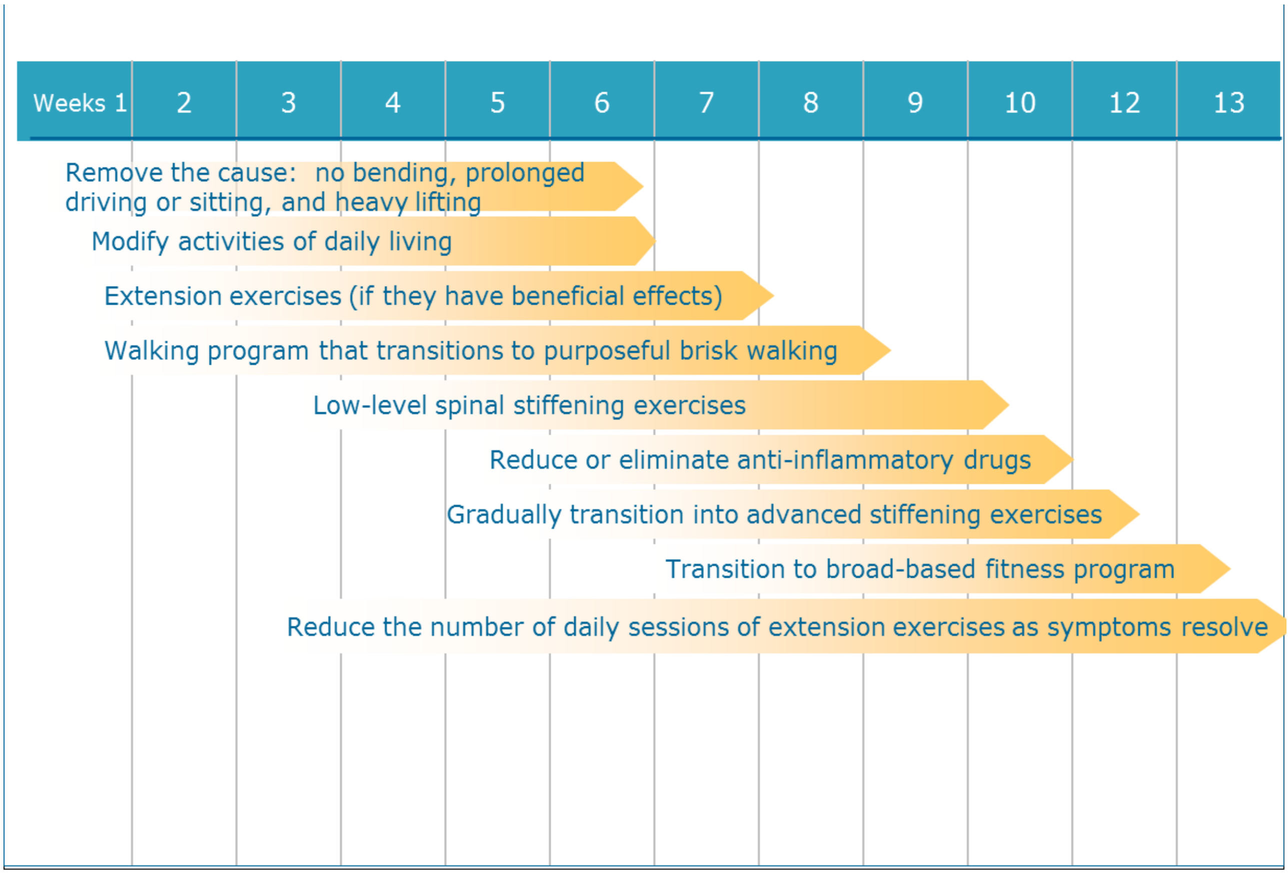
Patients with disc derangements should abide by these recommendations:

- Limit spinal flexion and twisting.
- Limit exertion and provocative activities during the first couple hours in the morning.
- Perform extension exercises if they do not produce pain.
- Do not smoke.
- Aerobically exercise three or more days per week.
- Do not exert yourself for the first 30 minutes after prolonged sitting.
- Reduce belly fat.
- Use heat and ice for pain relief.
- Reduce or eliminate the use of analgesic drugs as your condition allows.
- Eat an anti-inflammatory diet that is rich in fish, vegetables, nuts, and spices.
- Increase stabilization exercises as symptoms allow.
- Seek medical care immediately if you experience bowel or bladder dysfunction, numbness on the inside of your thighs, sexual dysfunction, or weakness.

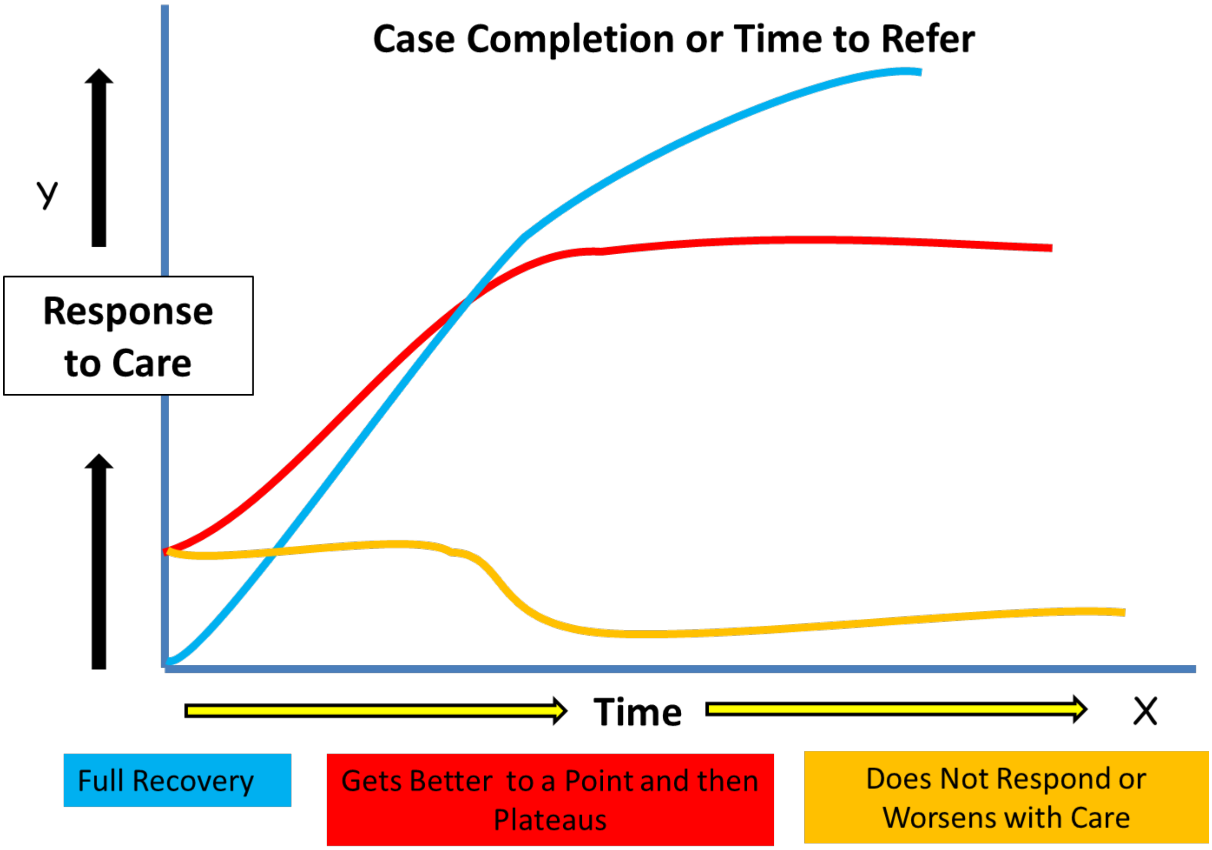
Relative Risks of Treatments



Sample Treatment Timeline



Case Completion



References

Adams MA, May S, Freeman BJC, Morrison HP, Dolan P. Effects of backward bending on lumbar intervertebral discs. *Spine*. Volume 25, Number 4, pp 4310437

Alexander LA, Hancock E, Agouris I, Smith FW, MacSween A. The response of the nucleus pulposus of the lumbar intervertebral discs to functionally loaded positions. *Spine*, Volume 32, Number 14, pp 1508-1512

Autio RA, Karppinen J, Niinima¨ki J, Ojala R, Kurunlahti M, et al. Determinants of Spontaneous Resorption of
Intervertebral Disc Herniations *Spine* Volume 31, Number 11, pp 1247–1252

BenEliyahu DJ. MRI and clinical followup study of 27 patients receiving chiropractic care for cervical and lumbar disc herniation. *JMPT* 1996;19(9):597-606.

Bozzao A. Lumbar disc herniation: MR imaging assessment of natural history in patients treated without surgery. *Radiology* 1992;185:135-141.

Cassidy JD, Thiel HW, Kirkaldy-Wills WH. Side posture manipulation for lumbar intervertebral disk herniation. *J Manip Physiol Ther* 1993;16:97-103. David Cassidy,DC, Kirkaldy Willis, MD, University of Saskatchewan, 1985.

Cooperstein R, Lisi AJ. Blocking procedures: an expanded approach. *JACA*. 2004.

Coopertein R, "Padded Wedges for Lumbopelvic Mechanical Analysis"Journal of the American Chiropractic Association,Oct 2000: 24-6.

Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, Von Korff M, Waddell G. Outcome measures for low back pain research. A proposal for standardized use. *Spine* (Phila Pa 1976). 1998 Sep 15;23(18):2003-13.

Donelson R, Aprill C, Medcalf R, Grant W. A prospective study of centralization of lumbar and referred pain: A predictor of symptomatic discs and anular competence. *Spine* 1997;22:1115–22

Komori H. Natural history of herniated nucleus pulposus with radiculopathy. *Spine* 1996;21(2):225-229.

Lisi AJ, Cooperstein R, Morshhauser E. A pilot study of provocation testing with pelvic wedges: can prone blocking demonstrate a directional preference? *The journal of chiropractic education*. 2002; 16(1): 30-31

Lisi AJ, Cooperstein R, Morschhauser E, An exploratory study of provocation testing with padded wedges: Can prone blocking demonstrate a directional preference?Journal of Manipulative and Physiological Therapeutics Feb 2004;27(2):103

Lisi AJ, O'Neill CW, Lindsey, Cooperstein R, Cooperstein, E, Zucherman JF. Measurement of in vivo lumbar intervertebral disc pressure during spinal manipulation: a feasibility study. *Journal of applied biomechanics*, 2006; 22:234-239

Lisi AJ. The centralization phenomenon in chiropractic spinal manipulation of the discogenic low back pain and sciatica. *JMPT* 2001; 24: 596-602.

Long AL. The centralization phenomenon. Its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). *Spine* 1995; 20: 2513-21.

Matsubara Y. Serial changes on MRI in lumbar disc herniations. *Neuroradiology* 1995;37:378-383.

McKenzie RA. The Lumbar Spine. Mechanical diagnosis and therapy. Waikanae: Spinal Publications; 1981.

McMorland G, Suter E, Casha S, du Plessis SJ, MD, Hurlbert RJ, MD. Manipulation or Microdiskectomy for Sciatica?
A Prospective Randomized Clinical Study. *J Manipulative Physiol Ther*. 2010 Oct;33(8):576-84.

Murphy DR, Hurwitz EL, McGovern EE. A nonsurgical approach to the management of patients with lumbar radiculopathy secondary to herniated disk: a prospective observational cohort study with follow-up. *J Manipulative Physiol Ther*. 2009 Nov-Dec;32(9):723-33.

Nachemson A. Disc pressure measurements. *Spine*. 1981;6:93–7.

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. *Spine* (Phila Pa 1976). 1990 Jul;15(7):683-6

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 Journal.* Mar-Apr 2006;6(2):131-137.

Triano J. The mechanics of spinal manipulation. In: Herzog W, editor. *Clinical biomechanics of spinal manipu*lation. Philadelphia. Churchill Livingstone; 2000.

Wilke HJ, Neef P, Caimi M, Hoolgand T, Claes LE. New in vivo measurements of pressure in the intervertebral disc in daily life. *Spine*, Volume 24, Number 8, 1999, pp 755 -762.

The Appendices

Appendix 1: Piriformis Syndrome

Piriformis Syndrome

When the sciatic nerve is compressed by the piriformis muscle, it can cause sciatica. This phenomenon is called piriformis syndrome. Piriformis syndrome is diagnosed clinically rather than through any specific test or radiographic (X-rays or MRI) examination. The reason this condition is included in this book is that it can mimic disc herniation. While much has been written about piriformis syndrome, its supporting citations come mainly from anecdotal sources rather than substantial research.

Piriformis syndrome is commonly mistaken for a disc herniation due in part to the high rate of asymptomatic disc herniation visible on MRI.

The symptoms of piriformis syndrome include:
•Sciatica
•Deep buttocks pain
•Pain that is worse with sitting, especially in a car or soft chair
•Pain relief with turning the foot outward and slightly bending the knee
•Pain relief with piriformis stretching exercises and walking

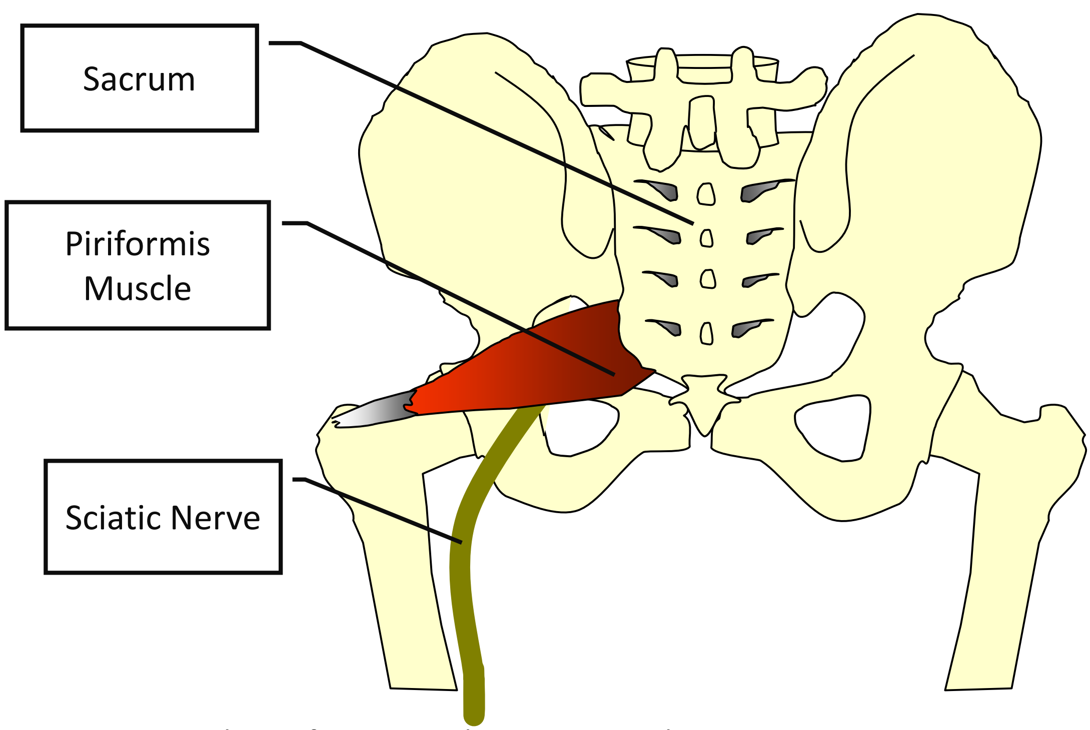
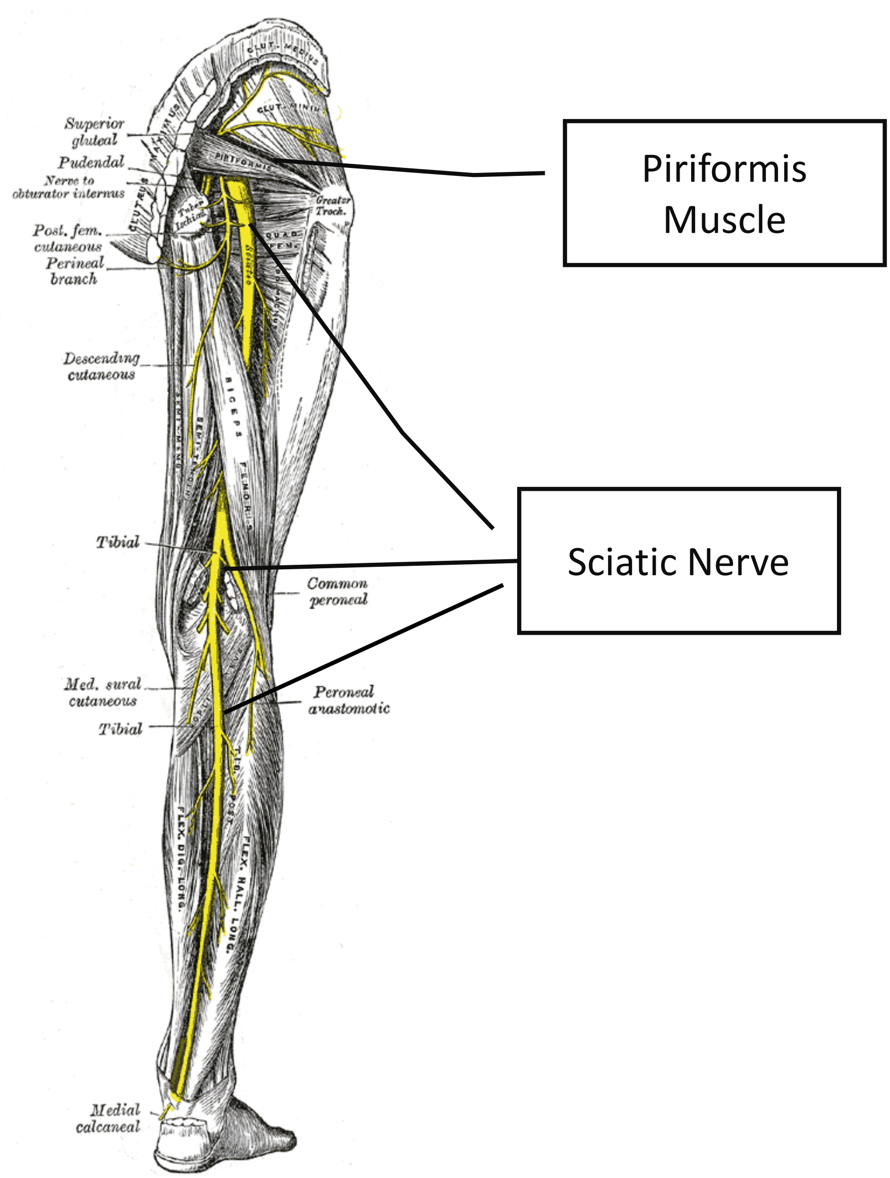


Figure A1:1. The piriformis muscle passes over the sciatic nerve.

After leaving the spine, the sciatic nerve passes under or in some cases through the piriformis muscle. This provides an opportunity for entrapment of the nerve. A diagnosis of piriformis syndrome is based on clinical presentation of symptoms which are very similar to those of a disc herniation.

Appendix 1: Piriformis Syndrome

The sciatic nerve passes under the piriformis muscle and travels down the entire length of the leg. Piriformis entrapment of the sciatic nerve can mimic lumbar disc disorders.



Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

Figure A1:2. The piriformis muscle passes over the sciatic nerve and the sciatic nerve traverses the entire length of the leg.

Appendix 1: Piriformis Syndrome

Overview of Piriformis Syndrome	
What is Piriformis Syndrome?	Piriformis syndrome is a relatively rare condition in which the piriformis muscle compresses or irritates the sciatic nerve.
Symptoms	Deep aching pain in the buttocks that is worse with sitting and pain radiating down the back of the leg (sciatica).
Radiographic Findings	Typically none
Physical Examination Findings	• Tenderness of the piriformis • Pain that is affected by stretching of the piriformis • Relief from standing with the affected leg bent and rotated outward • External (outward) rotation of the affected side foot provides relief
Treatment	• Cessation of activities that provoke this condition (prolonged sitting, bicycling, running, sitting in soft chairs, sitting on a wallet) • Stretching the piriformis • Addressing any femoral-pelvic (the bones of hip and pelvis) dysfunction • Strengthening the core muscles • Application of ice, heat, diathermy, or ultrasound • Prudent application of therapeutic massage or myofascial release • In rare cases this condition progresses to the point of needing injections; rarer still is the need for surgery.

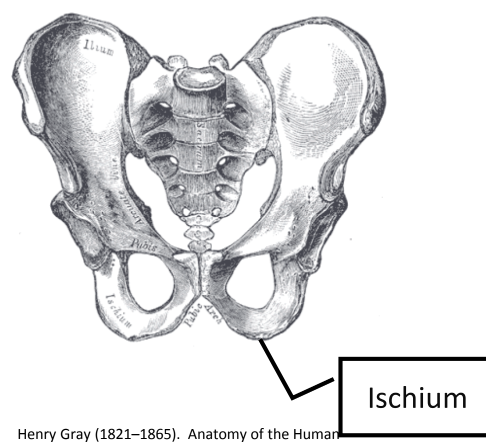
Figure A1:3. Overview of the piriformis syndrome.

Figure A1:4. Stretching the piriformis muscle.

The primary treatment for a piriformis syndrome is stretching. The piriformis stretch is performed by crossing the affected leg over the opposite knee. Gently pull the thigh toward your chest until a comfortable stretch is felt in the buttocks region. Hold this position for 30 seconds. Perform this stretch twice per leg, two sessions per day. Do not pull too hard as over-exertion will cause a worsening of the condition.

Figure A1:5. The piriformis stretch from a different angle. Note that the back is flat. Do not flex the spine.

Appendix 1: Piriformis Syndrome



Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

9

Figures A1:6, 7, 8, and 9. Piriformis pain can be reduced by sleeping with a bolster between your knees, usually with the affected side up (figure 6). Using a footstool (figure 7) will allow you to sit with most of your weight on the ischium of the pelvis (figure 8) rather than on the soft tissues of the pelvis (figure 9).

Piriformis syndrome is frequently managed by simple adaptations in activities of daily living. These include using a footstool to alter your sitting or sliding back in your chair so that you sit on the ischium of the pelvis instead of the soft tissues of the pelvis. Firmer chairs may also be more comfortable than soft chairs.

Treatment of piriformis syndrome consists of application of ice, decreased sitting, aerobic exercise, stretching, massage, trigger point therapy, ultrasound, electric muscle stimulation, chiropractic, ergonomics, and in some cases, injections into the muscle. However, for some people the solution is as easy as removing their wallet from their back pocket.

Appendix 2: Sciatic Nerve "Flossing"

Appendix 2: Sciatic Nerve Flossing

Nerve Flossing

Nerve flossing is a euphemism for nerve mobilization exercises. This technique is based on the premise that connective tissues can restrict the motion of nerves and that this restriction can cause nerve tension symptoms and signs. The goal of this treatment is to restore the normal nerve glide to reduce symptoms. More research is needed to confirm the benefits of this technique. This procedure has recently gained popularity with certain groups of chiropractors and manual therapy physical therapists.

The technique of nerve flossing, if improperly applied, has the potential to aggravate the sciatic or other involved nerves. Be very conservative if attempting this mobilization method. Nerve flossing may benefit those with chronic sciatica, but it may provoke symptoms of acutely inflamed sciatic nerves. If the nerve is anchored by the pressure of a disc or fibrotic adhesions, nerve flossing has the potential to increase inflammation. If you use this technique, proceed with caution. Do not perform this exercise if you have acute herniation (less than three months in duration).

Caution

"Nerve flossing" can tug on an irritated sciatic nerve. A significantly anchored or impinged upon nerve root will not move with this exercise and will be irritated by nerve flossing. Trying to stretch and mobilize nerve roots or the sciatic nerve can be provocative to an irritated nerve. Do not attempt to do this maneuver if you are suffering from an acutely herniated disc.

Do not mistake the author's description of nerve flossing as a primary treatment. This section is intended to describe alternative treatment options available.

Appendix 2: Sciatic Nerve Flossing

Technique for "Flossing" the Sciatic Nerve

While sitting with a lumbar arch (lordosis) maintained, slowly extend your leg while at the same time extending your head backward. Pause at your maximum level of comfortable extension, then bend your head forward while bending your knee.

Figures A2:1, 2, and 3. "Nerve flossing" is a self-treatment technique that is intended to free nerves from entrapment.

Method for "Flossing" the Sciatic Nerve

1. Move the neck and the leg in a coordinated manner. Do not straighten the leg and bend the head forward at the same time. This will tug on the nerve and provoke inflammation.
2. Each slide should last about 5 -8 seconds and should be implemented in a slow, continuous manner.
3. If relief is realized, then continue with this technique every 2-3 hours with 8 repetitions.
4. Do not perform this exercise if it provokes your symptoms, and do not perform it for the first 1½ hours after rising in the morning.

Appendix 3: Glossary

Appendix 3: Glossary

Glossary

Abdomen. The belly. The portion of the trunk which lies between the ribs and the pelvis

Acute. New, short in duration. Not chronic. Usually a condition that is less than three months in duration

Adjustment. Chiropractic term for a manipulation

Ankylosing spondylitis. An inflammatory joint disease that results in portions of the spine fusing together

Anterior. Pertaining to the front of the body

Arthritis. Inflammation of a joint

Asymptomatic. Without symptoms

Cartilage. A connective tissue that is characterized by lack of blood vessels and its rubbery consistency. Intervertebral discs consist of fibrocartilage

Cauda equina. Literally "the horse's tail." A bundle of nerves that begins where the spinal cord ends at about L1

Cauda equina syndrome. A rare condition that compromises the nerves of the cauda equina. This condition is a medical emergency

Cervical. The seven vertebrae that make up the neck; Non rib-bearing neck vertebrae

Chiropractic. Greek for manual medicine or skilled with hands

Chronic. Older, longer duration

Coccyx. The small bone at the base of the sacrum

Degenerative disc disease. Dehydration and reduction in the height of the lumbar disc

Discectomy. Surgical removal of a portion of an intervertebral disc

Discogram. An invasive radiographic study that involves the injection of dye (visible on x-ray) into the disc

DJD. Degenerative joint disease. Erosion of the joint surface, typically from age or wear and tear

Facets . The small joints in the back of the vertebra (see anatomy appendix)

Ilium. The large irregular shaped bones that join with the sacrum to form the pelvis

Incontinence of urine. Inability to restrain from urinating

Laminectomy. Literally "to cut the lamina." A surgery that cuts away the bony lamina to allow more room for the underlying nerves and access to the intervertebral disc

Lateral. Away from the midline of the body; Lateral is also a term in radiology used to describe an x-ray taken from the side view

Lordosis. The sway that makes the curves in your neck and lower back

Appendix 3: Glossary

Glossary

Lumbar radiculopathy. Symptoms and signs attributed to the pathology of an affected lumbar nerve. Signs of radiculopathy may include extremity pain, numbness, weakness, and/or loss of reflexes
McKenzie Exercises. A system of exercises that is used to reduce the symptoms of sciatica and other spinal conditions
Medial. Closer to the midline of the body
MRI. Magnetic resonance imaging (MRI), or nuclear magnetic resonance imaging (NMRI) is a diagnostic tool that uses magnetic fields and computer technology instead of radiation to create images of soft tissues such as intervertebral discs, nerves, muscles, and ligaments. MRI is the standard method for viewing disc injuries
Myelopathy . Damage to the spinal cord
Neuralgia. Nerve pain
NSAIDs . Non-Steroidal Anti-inflammatory Drugs. This class of drugs reduces inflammation without steroids
Nucleus pulposa. The gel-filled center of the disc
Osteophyte. A bony spur
Physical therapy. The name of a profession as well as a class of treatment modalities
Posterior. Towards the back of the body
Prolapse. “Prolapsed disc” is a non-standard term used to describe a herniated disc that is extruded from within the annular fibers. This is not a standard definition of disc derangement
Radiology. The discipline of health care concerned with diagnostic imagery such as X-rays, MRI, CT Scan, bone scans, and diagnostic ultrasound
Rupture. When something that is contained bursts through restraining tissues or barriers
Sacroiliac Joint. A large relatively stable joint between the sacrum and the ilium
Septic. Pertaining to an infection
Shingles (AKA Herpes Zoster). A viral infection that causes nerve pain and blebs on the skin along the path of nerves. The virus is the same as the one that is responsible for Chicken Pox
SI. Abbreviation for sacroiliac joint
Spasm. Abnormal involuntary contraction or tautness of muscles
Spina Bifida Occulta. A cleft in the posterior arch of one or more vertebrae
Spinal column. The 24 vertebrae and the sacrum comprise the spinal column
Spinal cord. An extension of the central nervous system from the brain through the spine
Spondylolithesis. A forward slippage of a vertebra on the vertebra below it. This can result from degeneration or from a defect in the integrity of the vertebra
Spondylosis . Literally “spinal condition;” This term pertains to spinal degeneration or “arthritis.”

Appendix 3: Glossary

Glossary

Stenosis. Narrowing or contracture of the spinal canal

TENS. Transcutaneous Electric Nerve Stimulator. A physical therapy modality that is intended to mitigate pain through the use of a mild electrical current running through the patient

Tender point. A focal point of tenderness that does not refer pain to other parts of the body. Often tender points are erroneously called *trigger points*

Trigger point. A focal point of muscle tautness that refers pain to other parts of the body

Urinary retention. he inability to urinate which is a serious neurological or urological symptom

Vertebra. An individual spinal bone

Vertebrae. Pleural of vertebra

Vertebroplasty . Injection of synthetic hardener to add strength to a vertebra; a treatment for compression fractures of the spine

William's exercise. An exercise program that is based on flexion exercises; William exercises are not indicated for disc patients

Zygapophysial joints. The small joints in the posterior of the vertebrae; These joints are also known as the facet joints

Appendix 4: Centralization and Peripheralization

Appendix 4: Centralization and Peripheralization

Centralization is a term that denotes the progressive regression of symptoms from the periphery (in lumbar discs the symptoms are usually down the leg)toward the midline. It is considered a positive indication in the treatment of lumbar disc herniation and sciatica.

Peripheralization is a term used to describe the advancement or worsening of symptoms. Any activities, treatment, exercise, or posture that causes peripheralization should be avoided.

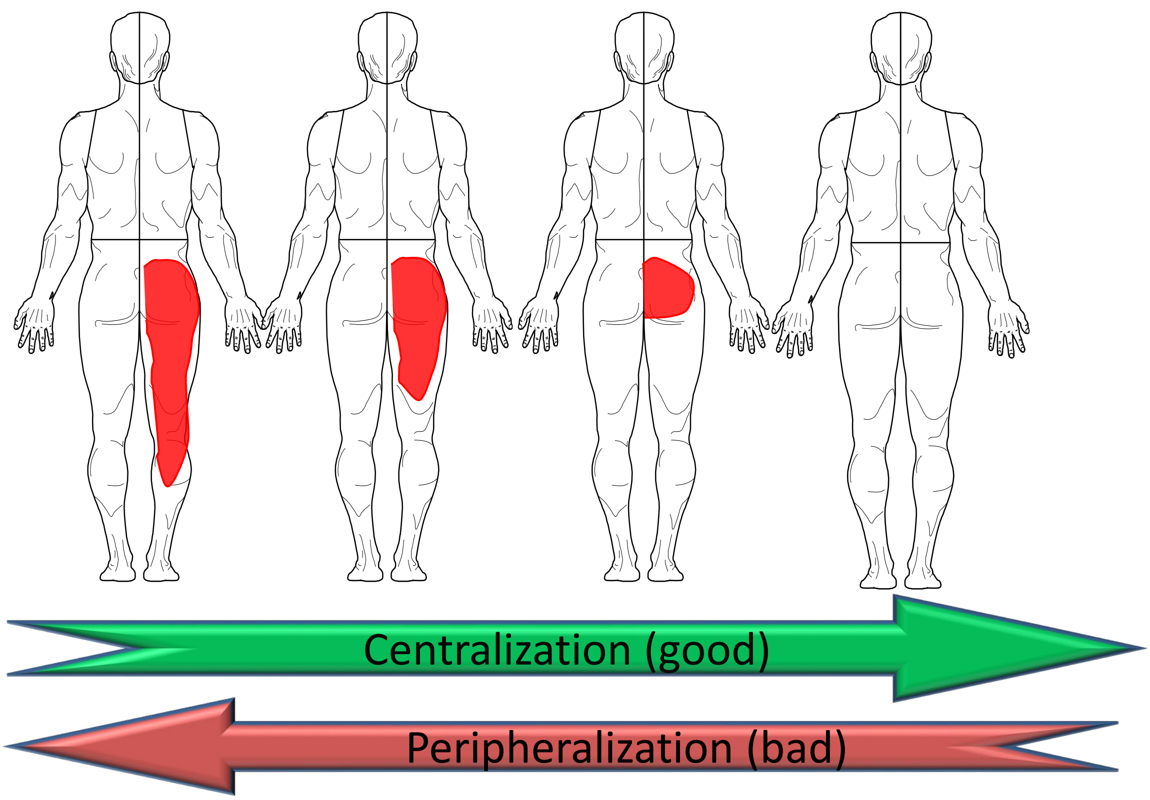


Figure A4:1. This schematic shows various distributions of leg pain in sciatica. Treatment that results in centralization (symptoms regressing toward a more central location) is considered to be successful, while treatment that results in peripheralization (symptoms extending further down the leg) is not successful. If extension exercises cause peripheralization, discontinue them immediately. You may note a temporary mild increase in back pain with extensions. This is acceptable as long as the leg pain centralizes.

Note: The terms peripheralization and centralization are based on the writings of by Robin McKenzie.

Appendix 5: Gallery of Lumbar Disc Derangements

Gallery of Lumbar Disc Derangements

This chapter is composed of a gallery of various lumbar disc derangements. This chapter will help unite the information provided in the last six chapters. As you view this pictorial essay take a moment to consider the components of each disc herniation. The vertebral level, the anatomic zone, and the type of derangement (tear, extrusion, protrusion, bulge, intravertebral herniation and so forth). In addition to identifying the nomenclature and classification of the disc lesions, take time to familiarize yourself with the other structures in each image. Of particular interest to clinicians is the disc injury's relationship to the cord, cauda equina, thecal sac, and nerve roots. Moreover, consider the impact of disc derangement on facets, muscles, ligaments, endplates, vertebral bodies, canal space, epidural venous plexus, sacroiliacs, and other anatomic structures. A disc herniation may be associated with facet effusion, multifidus atrophy, bony edema of the vertebral bodies, facetal imbrication, ligamentum flavum changes, posterior longitudinal ligament disruption, and other anatomical and functional failures.

Take time to consider the potential clinical consequences of particular disc injures: pain distribution, orthopedic-neurologic signs, and effects on other anatomical structures. By viewing a variety of different derangements, you will begin to gain a familiarity on this topic allowing you to discern nuances of disc disease.

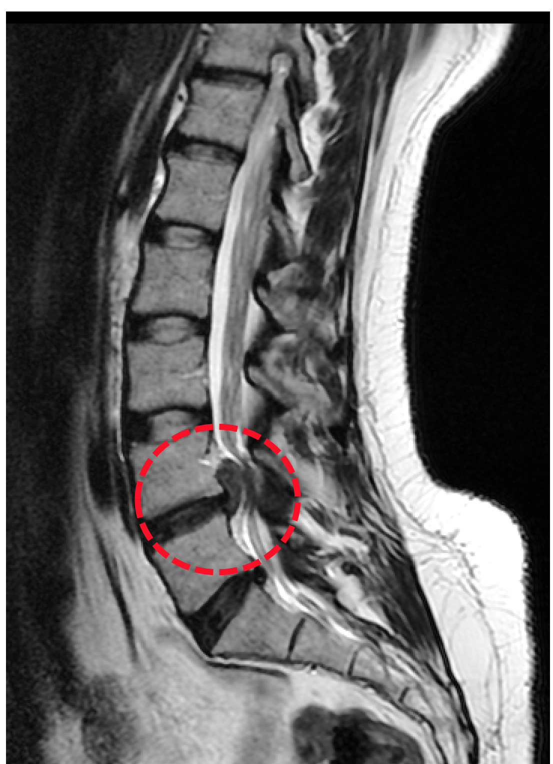


Figure A5:1. L4-L5 disc herniation with cephalad migration along the body of L4.

T1 versus T2 Weighted Images for Viewing Disc Derangements

Figure A5:2. T1 axial at L4-5.

Figure A5:3. T2 axial at L4-5, the same slice as figure A5:2.

Figure A5:4. T1 sagittal of a herniation at L4-5.

Figure A5:5. T2 sagittal of the same herniation at L4-5 as seen in figure A5:4.

T1 images have good anatomical detail, but since there is reduced contrast between the disc material and the cerebral spinal fluid in the thecal sac, it is more difficult to identify intervertebral herniations. It is easier to view disc herniations on T2 images. For this reason most of the disc herniations in this chapter will be presented in T2 weighted format.

Caudal Sequestered Extrusion into the Sacrum

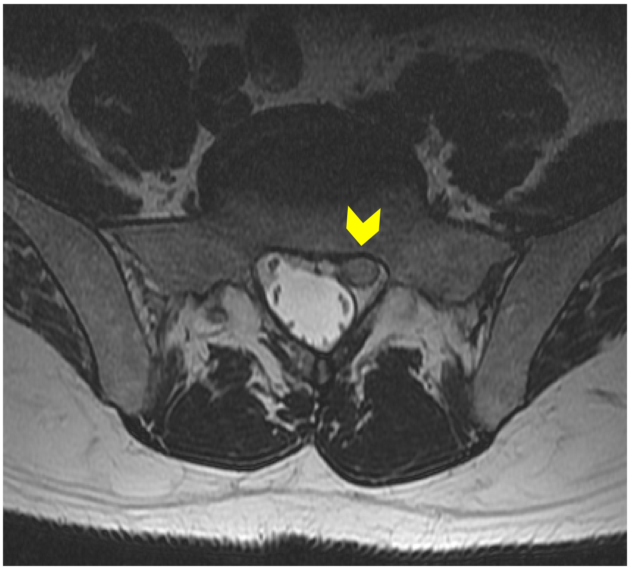


Figure A5:6. This T2 weighted axial image reveals a round circumscribed herniation (sequestered disc fragment) descending into the sacrum, displacing the thecal sac and the S1 nerve root.

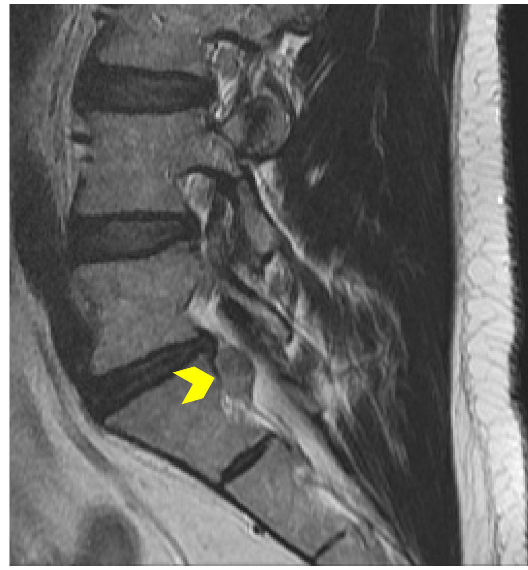


Figure A5:7. This T2 weighted sagittal image shows a light-colored sequestered disc fragment descending into the sacrum along the body of S1.

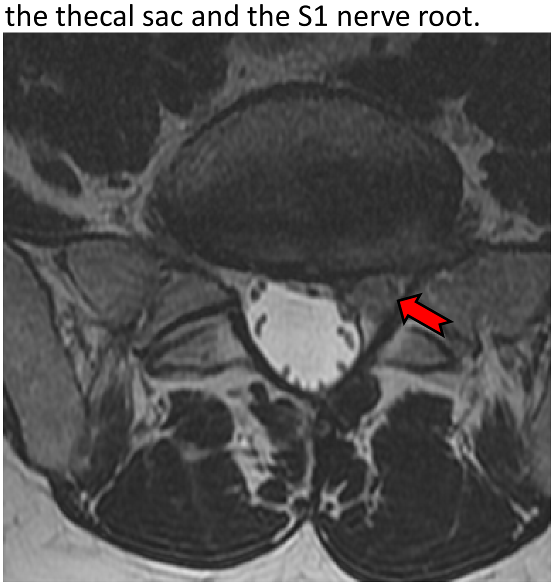


Figure A5:8. This image is an MRI slice that is cephalad to the slice in figure 7:6. The sequestered fragment is clearly seen.

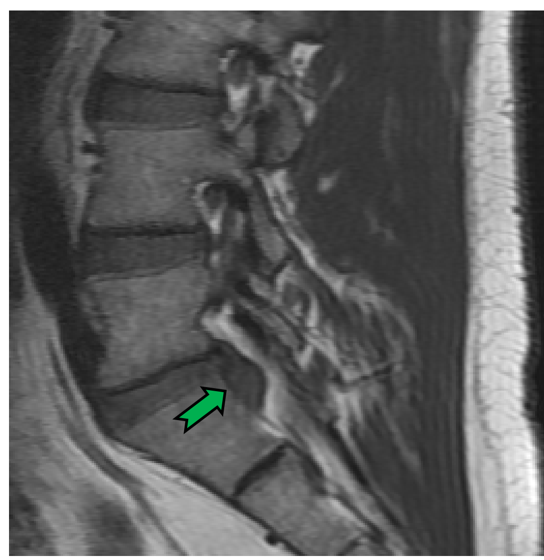


Figure A5:9. Sagittal T1 weighted image of caudal herniation (green arrow) of L5-S1 disc.

These four images show a large L5-S1 sequestered extrusion that extends caudally into the sacrum following the left S1 nerve root and displacing the thecal sac. The light color of this extrusion is indicative of high water content.

Foraminal Herniation

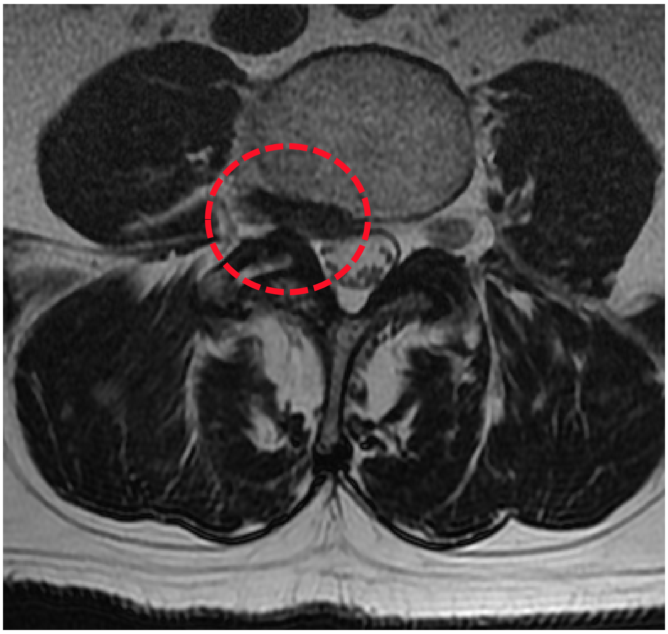


Figure A5:10. This T2 weighted axial image reveals a right foraminal herniation of the L4-5 disc.

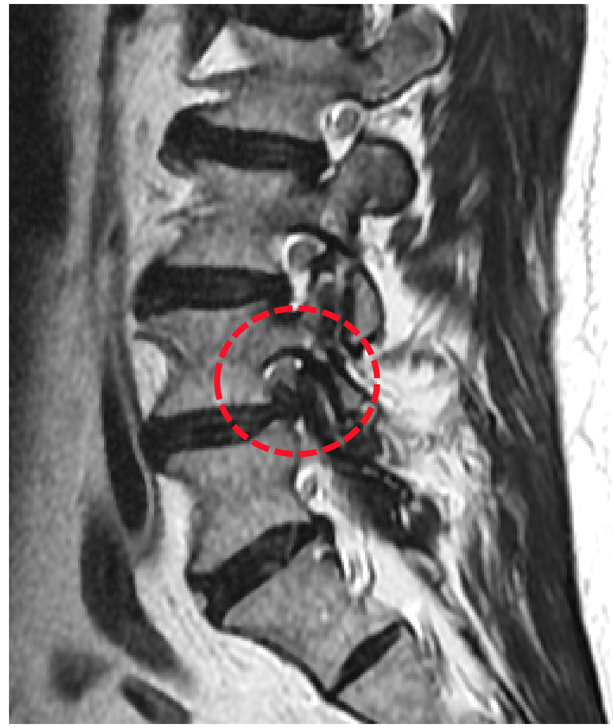


Figure A5:11. This sagittal T2 weighted image reveals a right foraminal herniation of the L4-5 disc. Note the disc of L4-5 extending upward into the IVF and compressing the exiting L4 nerve root.

These images reveal a foraminal herniation at L4-L5 with compression of the right L4 nerve root in a 69 year old man. Also of note in the axial image is increased intensity within the right zygopophyseal, joint and atrophy of the multifidus muscles. This focal herniation is an extrusion and extends cephalad into the IVF contacting and compressing the exiting nerve root.

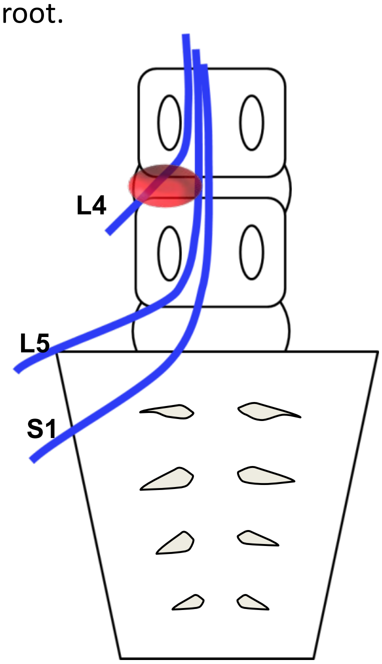


Figure A5:12. Schematic of a right sided L4-5 foraminal herniation.

Foraminal Herniation with Zygapophyseal Effusion

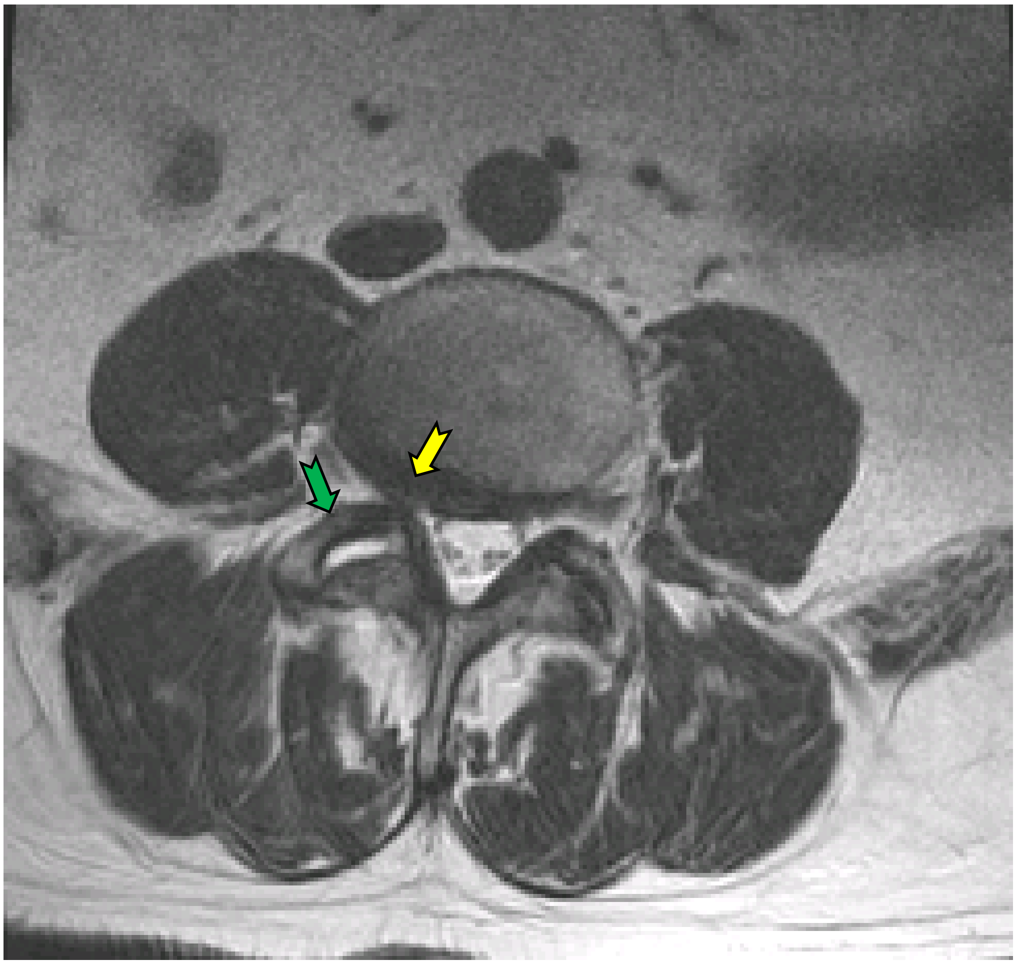


Figure A5:13. This axial image displays broad-based disc protrusion (yellow arrow) that crosses the right IVF. Note the effusion within the right *zygapophyseal* joint (green arrow).

Caudal Extrusion of the L4-5 Disc

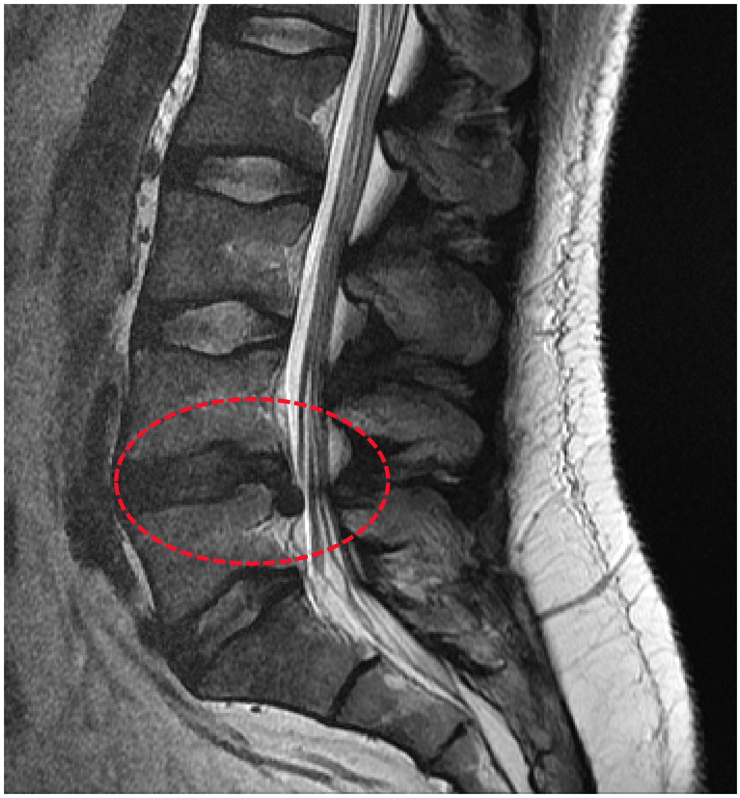


Figure A5:14. L4-L5 inferior extrusion and possible sequestration.

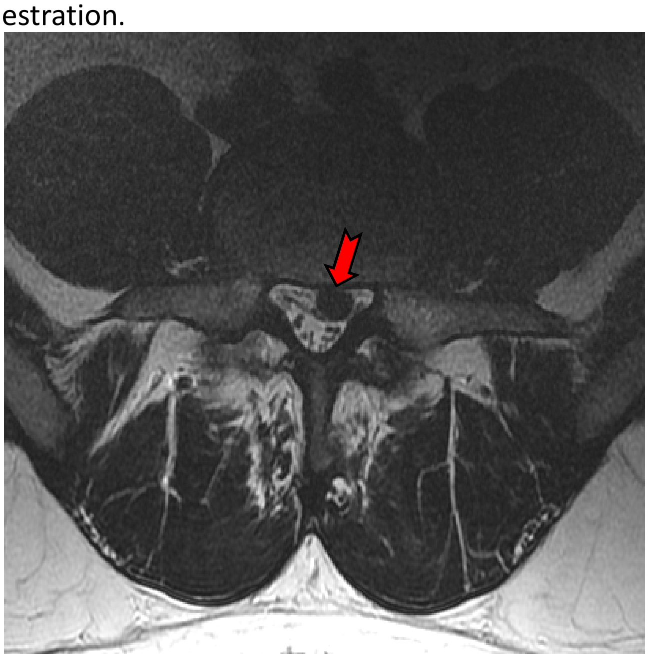


Figure A5:15. An axial view of the extrusion along the body of L5. Note the thecal sac displacement.

Regression of Disc Herniation

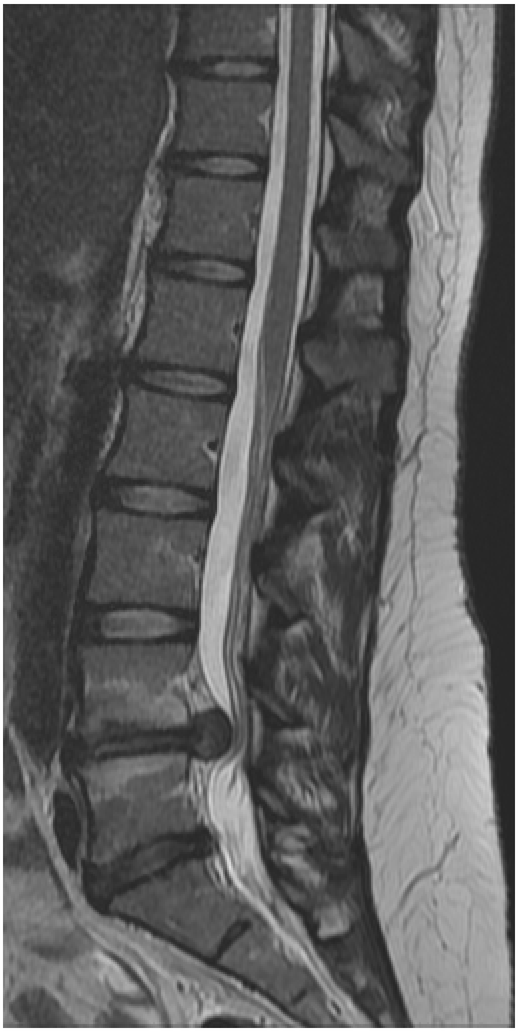


Figure A5:16. Large extrusion of the L4-5 disc.

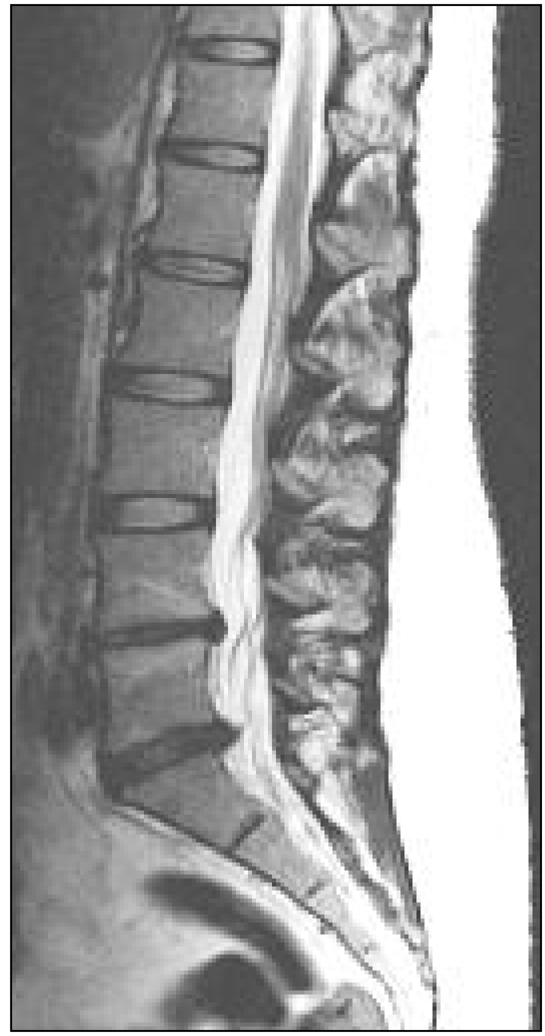


Figure A5:17. Follow-up MRI of the same patient six months later. Note the regression of the L4-5 disc herniation.

These images show the regression of a large extrusion of the L4-5 disc over a six month period of conservative care. Figure A5:16 reveals a huge herniation. A second MR taken six months later, figure A5:17, reveals a significant reduction in the mass of the herniation. Note the bony edema of the adjoining vertebral bodies. Endplate disruption and bony edema of the vertebral bodies discussed more fully in Chapter 21. Larger herniations tend to be more apt to regress than smaller herniations. Disc bulges tend not to regress in size. Axial images of this patient are displayed on the following page.

Regression of Disc Herniation (continued)

Figure A5:18. Large extrusion of the L4-5 disc. Note the extent of thecal sac effacement and displacement of the nerve rootlets.

Figure A5:19. Follow-up MRI of the same patient six months later. Note the regression of the L4-5 disc herniation.

Figure A5:18 reveals from an axial perspective the extent that this disc extrusion occupied the central canal, subarticular zone, and the foraminal zone. Figure A5:19, taken six months later, clearly demonstrates a profound reduction in the size of the herniation.

Extrusion and Post-Surgical Re-Herniation and Regression

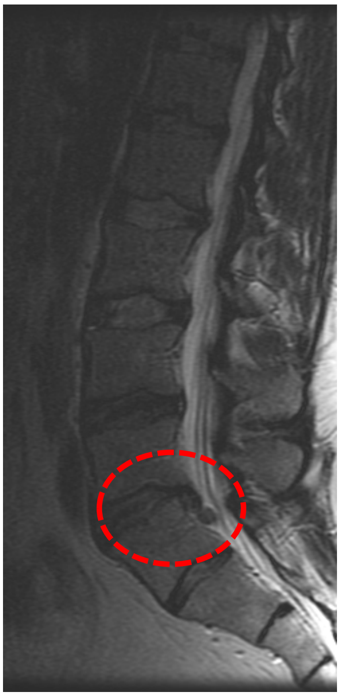


Figure A5:20. Pre-surgery.

Figure A5:21. Re-herniation two months post-discectomy.

Figure A5:22. Regression of disc six months after image A5:21 was taken.

This sequence of images shows a sequestered extrusion of the L5-S1 disc extending inferiorly into the central canal of the sacrum (figure A5:20). This patient was treated surgically with a microdiscectomy. Two months after surgery he re-herniated the L5-S1 disc, this time with superior migration of the extruded disc along the posterior body of L5 (figure A5:21). He was treated conservatively with chiropractic care, exercise, and modified work postures. A follow-up MRI six months following the second herniation revealed what appears to be a "deflated" herniation (figure A5:22). The herniation still extends superiorly along L5, but the mass of the herniation is significantly reduced.

Focal Central Herniation

Figure A5:23. T2 weighted sagittal image revealing a small extrusion of L5-S1.

Figure A5:24. T2W axial of a focal herniation arising from a broad-based herniation. Note the herniation is between the S1 nerve roots.

These images reveal a focal extrusion on top of a broad-based protrusion of the L5-S1 disc. The focal extrusion between the S1 nerve roots contacts both descending S1 nerve roots, and it effaces the thecal sac.

Herniations with Annular Tears

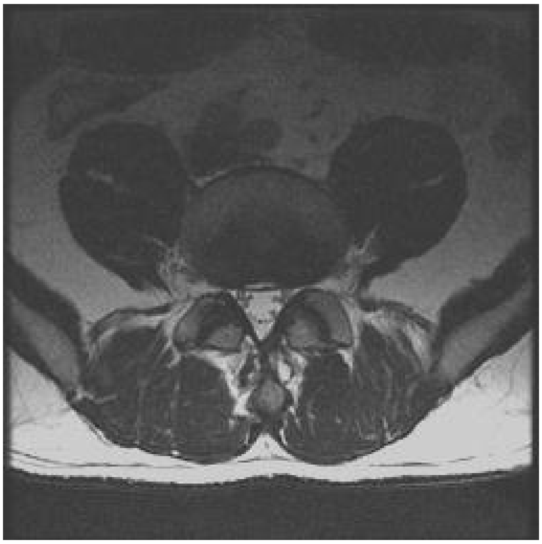


Figure A5:25. This T2 weighted axial image reveals a posterior concentric annular tear of the L4-5 disc.

Figure A5:26. This T2 weighted axial image reveals a broad-based herniation with a posterior paracentral concentric annular tear.

Figure A5:27. This T2 weighted sagittal image reveals a transverse annular tear of the anterior of L2-3 on the superior L3 endplate. There is also a tear along the superior endplate of L4 affecting the posterior portion of that disc.

Figure A5:28. This sagittal image displays a posterior transverse tear at the superior endplate of L4, a concentric tear of the posterior L5 disc, and a small portion of a transverse tear at the superior L3 endplate.

Paracentral Herniation

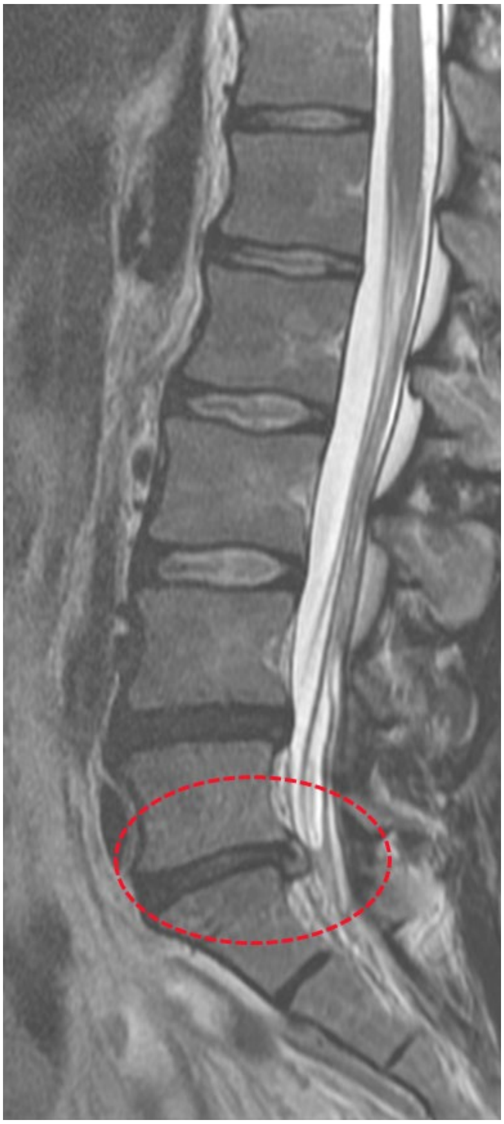


Figure A5:29. T2W sagittal image revealing desiccation of the L4-5 and L5-S1 and an extrusion of the L5-S1 disc.

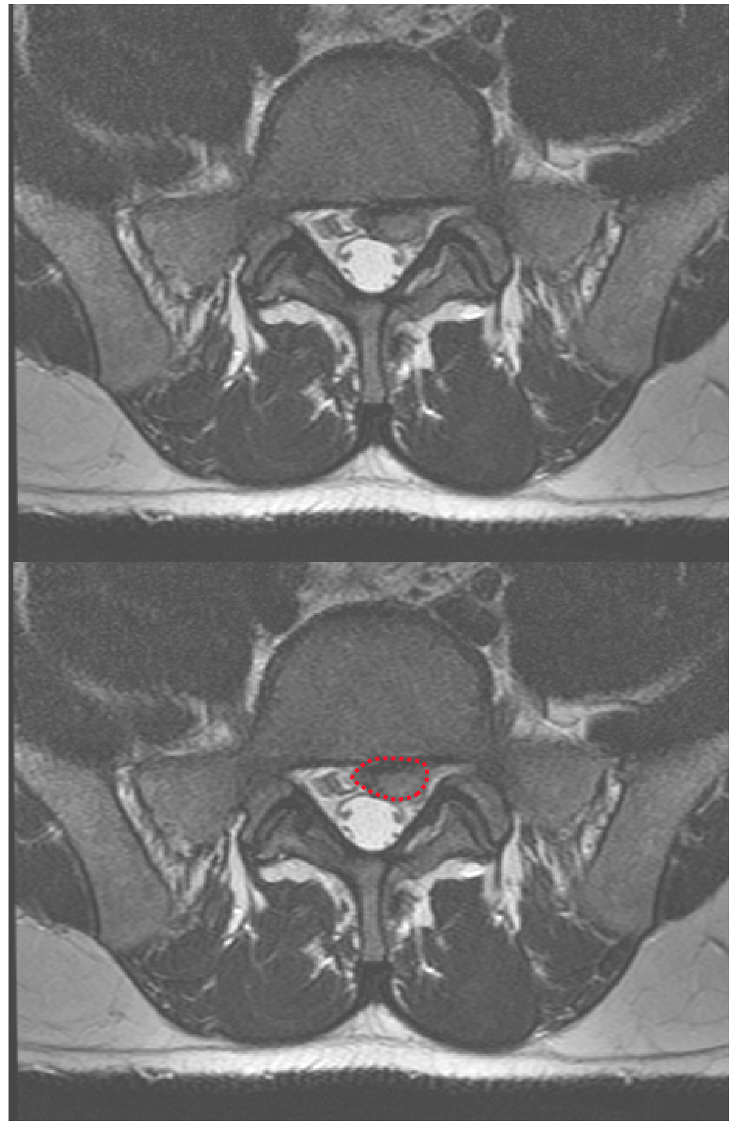


Figure A5:30. T2W axial image showing a left para-central extrusion of the L5-S1 disc.

These T2 weighted images reveal an L5-S1 paracentral disc extrusion displacing and compressing the left S1 nerve root. Notice the levels of brightness and darkness in these images. The extruded portion of the disc is light-colored, which on T2WI indicates a high degree of water content. In contrast, the L4-L5 disc is dark in color, indicating reduced water content and desiccation.

Paracentral Extrusion

Figure A5:31. Sagittal T2 weighted image of an L4-5 extrusion.

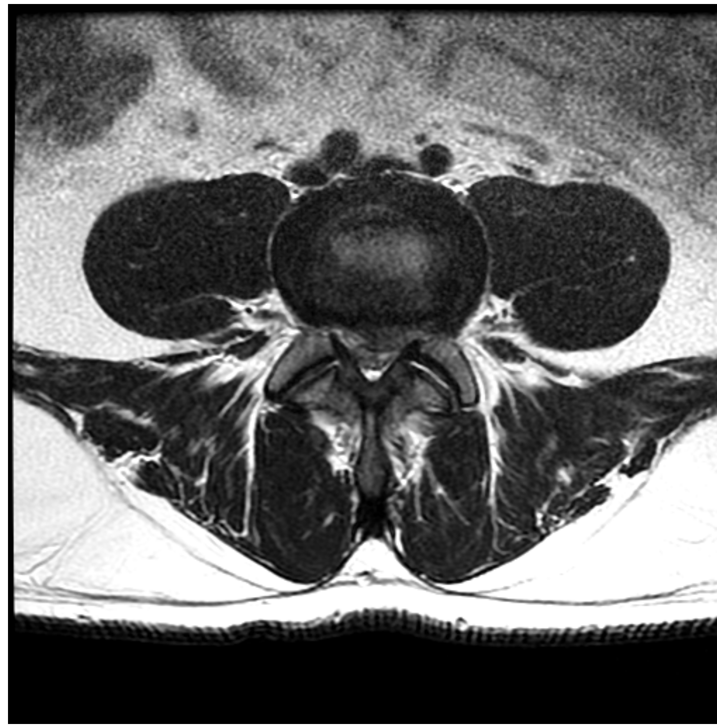


Figure A5:32. Axial T2WI of a paracentral L4-5 disc extrusion.

Broad-Based Protrusion

Figure A5:33. Sagittal T2 weighted image of an L4-5 protrusion.

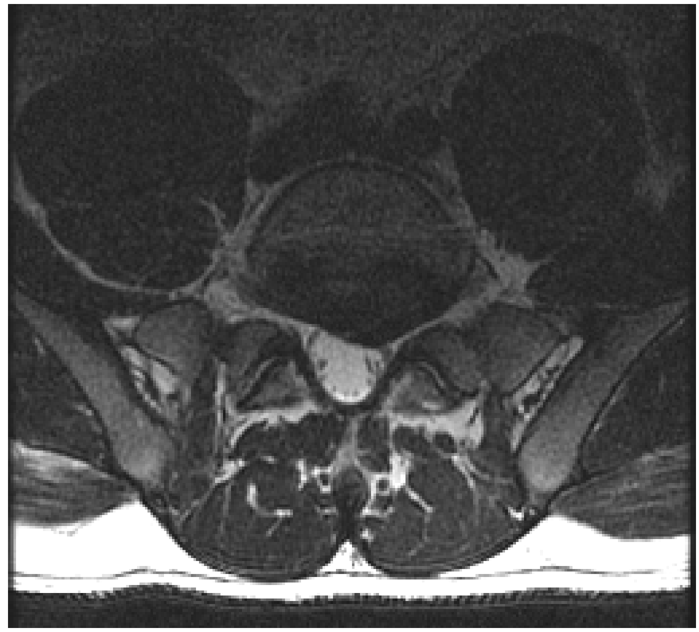


Figure A5:34. Sagittal T2 weighted image of an L4-5 extrusion.

Here we see a broad-based protrusion of L5-S1 that distorts the left anterior portion of the thecal sac and narrows both IVFs. The left IVF is particularly compromised.

Paracentral Extrusion

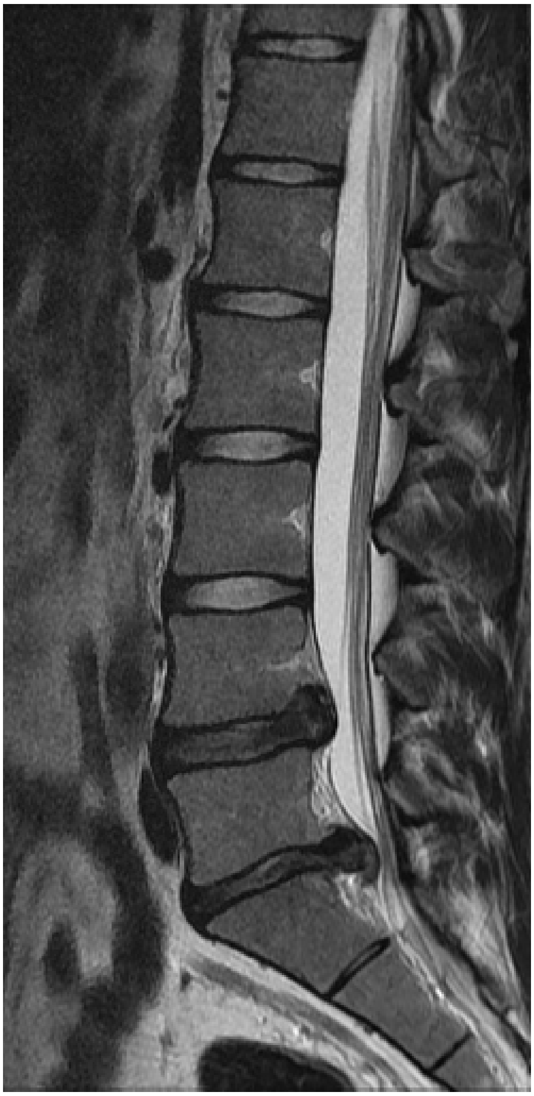


Figure A5:35. Sagittal T2 image revealing a relatively small L4-5 extrusion and a larger L5-S1 herniation. This extrusion has a “hook” extending caudally from the main herniation.

Figure A5:36. This axial represents the slice showing with the greatest herniation mass at L5-S1.

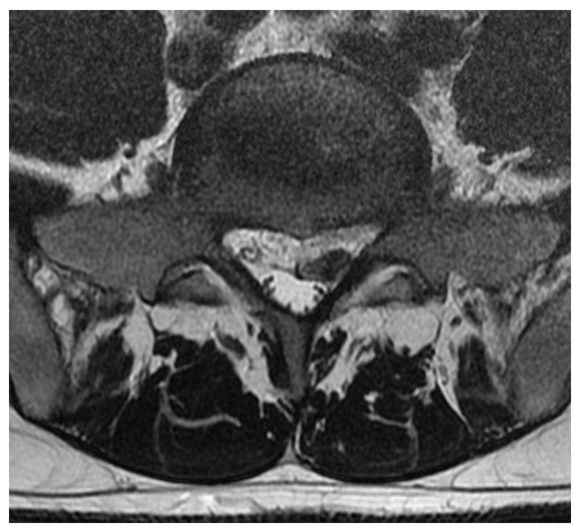


Figure A5:37. This slice shows the caudally migrated portion of the L5-S1 disc seen in image A5:35.

These three images show a large L5-S1 herniation (a focal herniation on top of a broad-based herniation) with a portion of the disc descending caudally. This portion of the L5-S1 disc may actually be a sequestered fragment that has not been displaced. In figure A5:36, the thecal sac effacement and nerve compression is worthy of note. In figure A5:37, the inferior portion of the L5-S1 disc is clearly visualized displacing the left S1 nerve. Also of note is the disc extrusion and desiccation at L4-5.

Two Level Herniation

Figure A5:38. Sagittal T2 of L3-4 and L4-5 extrusions.

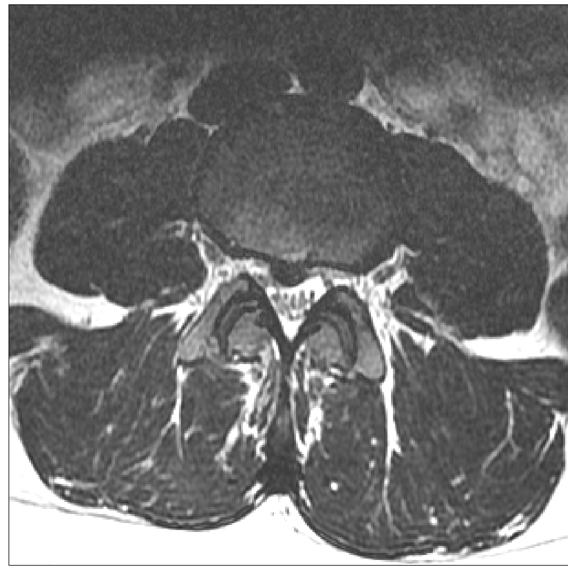


Figure A5:39. Focal paracentral extrusion at L3-4 displacing the thecal sac.

Figure A5:40. Broad-based herniation with a strong left foraminal component at L4-5.

These three images show two herniations migrating toward each other. The L3-4 herniation is seen on the sagittal image, figure A5:38, and figure A5:39. It extends inferior along the posterior body of L4. The L4-5 herniation is visualized in figure A5:38, and figure A5:40. The L4-5 herniation travels superiorly. Also of note in this series is the concentric annular disc tear affecting the posterior fibers of the L5-S1 disc.

Herniation with Nerve Root Entrapment

Figure A5:41. This focal foraminal zone herniation of the L5-S1 disc entraps and compresses the S1 nerve root. Also of note in this T2W axial image is the central canal stenosis and subarticular stenosis. Ligamentum flavum hypertrophy and facetal hypertrophy contribute to the stenosis.

Broad-based Extrusion

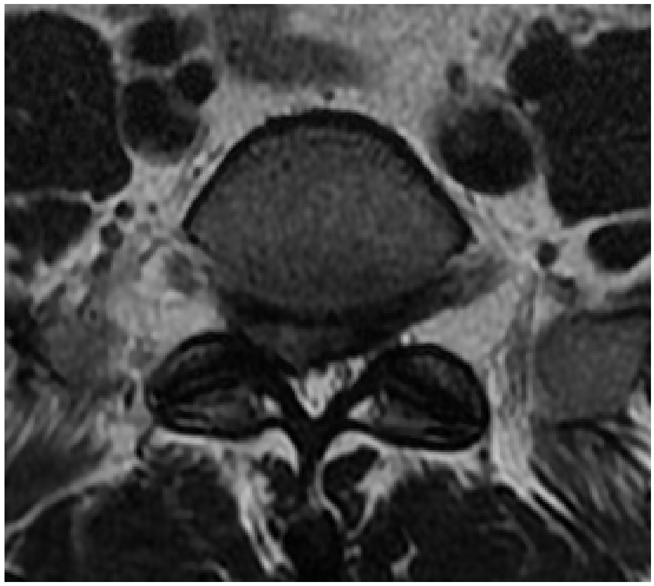


Figure A5:42. Moderate broad-based extrusion of the L5-S1 disc extending across both foramina favoring the right.

Figure A5:43. L5-S1 extrusion and L4-L5 protrusion.

Figure A5:44. Sagittal T2WI of L4 -5and L5-S1 herniations. L5-S1 is an extrusion.

Intravertebral Herniation

Intravertebral herniations occur when the disc breaks through the vertebral endplate of an adjoining vertebra. This schematic shows both an inferior and superior intravertebral herniation. These are commonly called Schmorl's nodes.

Figure A5:45. Sagittal T2 weighted image showing an intravertebral herniation (Schmorl's node) extending superiorly into T12. Note the halo of Modic 2 changes around the lesion and affecting the L2-3 vertebrae.

Figure A5:46. Sagittal T2 weighted image from the same study showing another intravertebral herniation extending superiorly into L4. Note the bony edema surrounding this bony disruption.

Herniation

Figure A5:47. Sagittal T2WI showing an extrusion and degeneration of the L5-S1 disc.

Figure A5:48. Axial T2WI of a left-sided paracentral herniation displacing the S1 nerve root and effacing the thecal sac.

Large Extrusion Projecting Inferiorly

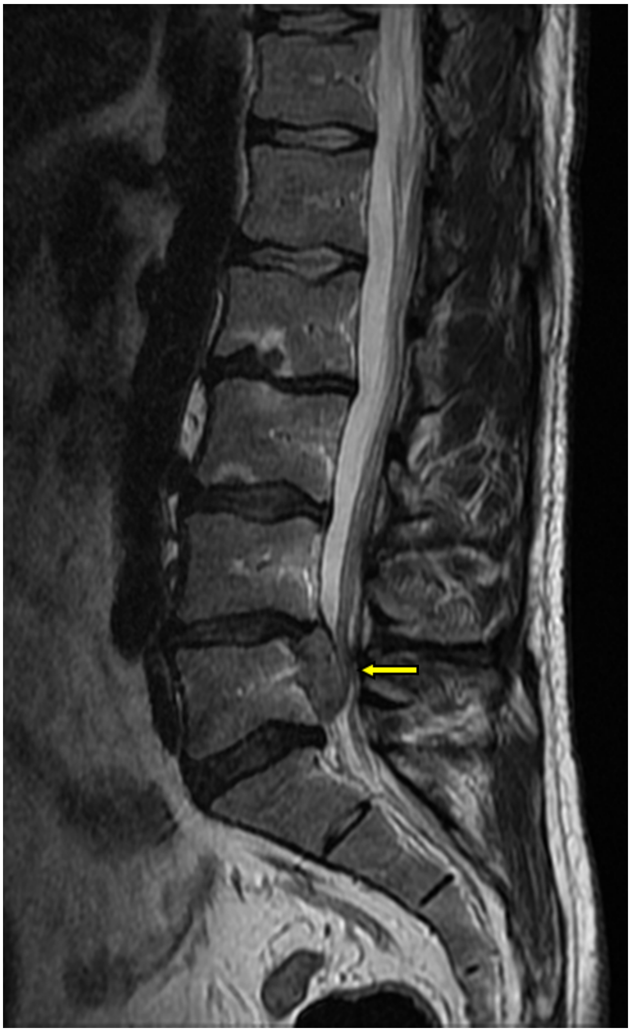


Figure A5:49. This sagittal image shows a huge L4-5 extrusion (probably a sequestered fragment) that projects inferiorly from the L4-5 disc interspace along the vertebral body of L5.

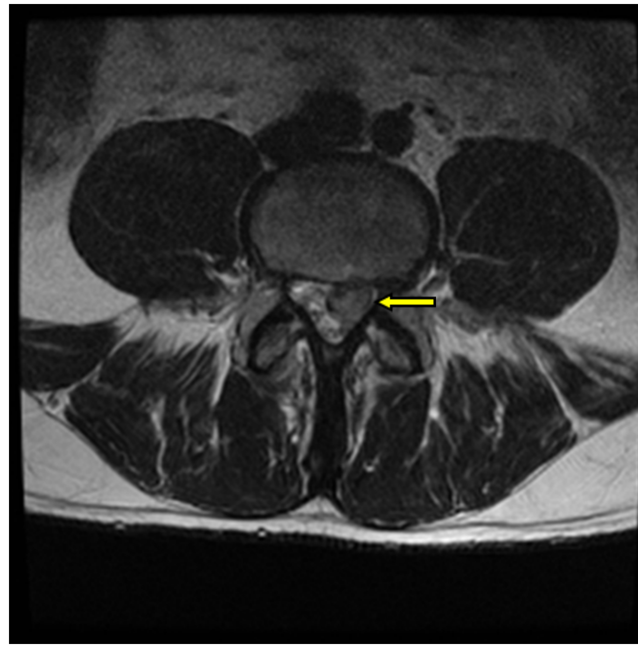


Figure A5:50. This T2 weighted axial image reveals the large extrusion that occupies a large portion of the central canal posterior to the body of L5.

From the axial image this herniation would be classified as being moderately large. The sagittal view is needed to fully grasp the mass of disc material that herniated from the L4-5 disc and descended along the body of L5. This herniation resulted in a left leg foot drop, which resolved after surgery.

Sequestered Fragment

Figure A5:51. This axial image shows a sequestered fragment from the L4-5. The sequestered fragment displaces the left S1 nerve root. The left S1 nerve appears to be inflamed.

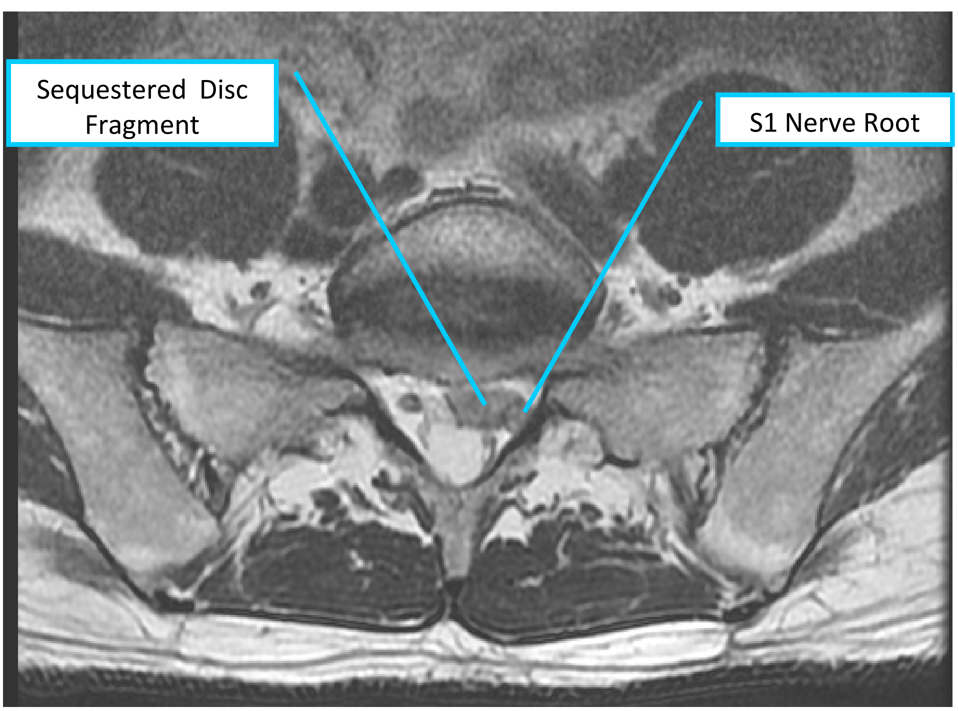


Figure A5:52. This image is a labeled version of the same axial slice that is seen in the image above.

Re-herniation 2 Weeks Post-Surgery

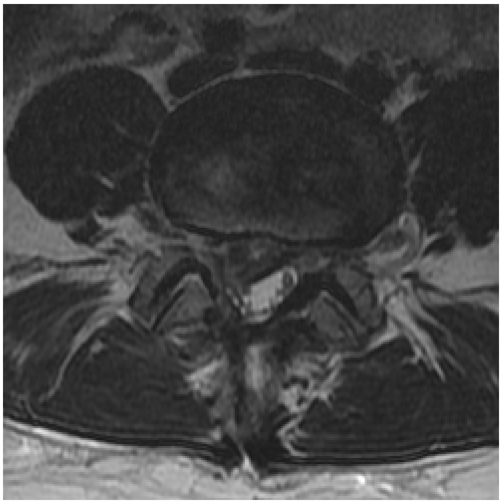


Figure A5:53. This image taken two weeks after a discectomy was done shows a large re-herniation of L4-5 (the same segment and same side that had been operated on).

Figure A5:54. In addition to the re-herniation of L4-5, this T2 weighted image shows a collection of fluid (bright on T2WI) posterior and to the right of midline.

Figure A5:55. Sagittal **T2WI** showing the L4-5 re-herniation and posterior fluid collection.

Figure A5:56. Sagittal **T1WI** showing the L4-5 re-herniation and posterior fluid collection.

This series of images taken two weeks following a discectomy reveal a re-herniation of the L4-L5 disc and a pseudomeningocele.

Figure A5:57. This sagittal image shows a large L4-5 extrusion that projects inferiorly from the L4-5 disc interspace.

Figure A5:58. This sagittal image of the same patient seen in figure 7:57 reveals significant regression of the L4-5 disc extrusion.

This series of seven images over the next three pages are taken from a patient who presented with a large herniation that regressed significantly over a five month period.

Regression of Disc Herniation on Axial Images (page 2 of 3)

Figures A5:59 and A5:60. These axial images are from the same patient from the previous page. These images reveal two axial slices of an L4-5 herniation.

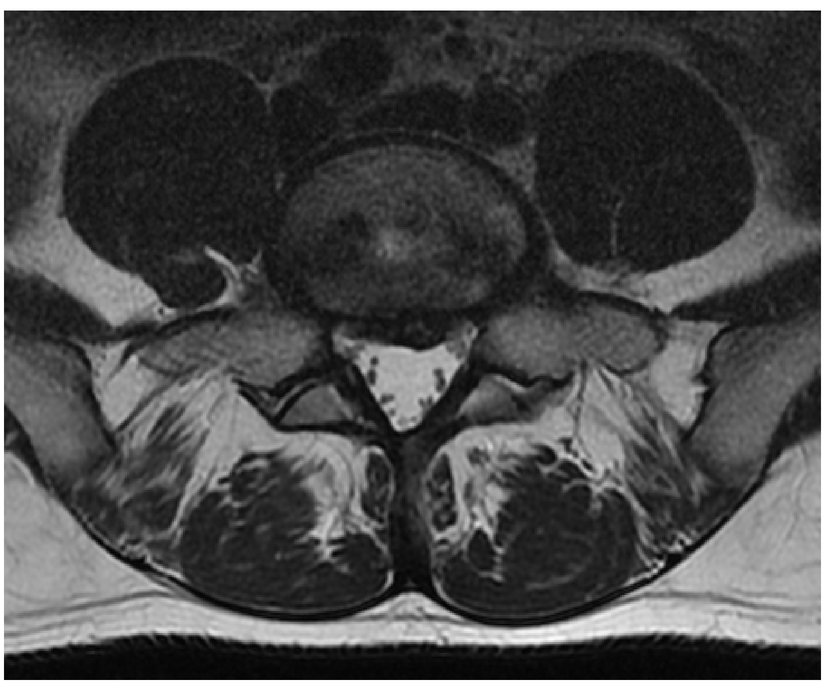


Figure A5:61. This axial slice represents the largest remnant visible of the L4-5 herniation of any image in the axial images of this level take five months after the series represented in figures A5:59 and A5:60.

Regression of Disc Herniation (page 3 of 3)

Figure A5:62. From this axial slice, this disc derangement looks like a free-floating sequestered fragment. It represents the slice depicted by the green line in figure A5:63.

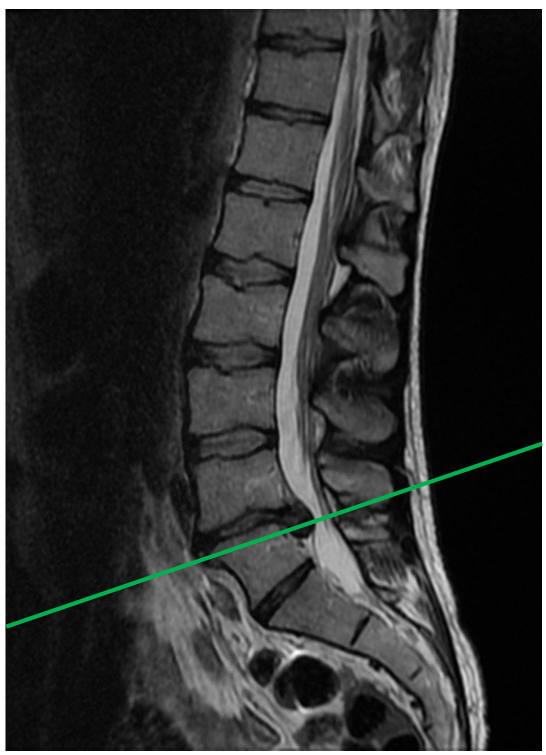


Figure A5:63. By correlating the axials with the sagittal images you will gain a more conceptual view of the anatomy. Here we can see that the axial slice in figure A5:62(green line) captures one portion of a larger caudal extrusion, not a sequestered fragment. This concludes a seven image series.

Figure A5:64. T1W sagittal image of a large intravertebral herniation through the inferior endplate of L1 into the body of L1.

Figure A5:65. T2W sagittal image of a large intravertebral herniation through the inferior endplate of L1 into the body of L1.

Figure A5:66. A different T2W sagittal slice from the same patient shows the halo of bony edema indicating that this injury is new and possibly a pain generator.

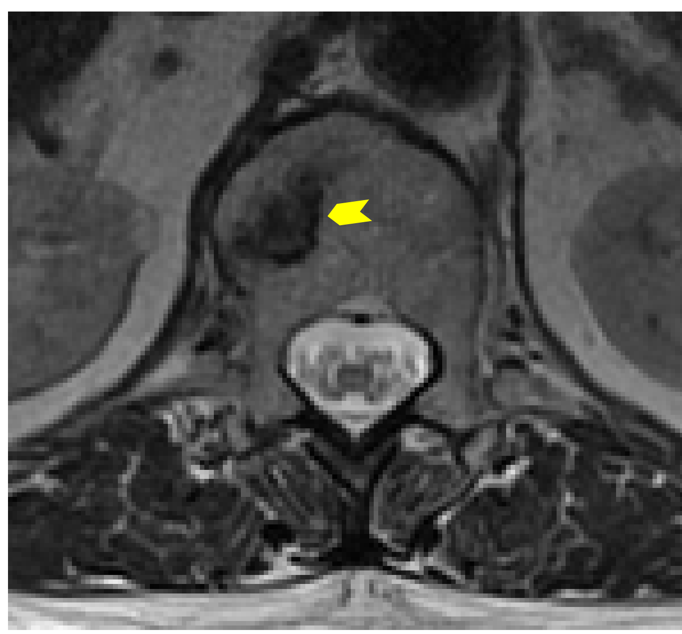


Figure A5:67. T2W axial image showing the disc material herniated into the vertebral body of L1.

Concentric Tear

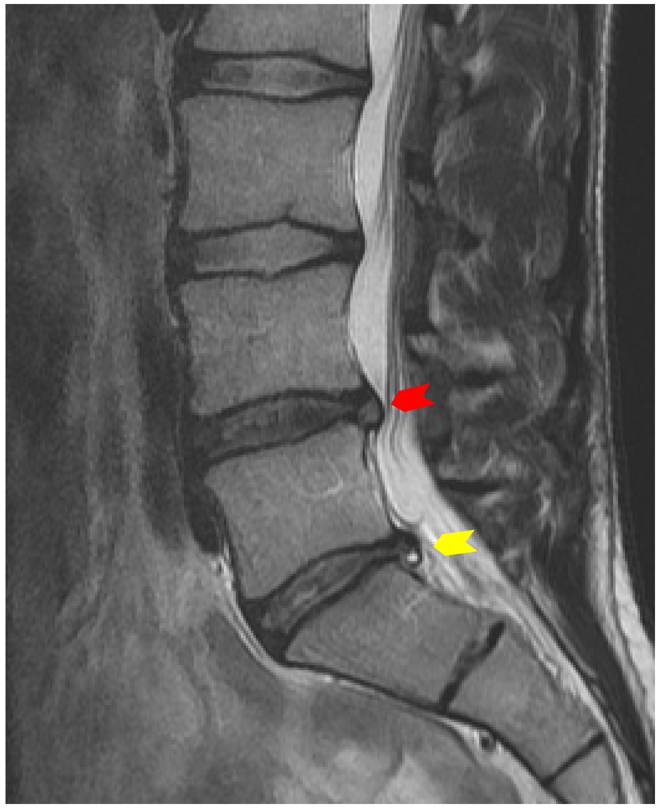


Figure A5:68. Sagittal T2WI showing an extrusion and degeneration of the L4-L5 (red arrow) and L5-S1 discs with a posterior concentric annular tear at L5-S1(yellow arrow).

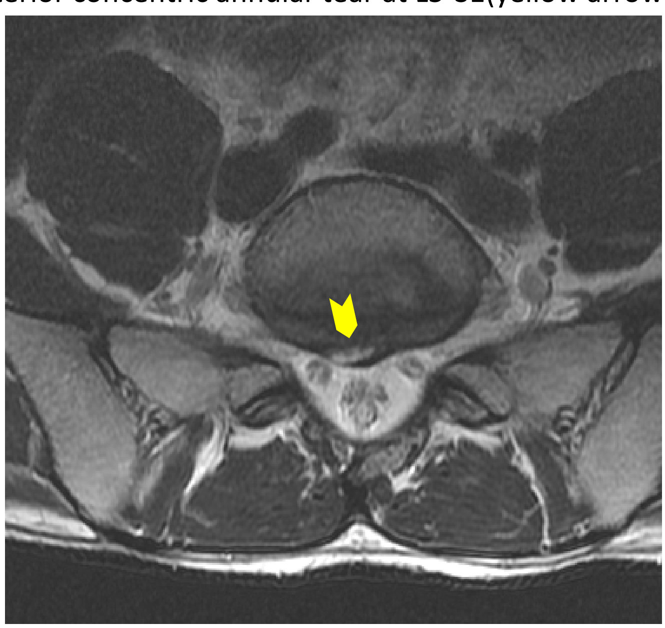


Figure A5:69. Axial T2WI of the concentric annular tear at L5-S1(yellow arrow).

Concentric Tear

Figure A5:70. Sagittal T2WI showing an extrusion and degeneration and posterior concentric annular tear at L4-L5.

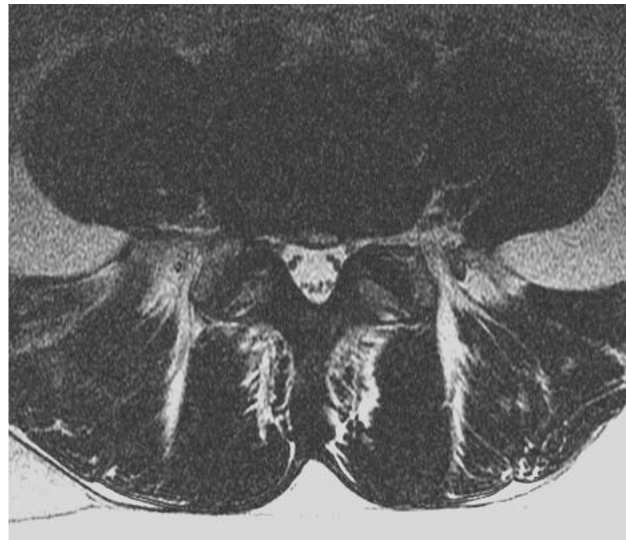


Figure A5:71. Sagittal T2WI showing an extrusion and degeneration and posterior concentric annular tear at L4-L5.

Paracentral Herniation

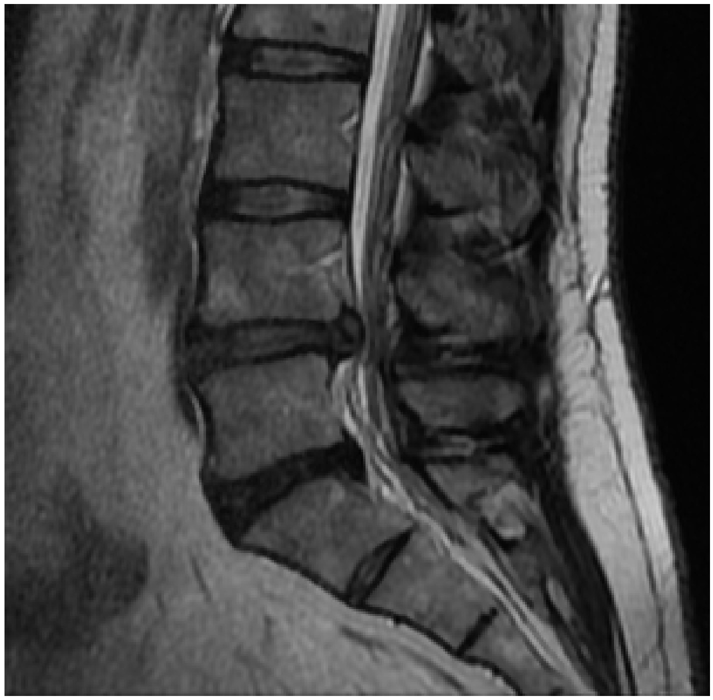


Figure A5:72. Sagittal T2WI showing an extrusion and degeneration at L4-L5. Desiccation is also visible at L5-S1.

Figure A5:73. Axial T2WI showing a left paracentral disc herniation.

Small Central Herniation

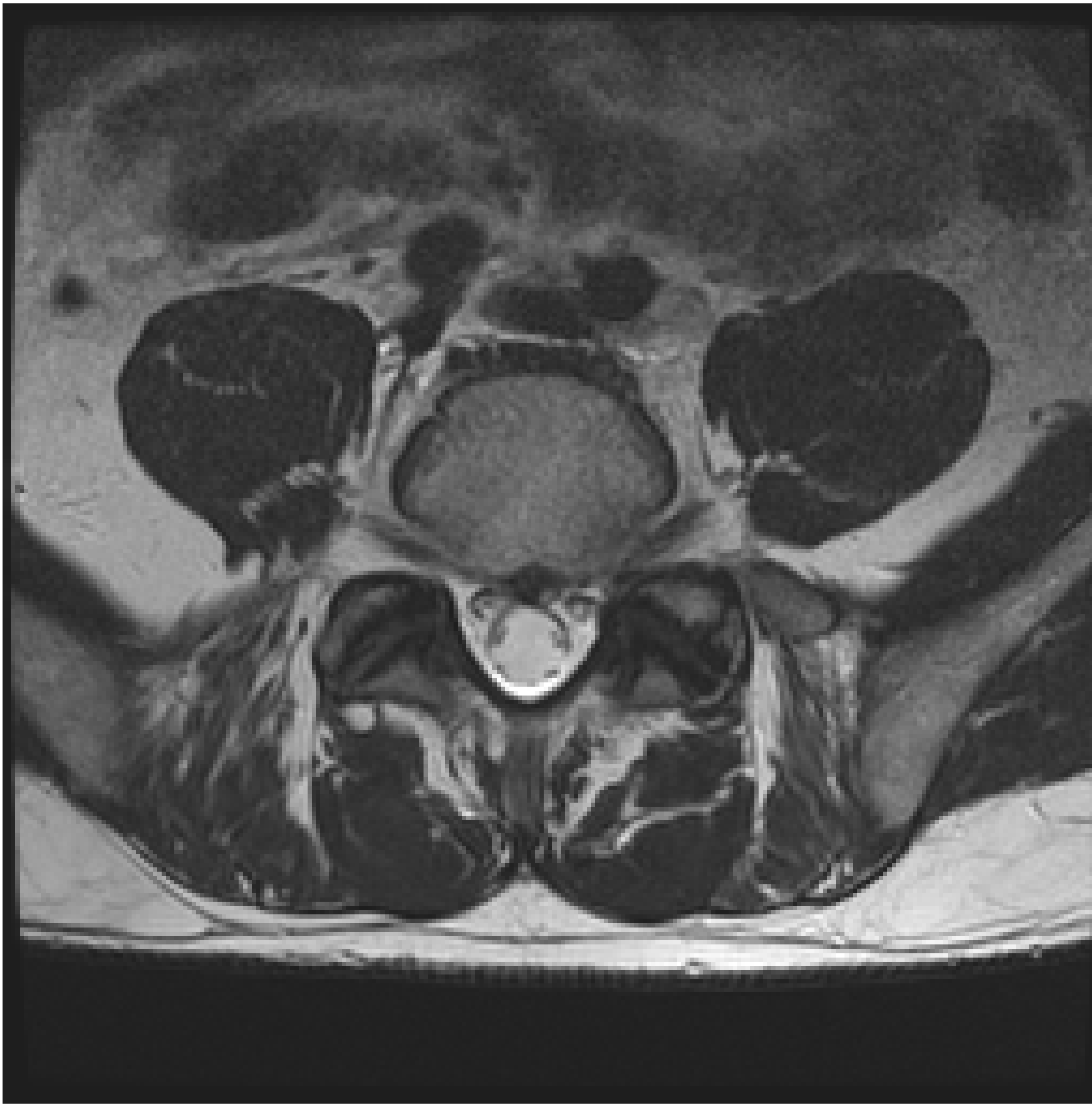


Figure A5:74. Small central herniation.

Paracentral Extrusion

Figure A5:75. Sagittal T2WI showing an extrusion of the L5-S1 disc. A sequestered fragment sits on the extrusion like the cap of a mushroom.

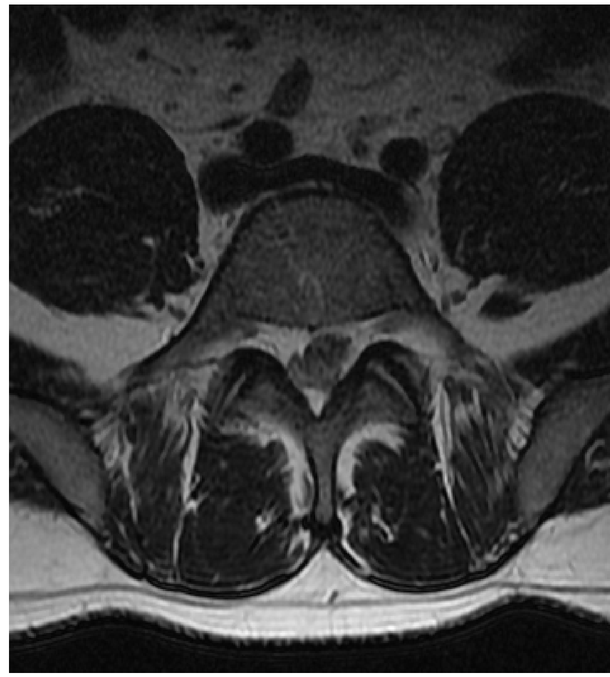


Figure A5:76. Axial T2WI showing an extrusion of the L5-S1 disc.

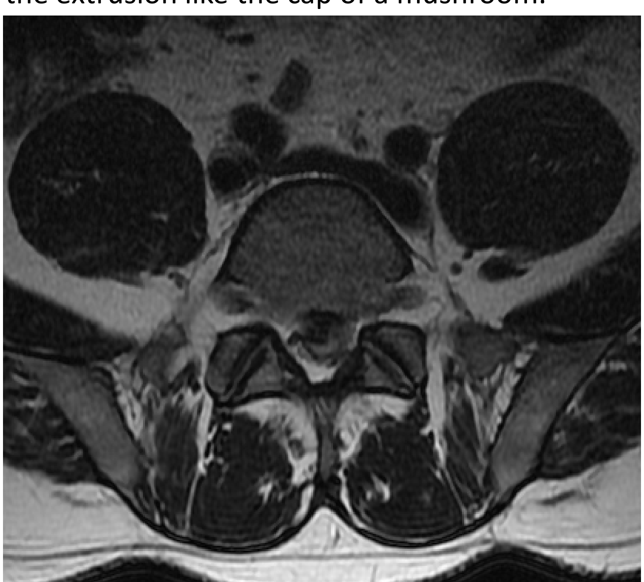


Figure A5:77. Axial T2WI showing an extrusion of the L5-S1 disc.

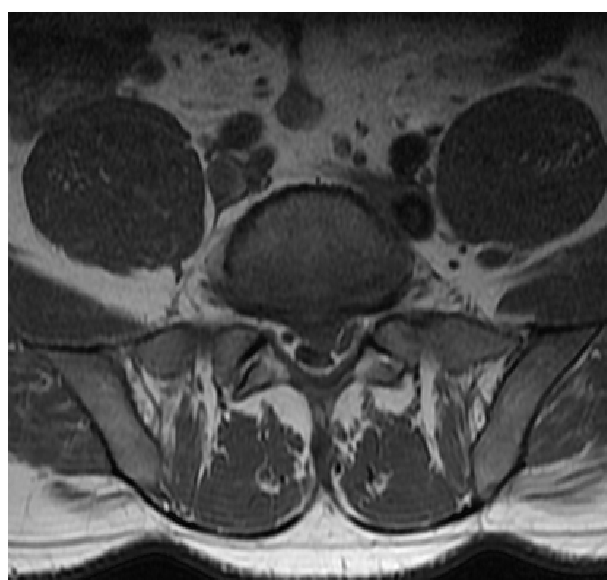


Figure A5:78. Axial T1WI showing an extrusion of the L5-S1 disc.

Central Extrusion

Figure A5:79. T2W sagittal image of a small L5-S1 extrusion with a concentric tear.

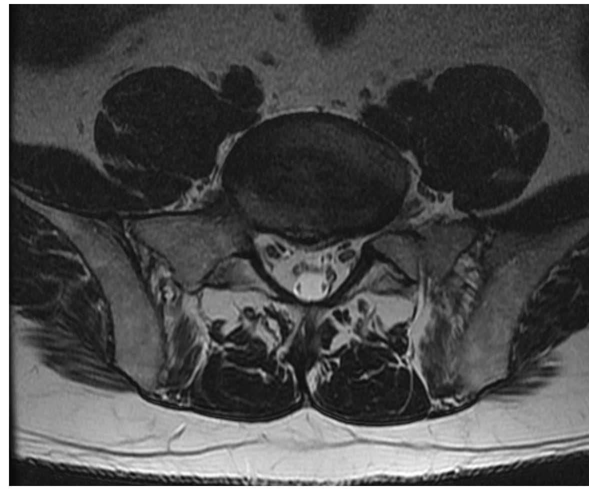


Figure A5:80. T2W axial image of the same disc derangement as seen in figure A5:79.

Paracentral Extrusion

Figure A5:81. L5-S1 extrusion, degeneration, desiccation. The discs of the upper lumbar vertebrae are light-colored in this T2WI indicating hydration. The black disc of L5-S1 shows reduced hydration and desiccation.

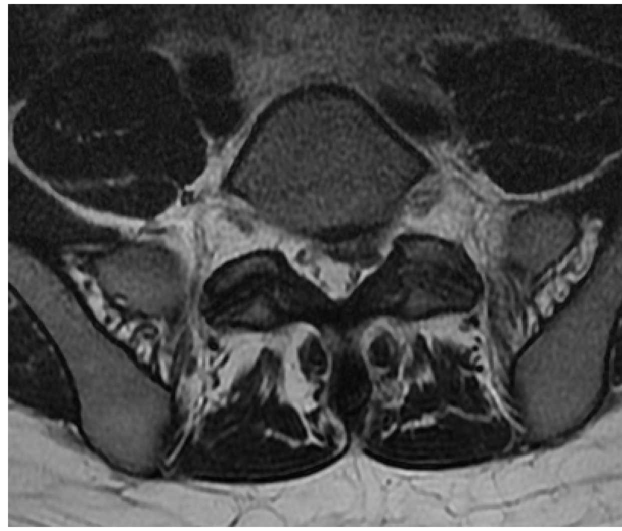


Figure A5:82. Left-sided paracentral extrusion effacing the thecal sac and displacing the left S1 nerve root. T2W axial image.

Paracentral Extrusion

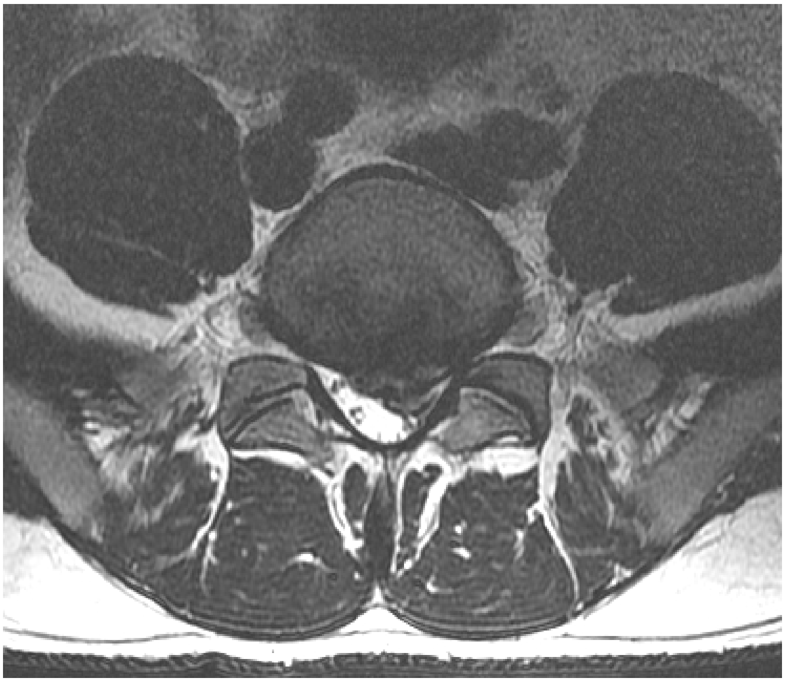


Figure A5:83. Moderate paracentral herniation on top of a broad-based herniation at L5-S1, T2WI.

Figure A5:84. Two extrusions are visible in this sagittal image: L4-5 and L5-S1. The upper discs appear well-hydrated, but L4-5 and L5-S1 are dark and appear to be desiccated in this T2WI.

Broad-based Herniation and Extrusion

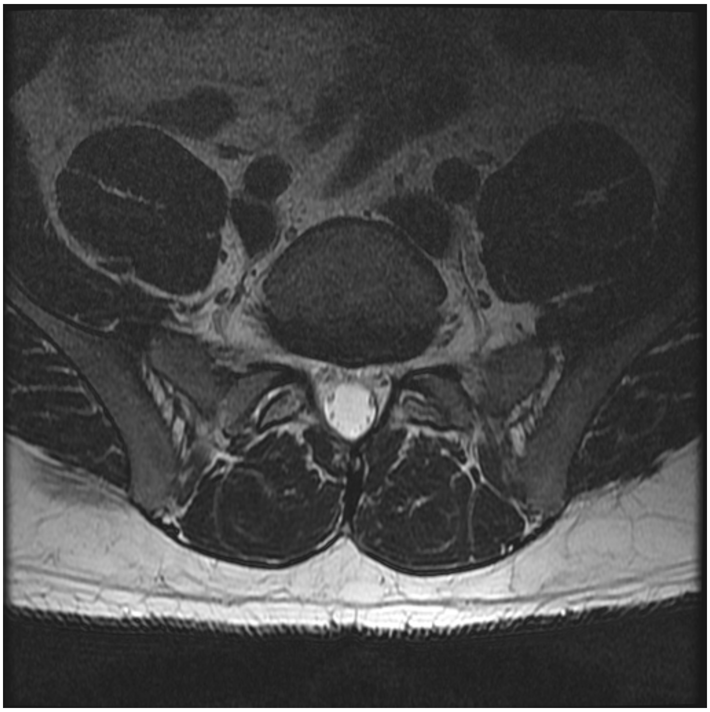


Figure A5:85. T2W axial image showing a broad-based herniation at L5-S1.

Figure A5:86. T2W sagittal image of the lumbar spine showing well-hydrated discs from L1-L5 and a cephalad migrating extrusion arising from L5-S1. Note the black disc of the L5-S1 disc indicative of desiccation.

Figure A5:87. T1W image of the herniation as it extends cephalad along the body of L5.

Focal Herniation into a Large Central Canal

Figure A5:88. Degenerative disc with end plate changes (see Chapter 21) at L5-S1. An extrusion exits from the L5-S1 disc into a very large central canal. Note a small hemangioma in the body of L3.

Figure A5:89. This image shows a focal disc herniation arising on top of a broad-based herniation. The herniation extends into a very large central canal.

Focal Extrusion Compresses and Deforms the Thecal Sac

Figure A5:90. The T2W axial image shows a focal extrusion compressing and deforming the thecal sac and its contents.

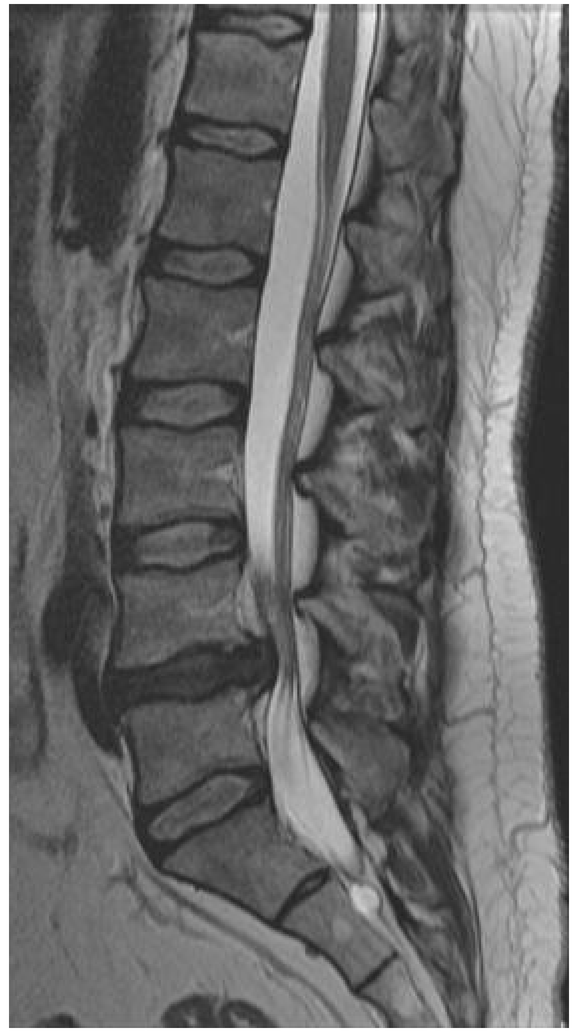


Figure A5:91. The sagittal view of this extrusion clearly shows deformation of the thecal sac at L4-5 along with disc desiccation at that level and a small S2 perineural cyst. This image also demonstrates a clear view of the conus medullaris terminating at L1.

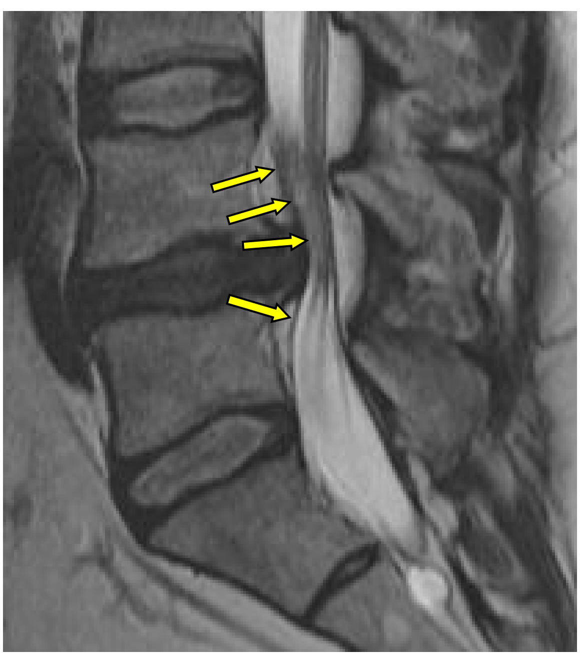


Figure A5:92. This enlargement of the sagittal slice from image A5:92 shows the boundary of the thecal sac (yellow arrows).

Severe Herniation

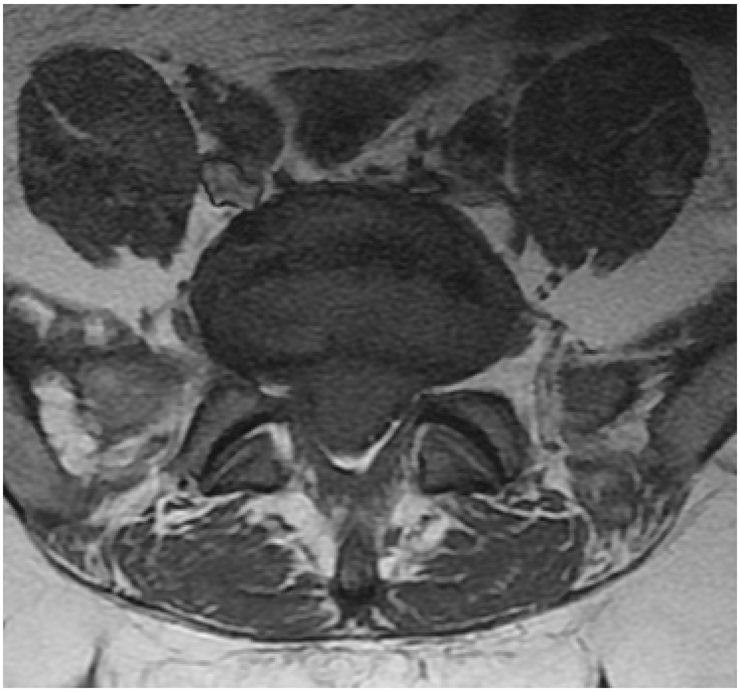


Figure A5:93. A very large disc herniation at L5-S1. The mass of the herniation occupies nearly the entire central canal.

Figure A5:94. A very large disc herniation at L5-S1.

Figure A5:95. Enlarged view of the sagittal from figure A5:94.

Large Central Lumbar Herniation

Figure A5:96. A large disc herniation at L5-S1. The mass of the herniation occupies a significant portion of the central canal.

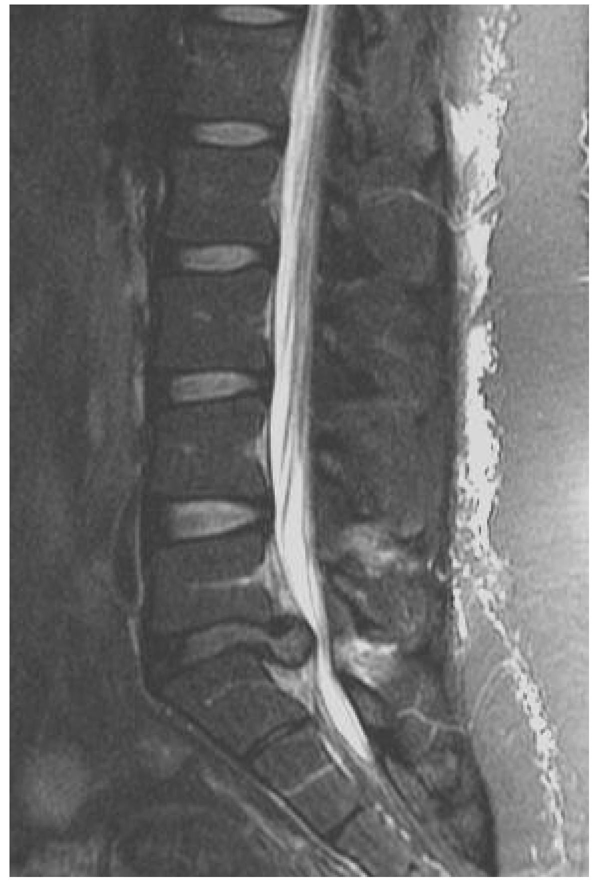


Figure A5:97. A very large disc herniation (extrusion) at L5-S1.

Sequestered Disc Fragment Following a Hemilaminectomy

Figure A5:98. A large disc herniation at L5-S1 along the sacrum and a sequestered fragment (yellow arrow) in the central canal posterior to the body of L5. These images denote that this patient had previously had a right hemilaminectomy at L5-S1.

Figure A5:99. This axial image shows three distinct hues from the same disc. These hues represent the fluid content of the derangement. The broad-based disc herniation is dark, the central portion of the herniation is neutral and the right foraminal herniation is light. The path of the surgeon is clearly visible along the right lamina.

Anterior Herniation

Figure A5:100. This T2W sagittal image clearly shows a large anterior herniation of L1-2.

Figure A5:101. This is a T1W sagittal image of the same herniation as seen in images A5:100 and A5:102**.**

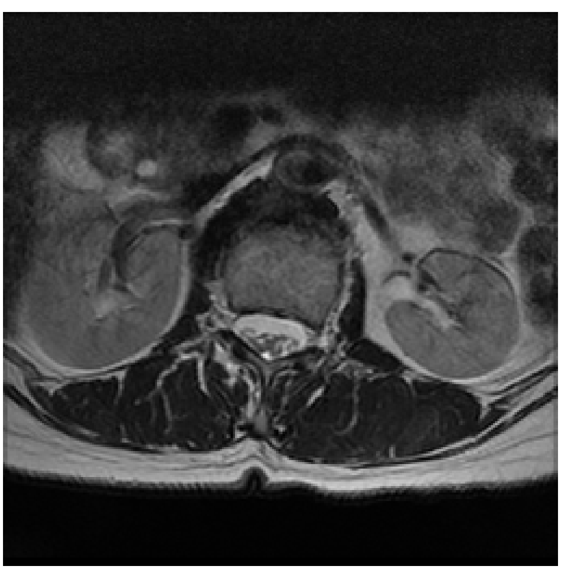


Figure A5:102. This T2W axial shows a broad anterior herniation of L1-L2 extending to the abdominal aorta.

Foraminal Herniation

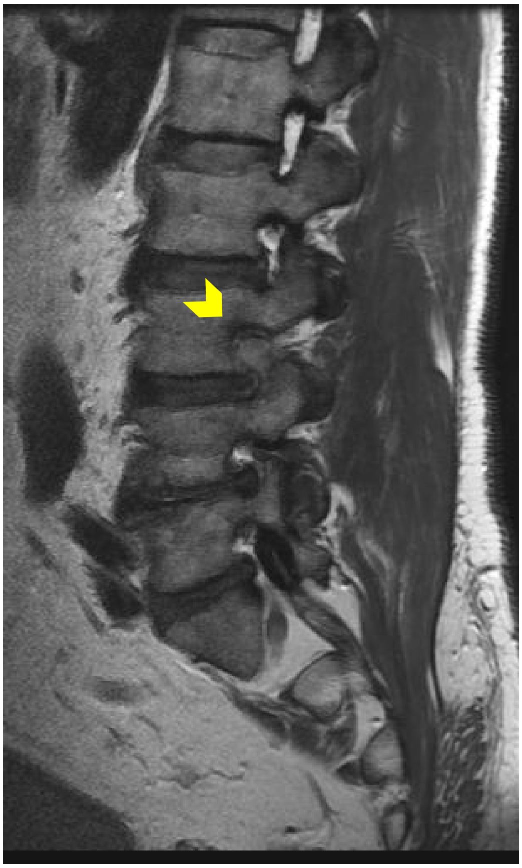


Figure A5:103. The L3-4 foramina is totally occluded by this foraminal herniation.

Figure A5:104. The left L3-4 foramina is totally occluded by this dumbbell-shaped foraminal herniation.

Right Paracentral Herniation

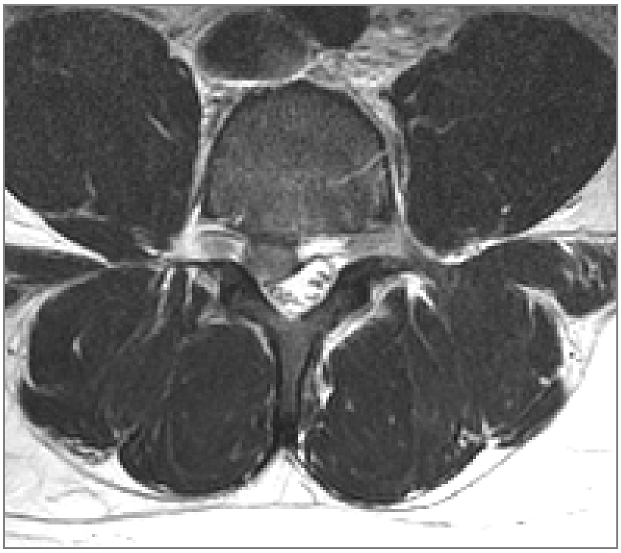


Figure A5:105. This paracentral extrusion deforms the thecal sac and extends into the right foramina.

Figure A5:106. L4-5 extrusion extending cephalad.

Multiple Disc Derangements

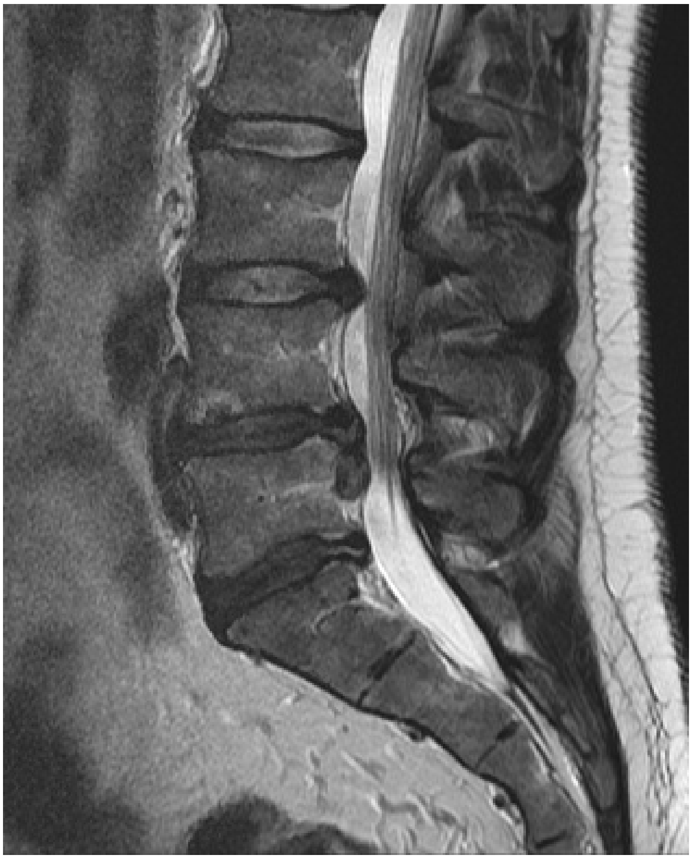


Figure A5:107. Disc derangements at L3-L4, L4-L5, and L5-S1. The extrusion at L4-L5 extends caudally along the body.

Figure A5:108. L4-L5 extrusion on axial imagery.

Figure A5:109. Note the horizontal radial tear of the disc in the posterior L5-S1 disc (yellow arrow).

Post-Surgical Re-herniation and Spondylolisthesis

Figure A5:110. Large disc herniation at the site of a previous surgery, L4-L5. Note the large canal in this patient that extends down into the sacrum. This T2W sagittal image also reveals a post-surgical anterolisthesis of L4 on L5.

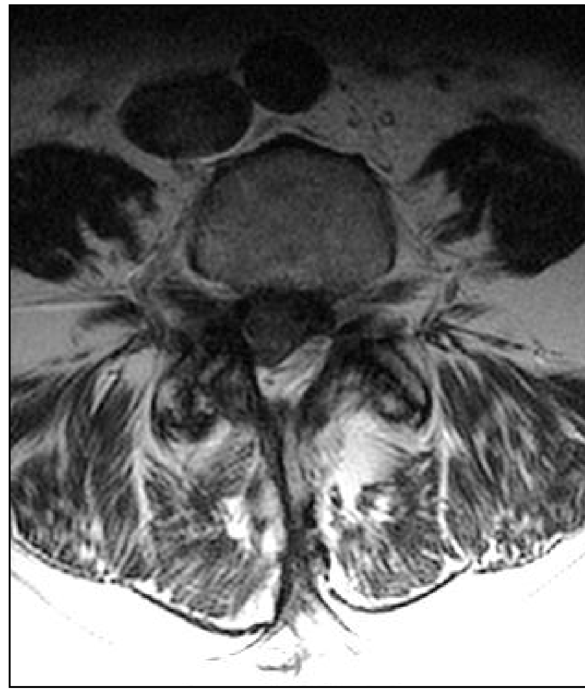


Figure A5:111. Disc herniation in axial T2WI. Note the fatty infiltration of the paraspinal muscles in this elderly patient.

Large Central Lumbar Herniation

Figure A5:112. This image shows a cephalad migration of an L4-L5 extrusion.

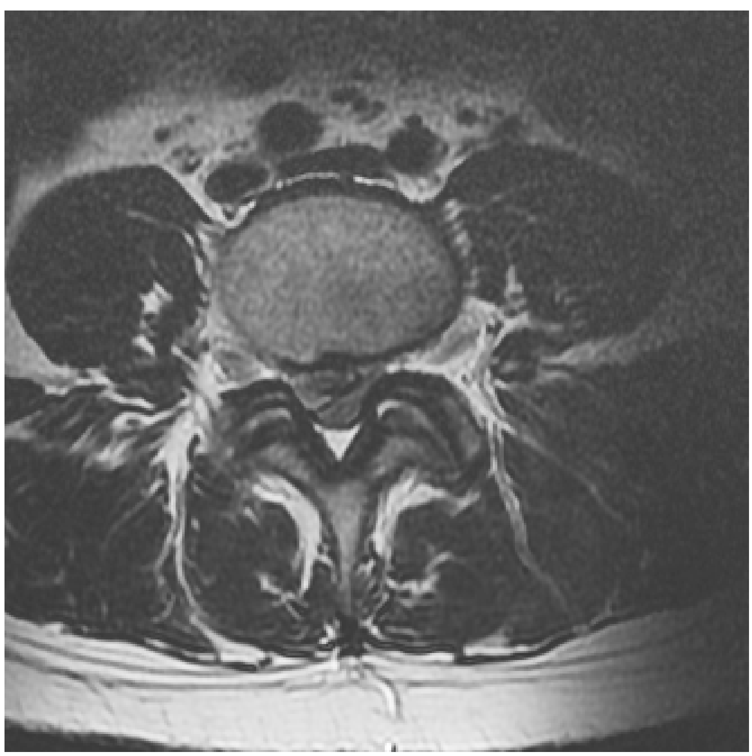


Figure A5:113. Axial image of the extrusion along L4.

Foraminal Protrusion

Figure A5:114. This axial (T2WI) reveals a foraminal herniation at L4-5.

Annular Tears

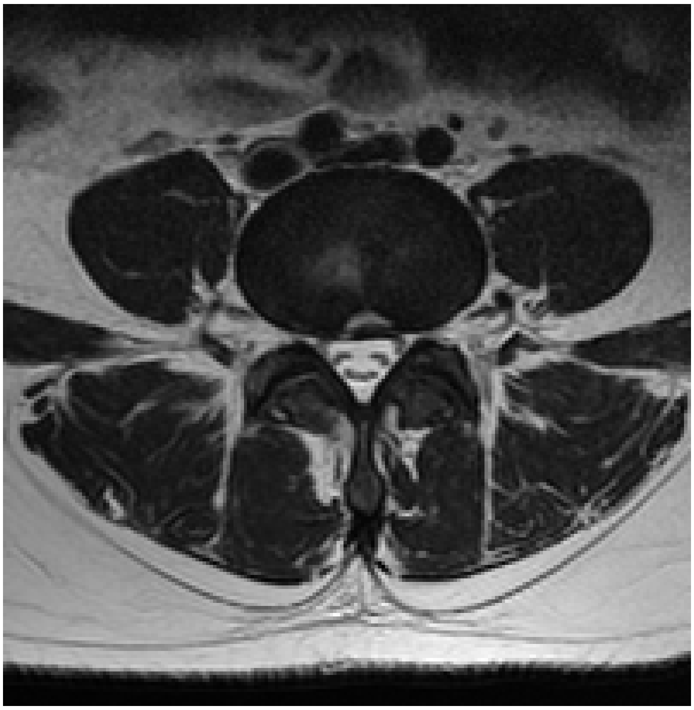


Figure A5:115. A crescent-shaped transverse tear in the posterior portion of the L4-L5 disc.

Figure A5:116. Annular tears are visible at multiple levels in this sagittal image (T2WI): a concentric tear in the posterior portion of the L5-S1 disc and transverse tears along the posterior superior endplate of L4 and the anterior superior endplate of L3.

Compressive Injuries

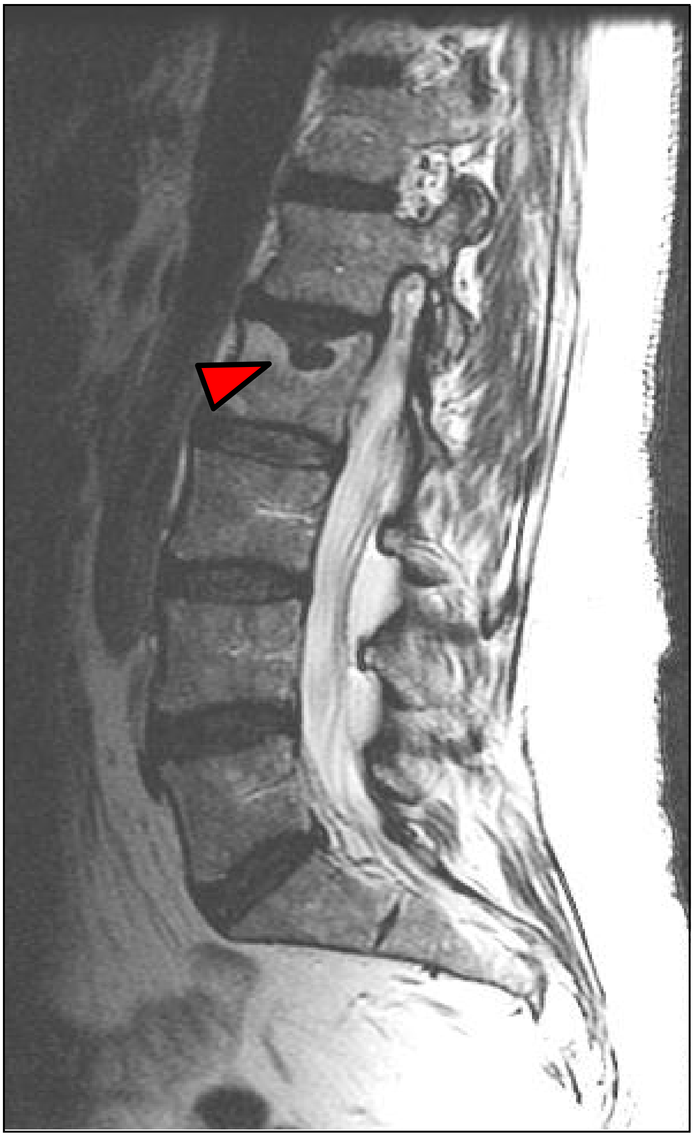


Figure A5:117. This image displays an intravertebral herniation (AKA Schmorl's node) extending through the superior endplate of L2. This injury was symptomatic.

Figure A5:118. The compressive forces that caused the L2 intravertebral herniation visible in figure A5:117 also caused the compression fracture seen in this thoracic MRI.

Sequestered Fragment and Thecal Sac Displacement

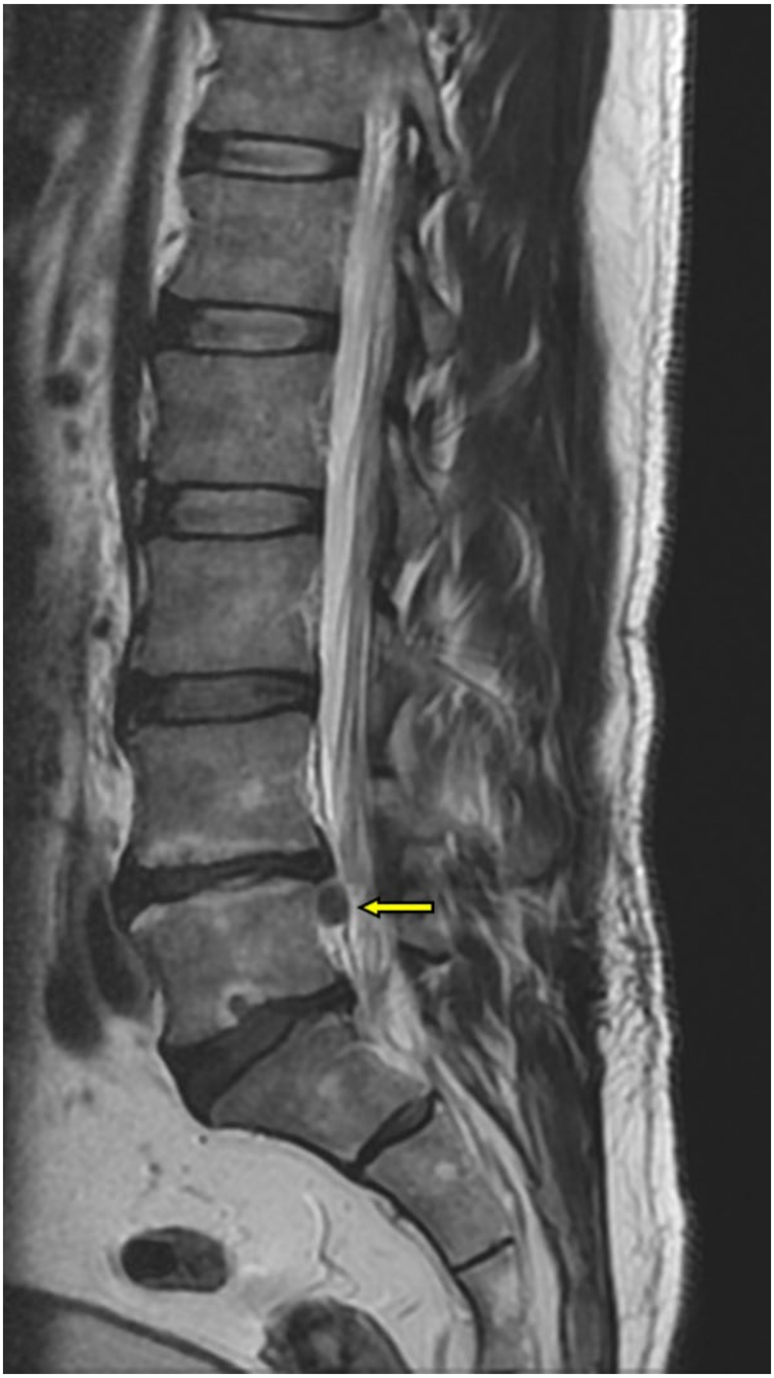


Figure A5:120. The thecal sac is displaced through a previous laminectomy in this T2 axial image (yellow arrow).

Figure A5:121. The thecal sac is displaced through a previous laminectomy in this T1 axial image (yellow arrow).

Figure A5:119. A sequestered fragment descends caudally from the L4-L5 disc (yellow arrow). Note the intradiscal herniation through the inferior end plate of L5 and the endplate changes of the L4-L5 endplates. These images reveal that a lumbar surgery had been performed at L4-L5.

Central L5-S1 Protrusion

Figure A5:122. Mild Central L5-S1 protrusion.

Figure A5:123. Mild Central L5-S1 protrusion.

Central L5-S1 Protrusion

Figure A5:122. Mild Central L5-S1 protrusion.

Figure A5:123. Mild Central L5-S1 protrusion.

References

Large Discs have the greatest tendency to regress in size:

Ahn SH, Ahn MW, Byun WM. Effect of the transligamentous extension of lumbar disc herniations on their regression and the clinical outcome of sciatica. Spine. 2000;25:475–80.

Bozzao A, Gallucci M, Masciocchi C, Aprile I, Barile A, Passariello R. Lumbar disk herniation: MR imaging assessment of natural history in patients treated without surgery. Radiology. 1992;185:135–41.

Delauche-Cavallier MC, Budet C, Laredo JD, Debie B, Wybier M, et al. Lumbar disc herniation. Computed tomography scan changes after conservative treatment of nerve root compression. Spine. 1992;17:927–33.

Komori H, Shinomiya K, Nakai O, Yamaura I, Takeda S, Furuya K. The natural history of herniated nucleus pulposus with radiculopathy. Spine. 1996;21:225–9.

Matsubara Y, Kato F, Mimatsu K, Kajino G, Nakamura S, Nitta H. Serial changes on MRI in lumbar disc herniations treated conservatively. Neuroradiology. 1995;37:378–83.

Modic MT, Ross JS, Obuchowski NA, Browning KH, Cianflocco AJ, Mazanec DJ. Contrast-enhanced MR imaging in acute lumbar radiculopathy: a pilot study of the natural history. Radiology. 1995;195:429–35.

Saal JA, Saal JS, Herzog RJ. The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine. 1990;15:683–6.

Cribb GL, Jaffray DC, Cassar-Pullicino VN. Observations on the natural history of massive lumbar disc herniation. J Bone Joint Surg Br. 2007;89:782–4.

References

Inflammation and Lumbar Disc Injury

Peng, Y., & Lv, F.-J. (2015). Symptomatic versus asymptomatic intervertebral disc degeneration: Is inflammation the key? Critical Reviews in Eukaryotic Gene Expression, 25(1), 13–21.
In this review, we revisit recent findings on the detection of inflammatory factors in d-IVDs and summarize the differences between d-IVDs that are painful and those that are pain-free. We postulate that persistent inflammation and innervation are the key factors distinguishing those that are symptomatic and those that are not. This highlights the necessity to use painful, rather than pain-free, degenerated discs in the mechanistic study of disc degeneration and in the development of regenerative approaches, to avoid false positive/negative outcomes. Based on previous molecular d-IVD studies, we also postulate the signaling events from disc overload/injury to discogenic pain. Although these proposed events are supported by experimental findings, many details about how they are interconnected are not addressed and therefore require experimental investigation. http://www.dl.begellhouse.com/.../6dbf508d3b17c437...

Wuertz, K., Vo, N., Kletsas, D., & Boos, N. (2012). Inflammatory and catabolic signaling in intervertebral discs: The roles of NF-κB and MAP Kinases. European Cells and Materials, 23, 102–120.
In this perspective, we aim to summarize the current state of knowledge concerning the inflammatory and catabolic molecular pathways of intervertebral disc disease (IDD), with a detailed description of NF-kB and MAP kinase-mediated signal transduction in disc cells. Furthermore, we will discuss the emerging novel molecular treatment modalities for IDD using pharmacological inhibitors targeting these pathways.
http://www.ecmjournal.org/papers/vol023/vol023a08.php

Molinos, M., Almeda C. R., Caldeira J., Cunha C., Gonçalves R. M. & Barbosa M. A. (2015). Inflammation in intervertebral disc degeneration and regeneration. Journal of the Royal Society Interface, (12), 20141191.
In this review, we focus on how inflammation has been associated with IVD degeneration by describing observational and in vitro studies as well as in vivo animal models. Finally, we provide an overview of IVD regenerative therapies that target key inflammatory players.
https://royalsocietypublishing.org/.../10.../rsif.2014.1191

Kepler, C. K., Ponnappan, R. K., Tannoury, C. A., Risbud, M. V., & Anderson, D. G. (2013). The molecular basis of intervertebral disc degeneration. The Spine Journal, 13(3), 318–330.
Decreased extracellular matrix production, increased production of degradative enzymes, and increased expression of inflammatory cytokines contribute to the loss of structural integrity and accelerate IVD degeneration. Neurovascular ingrowth occurs, in part, because of the changing degenerative phenotype. https://www.sciencedirect.com/.../abs/pii/S1529943012015185

References

Wuertz, K., & Haglund, L. (2013). Inflammatory mediators in intervertebral disk degeneration and discogenic pain. Global Spine Journal, 3(3), 175–184.
Both disk cells as well as invading macrophages can be the source of the detected cytokines. Importantly, occurrence of inflammatory mediators in the disk can worsen the progress of degeneration by inducing the expression of matrix degrading enzymes as well as by inhibiting extracellular matrix synthesis. In addition, inflammatory mediators play a crucial role in pain development during intervertebral disk herniation (i.e., sciatica) and disk degeneration (i.e., discogenic pain). This review provides information on the most relevant inflammatory mediators during different types of disk diseases and explains how these factors can induce disk degeneration and the development of discogenic and sciatic/radiculopathic pain.
https://journals.sagepub.com/doi/full/10.1055/s-0033-1347299

Alkhatib, B., Rosenzweig, D., Krock, E., Roughley, P., Beckman, L., Steffen, T., … Haglund, L. (2014). Acute mechanical injury of the human intervertebral disc: link to degeneration and pain. European Cells and Materials, 28, 98–111.
Injury also caused significantly reduced tissue proteoglycan content with a reciprocal increase of proteoglycan content in culture media. Increased aggrecan fragmentation was observed in injured tissue due to increased matrix metalloproteinase and aggrecanases activity. Injured-IVD conditioned media contained significantly elevated interleukin (IL)-5, IL-6, IL-7, IL-8, MCP-2, GROα, and MIG, and ELISA analysis showed significantly increased nerve growth factor levels compared to non-injured media. Injured-disc media caused significant neurite sprouting in PC12 cells compared to non-injured media. Acute mechanical injury of human IVDs ex vivo initiates release of factors and enzyme activity associated with degeneration and back pain. This work provides direct evidence linking acute trauma, inflammatory factors, neo-innervation and potential degeneration and discogenic pain in vivo.
https://www.safetylit.org/citations/index.php...

Lama, P., Maitre, C. L. L., Dolan, P., Tarlton, J. F., Harding, I. J., & Adams, M. A. (2013). Do intervertebral discs degenerate before they herniate, or after? The Bone & Joint Journal, 95-B(8), 1127–1133.
Herniated tissues showed significantly greater proteoglycan loss (outer annulus), neovascularization (annulus), innervation (annulus), cellularity/inflammation (annulus) and expression of matrix-degrading enzymes (inner annulus) than degenerated discs. No significant differences were seen in the nucleus tissue from herniated and degenerated discs. Degenerative changes start in the nucleus, so it seems unlikely that advanced degeneration caused herniation in 21 of these 32 discs. On the contrary, specific changes in the annulus can be interpreted as the consequences of herniation, when disruption allows local swelling, proteoglycan loss, and the ingrowth of blood vessels, nerves and inflammatory cells. In conclusion, it should not be assumed that degenerative changes always precede disc herniation.
https://online.boneandjoint.org.uk/.../0301-620X.95B8.31660

References

Zhang, Y.-G., Zhang, F., Sun, Z., Guo, W., Liu, J., Liu, M., & Guo, X. (2013). A controlled case study of the relationship between environmental risk factors and apoptotic gene polymorphism and lumbar disc herniation. The American Journal of Pathology, 182(1), 56–63.
Therefore, the risk of LDH was determined by both environmental and genetic risk factors, and the mechanisms of interactions between different genotypes and environmental factors also differed. https://www.sciencedirect.com/.../pii/S0002944012007262

Schoenfeld, A. J., Laughlin, M., Bader, J. O., & Bono, C. M. (2012). Characterization of the incidence and risk factors for the development of lumbar radiculopathy. Journal of Spinal Disorders & Techniques, 25(3), 163–167.
Conclusions The incidence of lumbar radiculopathy in this young, racially diverse, and physically active population is higher than many other degenerative conditions. In this study female sex and white race increased the risk of developing lumbar radiculopathy. However, increasing age seems to be one of the most significant independent factors for developing this disorder.
https://journals.lww.com/.../Characterization_of_the...

Shiri, R., Lallukka, T., Karppinen, J., & Viikari-Juntura, E. (2014). Obesity as a risk factor for sciatica: A meta-analysis. American Journal of Epidemiology, 179(8), 929–937.
Overweight (OR = 1.16, 95% CI: 1.09, 1.24; n = 358,328) and obesity (OR = 1.38, 95% CI: 1.23, 1.54; n = 358,328) were associated with increased risk of hospitalization for sciatica, and overweight/obesity was associated with increased risk of surgery for lumbar disc herniation (OR = 1.89, 95% CI: 1.25, 2.86; n = 73,982).
https://academic.oup.com/aje/article/179/8/929/108237/

Schroeder, G. D., Guyre, C. A., & Vaccaro, A. R. (2016). The epidemiology and pathophysiology of lumbar disc herniations. Seminars in Spine Surgery, 28(1), 2–7.
Patients with a family history of disc disease or are in physically demanding jobs, or who have certain medical comorbidities such as obesity, are at an increased risk of developing a lumbar disc herniation. Symptomatic herniations present as lumbar radiculopathy from both a mechanical compression and chemical irritation of the nerve root.
https://www.sciencedirect.com/.../pii/S1040738315000957

Tao, S., Jin, L., Hou, Z., Zhang, W., Chen, T., & Zhang, Y. (2017). A New radiographic feature of lower lumbar disc herniation in young patients. International Orthopaedics, 42(3), 583–586.
Laminae defects of L5 may be a congenitally potential risk factor leading to lower LDH in the young and this radiographic clue could be used for the diagnosis of symptomatic lower LDH patients. https://link.springer.com/article/10.1007/s00264-017-3723-8

References

Tian, P., Li, Z.-J., Fu, X., & Ma, X.-L. (2015). Role of interleukin-17 in chondrocytes of herniated intervertebral lumbar discs. Experimental and Therapeutic Medicine, 10(1), 81–87.
The intervertebral discs (IVDs) obtained from patients with NCDH showed significantly more neovascularization and granulation tissue than the discs obtained from patients with CDH (P<0.05). Furthermore, hypertrophic chondrocytes were more abundant in the NCDH specimens than in the CDH specimens (P<0.05). Similarly, the number of IL 17 immunoreactive cells was significantly higher in the NCDH specimens than that in the CDH specimens (P<0.01). In conclusion, local inflammation and autoreactive immune activation may play an important role in the pathogenesis of LDH. These results also suggest a role of chondrocytes in the repair of herniated IVDs. https://www.spandidos-publications.com/etm/10/1/81...

James, G., Sluka, K. A., Blomster, L., Hall, L., Schmid, A. B., Shu, C. C., … Hodges, P. W. (2018). Macrophage polarization contributes to local inflammation and structural change in the multifidus muscle after intervertebral disc injury. European Spine Journal, 27(8), 1744–1756.
These data support the proposal that macrophages and TNF (pro-inflammatory cytokine) play an active role in the subacute/early chronic phase of remodeling in muscle, adipose and connective tissues of the multifidus during IVD degeneration.
https://link.springer.com/article/10.1007/s00586-018-5652-7

Sun, Z., Zhang, M., Zhao, X. H., Liu, Z. H., Gao, Y., Samartzis, D., … Luo, Z. J. (2013). Immune cascades in human intervertebral disc: the pros and cons. International journal of clinical and experimental pathology, 6(6), 1009–1014. Consequently, a modulated immune network in degenerate disc is essential for the restoration of this immune-privileged organ. Until now, the understandings of immune response in disc degeneration still rest on the harmful aspect.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3657352/

Risbud, M. V., & Shapiro, I. M. (2013). Role of cytokines in intervertebral disc degeneration: pain and disc content. Nature Reviews Rheumatology, 10(1), 44–56.
Taken together, an enhanced understanding of the contribution of cytokines and immune cells to these catabolic, angiogenic and nociceptive processes could provide new targets for the treatment of symptomatic disc disease. In this Review, the role of key inflammatory cytokines during each of the individual phases of degenerative disc disease, as well as the outcomes of major clinical studies aimed at blocking cytokine function, are discussed.
https://www.nature.com/articles/nrrheum.2013.160

Albert, H. B., Lambert, P., Rollason, J., Sorensen, J. S., Worthington, T., Pedersen, M. B., … Elliott, T. (2013). Does nuclear tissue infected with bacteria following disc herniations lead to Modic changes in the adjacent vertebrae? European Spine Journal, 22(4), 690–696.
These findings support the theory that the occurrence of MCs Type 1 in the vertebrae adjacent to a previously herniated disc may be due to oedema surrounding an infected disc. The discs infected with anaerobic bacteria were more likely (P < 0.0038) to develop MCs in the adjacent vertebrae than those in which no bacteria were found or those in which aerobic bacteria were found. https://link.springer.com/article/10.1007/s00586-013-2674-z

References

Bishop, P. B., Street, J., Quon, J. A., Arthur, B. E., Nadeau, M., Ailon, T., … Kwon, B. K. (2019). P12. Comparisons of patterns of upregulation of inflammatory cytokines in herniated nucleus pulposus, disc and nerve root lavagates and in the serum of patients with acute sciatica secondary to lumbar disc herniation undergoing surgery. The Spine Journal, 19(9).
In patients with acute sciatica secondary to lumbar disc herniation, serum and intraoperative disc lavagate cytokine content patterns of upregulation were similar to those identified in extruded disc tissue. The cytokine concentrations in nerve root lavagate samples showed significant variation and correlations with clinical parameters in patients with AS/NPE should be interpreted with caution. https://www.sciencedirect.com/.../pii/S1529943019306229

Palada, V., Ahmed, A. S., Finn, A., Berg, S., Svensson, C. I., & Kosek, E. (2019). Characterization of neuroinflammation and periphery-to-CNS inflammatory crosstalk in patients with disc herniation and degenerative disc disease. Brain, Behavior, and Immunity, 75, 60–71.
Our results suggest that neuroinflammation mediated by elevated IL-8 concentrations in CSF and IL-8 mediated periphery-to-CNS inflammatory crosstalk contributes to pain in LDH patients and suggest a link between TSPO expression in discs and low back pain.
https://www.sciencedirect.com/.../pii/S0889159118305804

Conservative Care Disc Herniation

Leemann, S., Peterson, C. K., Schmid, C., Anklin, B., & Humphreys, B. K. (2014). Outcomes of acute and chronic patients with magnetic resonance imaging–Confirmed symptomatic lumbar disc herniations receiving high-velocity, low-amplitude, spinal manipulative therapy: A prospective observational cohort study with one-year follow-up. Journal of Manipulative and Physiological Therapeutics, 37(3), 155–163.
Significant improvement for all outcomes at all time points was reported (P < .0001). At 3 months, 90.5% of patients were “improved” with 88.0% “improved” at 1 year. Although acute patients improved faster by 3 months, 81.8% of chronic patients reported “improvement” with 89.2% “improved” at 1 year. There were no adverse events reported. Conclusions A large percentage of acute and importantly chronic lumbar disc herniation patients treated with chiropractic spinal manipulation reported clinically relevant improvement.
https://www.sciencedirect.com/.../pii/S0161475414000347

Choi, J., Lee, S., & Hwangbo, G. (2015). Influences of spinal decompression therapy and general traction therapy on the pain, disability, and straight leg raising of patients with intervertebral disc herniation. Journal of Physical Therapy Science, 27(2), 481–483.
Spinal decompression therapy and general traction therapy are effective at improving the pain, disability, and SLR of patients with intervertebral disc herniation. Thus, selective treatment may be required. https://www.jstage.jst.go.jp/.../27.../_article/-char/ja/

Bu, J. H., Kong, L. J., Guo, C. Q., Yang, X. C., & Cheng, Y.W. (2014). [Effectiveness of manual therapy and traction for lumbar disc herniation: a meta-analysis]. Zhongguo gu Shang = China Journal of Orthopedics and Traumatology. 27(5):409-414. The overall quality of the current RCT researches about manual therapy for lumbar disc herniation was lower and did not support the conclusion that manual therapy was more effective than traction for lumbar disc herniation.
https://europepmc.org/abstract/med/25167673

References

Yadav S., Nijhawan M. A., & Panda P. (2014). Effectiveness of spinal mobilization with leg movement (SMWLM) in patients with lumbar radiculopathy (L5/S1 nerve root) in lumbar disc herniation. International Journal of Physiotherapy and Research, 2(5), 712-18. Spinal Mobilization with Leg Movement technique in addition to conventional physical therapy produced significant improvement in leg pain intensity, location of pain and back specific disability in patients with lumbar radiculopathy in lumbar disc herniation. https://pdfs.semanticscholar.org/.../0f93b73303e60d4abfb6...

Karimi, N., Akbarov, P., & Rahnama, L. (2017). Effects of segmental traction therapy on lumbar disc herniation in patients with acute low back pain measured by magnetic resonance imaging: A single arm clinical trial. Journal of Back and Musculoskeletal Rehabilitation, 30(2), 247–253. Following the treatment protocol, herniated mass size and patients' pain were reduced significantly. In addition, lumbar flexion ROM showed a significant improvement. However, no significant change was observed for back extensor muscle endurance after the treatment procedure. https://content.iospress.com/.../journal-of-back.../bmr741

Mohanty, P. P., & Pattnaik, M. (2015). Manual therapy for the management of lumbar PIVD-an innovative approach. Indian Journal of Physiotherapy and Occupational Therapy - An International Journal, 9(4), 98.
Conclusion: stretching of levator scapulae muscles and mobilization of cervicothoracic spine that reproduced the original back pain with or without leg pain is found to be effective for the management of PIVD.
https://www.indianjournals.com/ijor.aspx?target=ijor:ijpot&volume=9&issue=4&article=019

Warude T., & Shanmugam S. (2012). The effect of McKenzie approach and Mulligan's mobilization (SNAGS) in lumbar disc prolapse with unilateral radiculopathy. International Journal of Science and Research, 3,(10), 59-63. McKenzie approach and Mulligan's mobilization (SNAGS) are effective in improving pain, functional ability & ROM in prolapse intervertebral disc with unilateral radiculopathy, later is more effective.
https://pdfs.semanticscholar.org/.../6e5568326e15e036246d...

Kasnakova, P., Mihaylova, A., & Petleshkova, P. (2018). Comprehensive rehabilitation of herniated disc in the lumbar section of the spine. Biomedical Research, 29(14)
Rehabilitation and physio prophylaxis facilitate the reduction of the risk of occurrence and development of herniated disc in the lumbar section of the spine through natural (water, air, movement and sunshine) and preformed physical factors, the main aim being achieving a good quality of life of both the sick and the healthy. The so called 'spine school', which includes training the patient to have a good posture, a good stance, to walk correctly and to improve his/her motor stereotype through control and self-control, plays a major role. In developing the individual treatment scheme for each patient at a certain stage of his/her condition, it is vital to attempt to achieve a synergic effect of the optimal combination of electrotherapeutic, peloid therapeutic and kinesitherapies methods. Regular courses in physio prophylaxis and kinesio-prophylaxis significantly boost the effect of the medicamentous therapy in patients with herniated lumbar disc and improve their quality of life.
https://www.alliedacademies.org/articles/comprehensive-rehabilitation-of-herniated-disc-in-the-lumbar-section-of-the-spine-10642.html

References

Ahmed, N., & Khan, Z. (2016). Comparison of Mulligans Spinal Mobilization with Limb Movement (SMWLM) and Neural Tissue Mobilization for the treatment of lumbar disc herniation: A Randomized Clinical Trial. Journal of Novel Physiotherapies, 6(4). This concludes the fact that the neural tissue mobilization group was statistically better than the spinal mobilization with limb movement (SMWLM) group and hence the magnitude of response in relieving pain, improving functional disability and promoting centralization was better in patients who received neural tissue mobilization. https://www.semanticscholar.org/.../0a55fce8920716527df08...

Vangelder, L. H., Hoogenboom, B. J., & Vaughn, D. W. (2013). A phased rehabilitation protocol for athletes with lumbar intervertebral disc herniation. International journal of sports physical therapy, 8(4), 482–516.The purpose of this clinical commentary is to propose a framework for rehabilitation that is built around the phases of healing of the disc. Phase I: Non-Rotational/Non-Flexion Phase (Acute Inflammatory Phase), Phase II: Counter rotation/Flexion Phase (Repair Phase), Phase III: Rotational Phase/Power development (Remodeling Phase), and Phase IV: Full return to sport. This clinical commentary provides a theoretical basis for these phases based on available literature as well as reviewing many popular current practice trends in the management of an HLD. The authors recognize the limits of any general exercise rehabilitation recommendation with regard to return to sport, as well as any general strength and conditioning program. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3812831

Oh, H., Lee, S., Lee, K., & Jeong, M. (2018). The effects of flexion-distraction and drop techniques on disorders and Ferguson's angle in female patients with lumbar intervertebral disc herniation. Journal of Physical Therapy Science, 30(4), 536–539. Thirty female patients with lumbar intervertebral disc herniation were divided into an experimental group (n=15) treated with flexion-distraction and drop techniques and a control group (n=15) treated with spinal decompression therapy. Both groups were treated three times a week over an eight-week period. [Results] In the comparison of changes within each group after treatment, both groups showed statistically significant decreases in disorders and in Ferguson's angle. [Conclusion] Flexion-distraction and drop techniques may be an effective intervention to improve disorders and Ferguson's angle in female patients with lumbar intervertebral disc herniation. https://www.jstage.jst.go.jp/.../30.../_article/-char/ja/

Mo, Z., Zhang, R., Chen, J., Shu, X., & Shujie, T. (2018). Comparison between oblique pulling spinal manipulation and other treatments for lumbar disc herniation: A systematic review and meta-Analysis. Journal of Manipulative and Physiological Therapeutics, 41(9), 771–779. In the treatment of lumbar disc herniation, oblique pulling spinal manipulation presented with a higher effective rate than acupuncture and lumbar traction. Manipulation had a favorable effect in alleviating pain, and modified oblique pulling manipulation had significant superiority in improving lumbar function when compared with lumbar traction. https://www.sciencedirect.com/.../pii/S0161475417303147

References

Lee, Y., Lee, C.-R., & Cho, M. (2012). Effect of decompression therapy combined with joint mobilization on patients with lumbar herniated nucleus pulposus. Journal of Physical Therapy Science, 24(9), 829–832.
[Results] Comparison of visual analog scale scores and the ranges of motion before and after treatment showed greater statistically significant differences in the experimental group than in the control group. [Conclusion] Decompression therapy combined with joint mobilization was effective as an intervention method for relieving pain and increasing the range of motion of the lumbar spine in patients with lumbar herniated nucleus pulposus.
https://www.jstage.jst.go.jp/.../9/24_829/_article/-char/ja/

Deyo, R. A., & Mirza, S. K. (2016). Herniated lumbar intervertebral disk. New England Journal of Medicine, 374(18), 1763–1772. Pain from disk herniation, the leading cause of sciatica, usually resolves within several weeks with conservative therapy. In patients with sciatica for 6 weeks, pain relief is faster with surgery than with conservative therapy; however, outcomes are similar at 1 year. https://www.nejm.org/doi/full/10.1056/NEJMcp1512658

Yu, P-f., Jiang, F-D., Liu, J-T., & Jiang, H. (2013). Outcomes of conservative treatment for ruptured lumbar disc herniation. Acta Orthopædica Belgica, 79(6), 726-730.The authors set up a prospective study of the effect of conservative treatment on a ruptured lumbar disc herniation in 89 patients, between June 2008 and June 2010. Seventy-two patients (81%) improved, while the other 17 (19%) needed surgery. The JOA score (best possible result : 29) was found to be significantly improved in the 72 patients of the conservative group, at 1 month, 3months, 6 months, 1 year and 2 years (t-test : $p < 0.001$). At final follow-up, after 2 years, 84.7% of the patients in the conservative group had a good or excellent result. However, if the 17 surgical cases were included, this proportion dropped to 68.5% The volume of the protrusion decreased significantly in the 72 patients of the conservative group : from 1422.52 ± 539.10 mm3 to 1027.35 ± 585.51 mm3 (paired t-test : $p < 0.001$). There was a definite correlation, in the conservative group, between the final resorption rate on the one hand and the percentage of combined excellent and good results on the other hand (72 cases ; Spearman rank correlation coefficient : $r_{0.01} = 0.470$, $p < 0.001$).
https://pdfs.semanticscholar.org/.../376729733e55bab376a9...

Zhang, W., Guo, W., Zhao, P., Zhou, W., Wei, J., Li, X.-D., & Liu, L. (2013). Therapeutic effects of Chinese Osteopathy in patients with lumbar disc herniation. The American Journal of Chinese Medicine, 41(05), 983–994. The results showed that the SISC and QSI significantly decreased after treatment in the LDH group ($p < 0.01$). The SISC before and after treatment was closely correlated with the improvement of QSI, although there was no change in protruded nucleus pulposus following the therapy. Among the five components in SISC, the LR was found to be an ideal indicator for evaluation of the real circumstances in LDH patients. Our data suggested that FSM achieved satisfactory therapeutic effects in relieving the symptom of LDH while no effects were observed in asymptomatic subjects.
https://www.worldscientific.com/.../10.../S0192415X13500663

References

Yu, P.-F., Jiang, H., Liu, J.-T., Li, X.-C., Qian, X., Han, S., & Ma, Z.-J. (2014). Traditional Chinese Medicine Treatment for ruptured lumbar disc herniation: Clinical observations in 102 Cases. Orthopaedic Surgery, 6(3), 229–235. Conservative treatment with a TCM regimen is effective for ruptured lumbar disc herniation and can promote resorption of the protrusion; however, patients who develop specific indications for surgery during such treatment should undergo surgery in a timely manner. https://onlinelibrary.wiley.com/doi/full/10.1111/os.12120

Annen, M., Peterson, C., Leemann, S., Schmid, C., Anklin, B., & Humphreys, B. K. (2016). Comparison of outcomes in MRI confirmed lumbar disc herniation patients with and without modic changes treated with high velocity, low amplitude spinal manipulation. Journal of Manipulative and Physiological Therapeutics, 39(3), 200–209. 76.5% of Modic positive patients reported 'improvement' compared to 53.3% of Modic negative patients (P = .09) at 2 weeks. Modic positive patients had larger decreases in leg pain (P = .02) and disability scores (P = .012) at 2 weeks. Modic positive patients had larger reductions in disability levels at 3 (P = .049) and 6 months (P = .001). A significant difference (P = .001) between patients with Modic I vs. Modic II was found at 1 year, where Modic II patients did significantly better. https://www.sciencedirect.com/.../pii/S0161475416000592

Shan, Z., Fan, S., Xie, Q., Suyou, L., Liu, J., Wang, C., & Zhao, F. (2014). Spontaneous resorption of lumbar disc herniation is less likely when modic changes are present. Spine, 39(9), 736–744. Conclusion. MCs in patients with LDH are associated with cartilaginous herniations that resorb poorly, so that patients respond less well to conservative treatments. Loss of cartilaginous endplate may explain the origins of MCs and their association with disc infection https://journals.lww.com/.../Spontaneous_Resorption_of...

Ahmed, S., Hassan, T., & Hanif, A. (2013). Effects of lumbar stabilization exercise in management of pain and restoration of function in patients with posterolateral disc herniation. Annals of King Edward Medical University, 18(2), 152. Conclusion: The Lumbar Stabilization exercises pro-vide significantly better results compared with conventional physical therapy regimen in patients with disc herniation. Lumber stabilization exercises were safe and easy to perform. https://www.annalskemu.org/.../annals/article/view/393

Sutheerayongprasert, C., Paiboonsirijit, S., Kuansongtham, V., Anuraklekha, S., Hiranyasthiti, N., & Neti, S. (2012). Factors predicting failure of conservative treatment in lumbar-disc herniation. Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 95 5, 674-80 . Conclusion: Long-duration, sequestered herniation and large fragment are predictive of failure in the conservative treatmentof lumbar-disc herniation. http://www.thaiscience.info/jou.../Article/JMAT/10971511.pdf

Gugliotta, M., da Costa, B. R., Dabis E., Theiler, R., Jüni P., Reichenback, S., Landolt H., & Hasler P. (2016). Surgical versus conservative treatment for lumbar disc herniation: a prospective cohort study. BMJ Open, 6, e012938. Surgical versus conservative treatment for lumbar disc herniation: a prospective cohort study Conclusions Compared with conservative therapy, surgical treatment provided faster relief from back pain symptoms in patients with lumbar disc herniation, but did not show a benefit over conservative treatment in midterm and long-term follow-up. https://bmjopen.bmj.com/content/6/12/e012938?cpetoc=...

References

Lequin, M. B., Verbaan, D., Jacobs, W. C. H., Brand, R., Bouma, G. J., Vandertop, W. P., & Peul, W. C. (2013). Surgery versus prolonged conservative treatment for sciatica: 5-year results of a randomized controlled trial. BMJ Open, 3(5). Conclusions In the long term, 8% of the patients with sciatica never showed any recovery and in at least 23%, sciatica appears to result in ongoing complaints, which fluctuate over time, irrespective of treatment. Prolonged conservative care might give patients a fair chance for pain and disability to resolve without surgery, but with the risk to receive delayed surgery after prolonged suffering of sciatica. Age above 40 years, severe leg pain at baseline and a higher affective Mc Gill pain score were predictors for unsatisfactory recovery. https://bmjopen.bmj.com/content/3/5/e002534..

Albert, H. B., & Manniche, C. (2012). The efficacy of systematic active conservative treatment for patients with severe sciatica. Spine, 37(7), 531–542.
Results. A mean of 4.8 treatment sessions were provided. All patients experienced statistically significant and clinically important improvements in global assessment, functional status, pain, vocational status, and clinical findings. The symptom-guided exercise group improved significantly more than the sham exercise group in most outcomes. Conclusion. Active conservative treatment was effective for patients who had symptoms and clinical findings that would normally qualify them for surgery. Although participating patients had greater faith in the sham exercises before treatment, the symptom-guided exercises were superior for most outcomes. https://journals.lww.com/.../The_Efficacy_of_Systematic...

Di Ciaccio, E., Polastri, M., Bianchini, E., & Gasbarrini, A. (2012). Herniated lumbar disc treated with Global Postural Reeducation. A middle-term evaluation. European Review for Medical and Pharmacological Sciences,16(8), 1072-7. CONCLUSIONS, The present study indicates that Global Postural Reeducation is suitable for the conservative management of HLID. Moreover, patients gained a therapeutic benefit from being active participants in their recovery.
http://citeseerx.ist.psu.edu/viewdoc/download...

Schroeder, J., Dettori, J., Brodt, E., & Kaplan, L. (2013). Disc degeneration after disc herniation: are we accelerating the process? Evidence-Based Spine-Care Journal, 3(04), 33–40.
Following conservative care for first-time HNP in the third study, the risk of progression of lumbar disc degeneration was 47.6% over the first 2 years of follow-up and 95.2% over the next 6 years of follow-up. In the same study, the risk of lumbar disc degeneration was shown to increase incrementally over the course of the 8-year follow-up, with all patients showing signs of degeneration at final examination. https://www.thieme-connect.com/.../10.1055/s-0032-1328141

Demirel, A., Yorubulut, M., & Ergun, N. (2017). Regression of lumbar disc herniation by physiotherapy. Does non-surgical spinal decompression therapy make a difference? Double-blind randomized controlled trial. Journal of Back and Musculoskeletal Rehabilitation, 30(5), 1015–1022. CONCLUSIONS: This study showed that patients with LHNP received physiotherapy had improvement based on clinical and radiologic evidence. NSDT can be used as assistive agent for other physiotherapy methods in treatment of lumbar disc herniation.
https://content.iospress.com/.../journal-of.../bmr169581

References

Ehrler, M., Peterson, C., Leemann, S., Schmid, C., Anklin, B., & Humphreys, B. K. (2016). Symptomatic, MRI confirmed, lumbar disc herniations: A comparison of outcomes depending on the type and anatomical axial location of the hernia in patients treated with high-velocity, low-amplitude spinal manipulation. Journal of Manipulative and Physiological Therapeutics, 39(3), 192–199.
A higher proportion of patients with disc sequestration reported relevant improvement at each time point but this did not quite reach statistical significance. Patients with disc sequestration had significantly higher reduction in leg pain at 1 month compared to those with extrusion (P = .02). Reliability of MRI diagnosis ranged from substantial to perfect (K = .733-1.0).
https://www.sciencedirect.com/.../pii/S0161475416000609

Hincapié, C. A., Tomlinson, G. A., Côté, P., Rampersaud, Y. R., Jadad, A. R., & Cassidy, J. D. (2017). Chiropractic care and risk for acute lumbar disc herniation: a population-based self-controlled case series study. European Spine Journal, 27(7), 1526–1537.
Both chiropractic and primary medical care were associated with an increased risk for acute LDH requiring ED visit and early surgery. Our analysis suggests that patients with prodromal back pain from a developing disc herniation likely seek healthcare from both chiropractors and PCPs before full clinical expression of acute LDH. We found no evidence of excess risk for acute LDH with early surgery associated with chiropractic compared with primary medical care.
https://link.springer.com/article/10.1007/s00586-017-5325-y

Hincapié, C. A., Cassidy, J. D., Côté, P., Rampersaud, Y. R., Jadad, A. R., & Tomlinson, G. A. (2017). Chiropractic spinal manipulation and the risk for acute lumbar disc herniation: a belief elicitation study. European Spine Journal, 27(7), 1517–1525.
Chiropractors expressed the most optimistic belief (median RR 0.56; IQR 0.39–1.03); family physicians expressed a neutral belief (median RR 0.97; IQR 0.64–1.21); and spine surgeons expressed a slightly more pessimistic belief (median RR 1.07; IQR 0.95–1.29). Clinicians with the most optimistic views believed that chiropractic SMT reduces the incidence of acute LDH by about 60% (median RR 0.42; IQR 0.29–0.53). Those with the most pessimistic views believed that chiropractic SMT increases the incidence of acute LDH by about 30% (median RR 1.29; IQR 1.11–1.59). https://link.springer.com/article/10.1007/s00586-017-5295-0

Gupta, A., Upadhyaya, S., Yeung, C. M., Ostergaard, P. J., Fogel, H. A., Cha, T., … Hershman, S. (2019). Does size matter? An analysis of the effect of lumbar disc herniation size on the success of nonoperative treatment. Global Spine Journal, 219256821988082.
After controlling for age, race, gender, and location of herniation through a logistic regression, it was found that the size of the herniation and the percentage of the canal that was occupied had no predictive value with regard to failure of conservative management, generating an odds ratio for surgery of 1.00. https://journals.sagepub.com/.../10.1177/2192568219880822

References

Selva-Sevilla, C., Ferrara, P., & Gerónimo-Pardo, M. (2019). Cost-utility analysis for recurrent lumbar disc herniation. Clinical Spine Surgery, 32(5).
This cost-utility analysis showed that conservative treatment is more cost-effective than discectomy in patients with lumbar disc herniation recurrence. In cases of recurrence in which conservative treatment is not feasible, and another surgery must be performed for the patient, discectomy is a more cost-effective surgical alternative than discectomy with fusion. https://insights.ovid.com/crossref...

Arts, M. P., Kuršumović, A., Miller, L. E., Wolfs, J., Perrin, J. M., Van de Kelft, E., & Heidecke, V. (2019). Comparison of treatments for lumbar disc herniation: Systematic review with network meta-analysis. Medicine, 98(7), e14410.
Results of a network meta-analysis show LD is more effective than CC in alleviating symptoms of lumbar disc herniation refractory to initial conservative management. Further, LD + AC lowers risk of reherniation and reoperation versus LD and may improve patient symptoms more than CC. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6408089/

Boote, J., Newsome, R., Reddington, M., Cole, A., & Dimairo, M. (2016). Physiotherapy for patients with sciatica awaiting lumbar micro-discectomy surgery: A nested, qualitative study of patients views and experiences. Physiotherapy Research International, 22(3).
Most patients in the sample found the physiotherapy valuable, appreciating the individual nature of the approach, the exercises to reduce pain and discomfort, techniques for improving functional spinal movement, walking and dynamic posture, and manual therapy and cardiovascular exercise. A small number did not find the physiotherapy of benefit. Sixteen patients in the sample went on to proceed with surgery, but most of these found value in having had the physiotherapy first. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5516132/

Gugliotta, M., Costa, B. R. D., Dabis, E., Theiler, R., Jüni, P., Reichenbach, S., … Hasler, P. (2016). Surgical versus conservative treatment for lumbar disc herniation: a prospective cohort study. BMJ Open, 6(12).
Compared with conservative therapy, surgical treatment provided faster relief from back pain symptoms in patients with lumbar disc herniation, but did not show a benefit over conservative treatment in midterm and long-term follow-up.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5223716/

Cowperthwaite, M. C., Hout, W. B. V. D., & Webb, K. M. (2013). The impact of early recovery on long-term outcomes in a cohort of patients undergoing prolonged nonoperative treatment for lumbar disc herniation. Journal of Neurosurgery: Spine, 19(3), 301–306.
This study is the first to comprehensively consider the utility recovery of individual patients within a treatment cohort for lumbar disc herniation. The results suggest that most utility is recovered during the early treatment period. Moreover, the findings suggest that initial improvement is critical to a patient's long-term outcome: patients who do not experience significant initial recovery appear unlikely to do so at a later time under the same treatment protocol. https://thejns.org/.../j-neurosurg.../19/3/article-p301.xml

References

Sutheerayongprasert, C., Paiboonsirijit, S., Kuansongtham, V., Anuraklekha, S., Hiranyasthiti, N., & Neti, S. (2012). Factors predicting failure of conservative treatment in lumbar-disc herniation. Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 95 5, 674-80 .
Factors predicting failure of conservative treatment in lumbar-disc herniation.
Long-duration, sequestered herniation and large fragment are predictive of failure in the conservative treatment of lumbar-disc herniation.
https://www.ncbi.nlm.nih.gov/pubmed/22994027

Activities of Daily Living Lumbar Disc Herniation

Kuai, S., Zhou, W., Liao, Z., Ji, R., Guo, D., Zhang, R., & Liu, W. (2017). Influences of lumbar disc herniation on the kinematics in multi-segmental spine, pelvis, and lower extremities during five activities of daily living. BMC Musculoskeletal Disorders, 18(1).
LDH patients mainly restrict the motion of LLx and ULx in the spinal region during the five ADLs. Pelvic rotation is an important method to compensate for the limited lumbar motion. Furthermore, pelvic tilt and lower extremities' flexion increased when ADLs were quite difficult for LDH patients. https://bmcmusculoskeletdisord.biomedcentral.com/.../s128...

Ruiz, F. K., Bohl, D. D., Webb, M. L., Russo, G. S., & Grauer, J. N. (2014). Oswestry Disability Index is a better indicator of lumbar motion than the Visual Analogue Scale. The Spine Journal, 14(9), 1860–1865.
Extremes of lumbar motion and motions associated with ADLs are of increasing clinical interest. Although the ODI and VAS are associated with each other, the ODI appears to be a better predictor of these motion parameters than the VAS (axial extremity, lower extremity, or combined) and may be more useful in the clinical setting when considering functional movement parameters. https://www.sciencedirect.com/.../abs/pii/S1529943013016227

Chen, H.-N., & Tsai, Y.-F. (2013). A predictive model for disability in patients with lumbar disc herniation. Journal of Orthopaedic Science, 18(2), 220–229.
In path analysis, the most influential factor affecting the disability level was the pain level (standardized regression coefficient, b = 0.746), followed by the fatigue level (b = 0.138) and depression level (b = 0.100). The depression level was directly affected by the fatigue level (b = 0.416) and the pain level (b = 0.367), the fatigue level was directly affected by the pain level (b = 0.538), and the pain level was directly affected by age (b = 0.140) and previous surgery (b = 0.260). https://link.springer.com/article/10.1007/s00776-012-0354-1

Kesikburun, B., Eksioglu, E., Turan, A., Adiguzel, E., Kesikburun, S., & Cakci, A. (2019). Spontaneous regression of extruded lumbar disc herniation: Correlation with clinical outcome. Pakistan Journal of Medical Sciences, 35(4)
The majority of the patients with extruded lumbar disc herniation might have reduction in size of herniated disc in the long run along with improvement in symptoms and function with conservative care. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6659070/

References

Clinical Presentation Lumbar Disc Herniation

Cai, Z., Ma, D., Li, F., Chen, R., Liu, Z., Zhang, Z., … Lu, X. (2013). Trend of the incidence of lumbar disc herniation: decreasing with aging in the elderly. Clinical Interventions in Aging, 1047.
The imaging examination with computed tomography and/or magnetic resonance imaging showed the occurrence of degeneration in LDH patients over 65 years of age. The most common site of LDH is toward the bottom of the spine at L4–L5 and/or L5–S1. The incidence of LDH drops with age in the elderly, especially after the age of 80 years. There is an obvious decrease in LDH in the elderly female. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743527/

Brinjikji, W., Luetmer, P., Comstock, B., Bresnahan, B., Chen, L., Deyo, R., … Jarvik, J. (2014). Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. American Journal of Neuroradiology, 36(4), 811–816.
The prevalence of disk degeneration in asymptomatic individuals increased from 37% of 20-year-old individuals to 96% of 80-year-old individuals. Disk bulge prevalence increased from 30% of those 20 years of age to 84% of those 80 years of age. Disk protrusion prevalence increased from 29% of those 20 years of age to 43% of those 80 years of age. The prevalence of annular fissure increased from 19% of those 20 years of age to 29% of those 80 years of age.
http://www.ajnr.org/content/36/4/811.short

Rainville, J., & Lopez, E. (2013). Comparison of radicular symptoms caused by lumbar disc herniation and lumbar spinal stenosis in the elderly. Spine, 38(15), 1282–1287.
Results. Participants with LSS had more medical comorbidity, less intense leg pain, and less disability than those with LDH. Leg pain was more common in the anterior thigh, anterior knee and shin in LDH, and in the posterior knee in LSS. Trunk flexion was more impaired in LDH. Positive straight leg raising, and femoral stretch signs were common in LDH, and rare in LSS. Abnormal Achilles reflexes were noted more frequently in LSS.
https://journals.lww.com/.../Comparison_of_Radicular...

Suri, P., Rainville, J., Hunter, D. J., Li, L., & Katz, J. N. (2012). Recurrence of radicular pain or back pain after nonsurgical treatment of symptomatic lumbar disk herniation. Archives of Physical Medicine and Rehabilitation, 93(4), 690–695.
Twenty-five percent (95% confidence interval [CI], 15–35) of individuals with resolution of radicular pain for at least 1 month reported subsequent recurrence of pain within 1 year after resolution. The only factor independently associated with radicular pain recurrence was the number of months prior to resolution of pain (hazard ratio per month=1.24; 95% CI, 1.13–1.37; P<.001). The 1-year incidence of back pain recurrence was 43% (95% CI, 30–56), and older age decreased the hazard of recurrence.
https://www.sciencedirect.com/.../abs/pii/S0003999311010550

References

Scaia, V., Baxter, D., & Cook, C. (2012). The pain provocation-based straight leg raise test for diagnosis of lumbar disc herniation, lumbar radiculopathy, and/or sciatica: A systematic review of clinical utility. Journal of Back and Musculoskeletal Rehabilitation, 25(4), 215–223.
Results: The systematic review and hand search identified 7 articles for inclusion; three of these articles were rated as high quality using QUADAS scores. Sensitivity and specificity varied among the 7 studies with 4 suggesting that a pain response SLR is sensitive whereas 3 suggested it is a specific measure. Conclusions: Variability in reference standard may partly explain the inconsistencies in the diagnostic accuracy findings. Further, pain that is not specific to lumbar radiculopathy, such as that associated with hamstring tightness, may also lead to false positives for the SLR; and may inflate the sensitivity of the test. https://content.iospress.com/.../journal-of-back.../bmr00339

Motiei-Langroudi, R., Sadeghian, H., & Seddighi, A. S. (2014). Clinical and magnetic resonance imaging factors which may predict the need for surgery in lumbar disc herniation. Asian Spine Journal, 8(4), 446.
Among 134 patients, 80.6% were successfully treated with conservative therapy and 19.4% finally underwent surgery. Sex, occupation, involved root level, presence of Modic changes, osteophytes or annular tears were not significantly different between the 2 groups, while cerebrospinal fluid block, Pfirrmann's grade, location of herniation with regard to the midline, and type of herniation were significantly different. Anteroposterior fragment size was significantly higher and intervertebral foramen height and thecal sac diameters were significantly lower in the surgical group.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4149987/

Wang, Q., Zhang, H., Zhang, J., Zhang, H., & Zheng, H. (2019). The relationship of the shear wave elastography findings of patients with unilateral lumbar disc herniation and clinical characteristics. BMC Musculoskeletal Disorders, 20(1).
According to these findings, ultrasound imaging can be considered as a useful tool to detect changes in the sciatic nerve due to disc herniation. This technique will have a promising prospect for many patients with unilateral LDH in monitoring stiffness during rehabilitation and before or after surgery. https://link.springer.com/article/10.1186/s12891-019-2814-7

Iversen, T., Solberg, T. K., Romner, B., Wilsgaard, T., Nygaard, Ø., Waterloo, K., … Ingebrigtsen, T. (2013). Accuracy of physical examination for chronic lumbar radiculopathy. BMC Musculoskeletal Disorders, 14(1).
The accuracy of individual clinical index tests used to predict imaging findings of nerve root impingement in patients with chronic lumbar radiculopathy is low when applied in specialized care, but clinicians' overall evaluation improves diagnostic accuracy slightly. The tests are not very helpful in clarifying the cause of radicular pain and are therefore inaccurate for guidance in the diagnostic workup of the patients.
https://bmcmusculoskeletdisord.biomedcentral.com/.../1471...

References

Tawa, N., Rhoda, A., & Diener, I. (2017). Accuracy of clinical neurological examination in diagnosing lumbo-sacral radiculopathy: a systematic literature review. BMC Musculoskeletal Disorders, 18(1).
There is a scarcity of studies on the diagnostic accuracy of clinical neurological examination testing. Furthermore, there seem to be a disconnect among researchers regarding the diagnostic utility of lower limb neuro-dynamic tests which include the Straight Leg Raise and Femoral Nerve tests for sciatic and femoral nerve respectively. Whether these tests are able to detect the presence of disc herniation and subsequent nerve root compression or hyper-sensitivity of the sacral and femoral plexus due to mechanical irritation still remains debatable. https://bmcmusculoskeletdisord.biomedcentral.com/.../s128...

Lumbar Disc Herniation on MRI

Wassenaar, M., Rijn, R. M. V., Tulder, M. W. V., Verhagen, A. P., Danielle A. W. M. Van Der Windt, Koes, B. W., … Ostelo, R. W. J. G. (2011). Magnetic resonance imaging for diagnosing lumbar spinal pathology in adult patients with low back pain or sciatica: a diagnostic systematic review. European Spine Journal, 21(2), 220–227.
The results suggest that a considerable proportion of patients may be classified incorrectly by MRI for HNP and spinal stenosis. However, the evidence for the diagnostic accuracy of MRI found by this review is not conclusive, since the results could be distorted due to the limited number of studies and large heterogeneity. https://link.springer.com/article/10.1007/s00586-011-2019-8

Orief, T., Orz, Y., Attia, W., & Almusrea, K. (2012). Spontaneous resorption of sequestrated intervertebral disc herniation. World Neurosurgery, 77(1), 146–152.
We found that sequestrated disc herniation has potential for regression, which can be clearly demonstrated by magnetic resonance imaging, because of having higher water content, and therefore, may regress through both dehydration and inflammation-mediated resorption. We suggest conservative treatment in the initial course of the sequestrated type of disc herniation for at least 2 months before recommending surgical intervention unless severe neurologic deterioration takes place. https://www.sciencedirect.com/.../abs/pii/S1878875011004992

Kanna, R. M., Shetty, A. P., & Rajasekaran, S. (2014). Patterns of lumbar disc degeneration are different in degenerative disc disease and disc prolapse magnetic resonance imaging analysis of 224 patients. The Spine Journal, 14(2), 300–307.
Group 1 (DP) had 91 patients and group 2 (DDD) had 133 patients. DP and DDD patients differed significantly in the number, extent, and severity of degeneration. DDD patients had a significantly higher number of degenerated discs than DP patients ($p<.000$). The incidence of multilevel and pan-lumbar degeneration was also significantly higher in DDD group. The pattern of degeneration also differed in both the groups. DDD patients had predominant upper lumbar involvement, whereas DP patients had mainly lower lumbar degeneration. Modic changes were more common in DP patients, especially at the prolapsed level. Modic changes were present in 37% of prolapsed levels compared with 9.9% of normal discs ($p<.00$). The total end-plate damage score had a positive correlation with disc degeneration in both the groups. Further the mean total end-plate damage score at prolapsed level was also significantly higher. https://www.sciencedirect.com/.../abs/pii/S1529943013016471

References

Suthar, P. (2015). MRI Evaluation of lumbar disc degenerative disease. Journal Of Clinical And Diagnostic Research. 9(4), TC04–TC09.
Annular disc tear, disc herniation, disc extrusion, narrowing of spinal canal, narrowing of lateral recess, compression of neural foramen, ligamentum flavum thickening and facetal arthropathy was common at the L4 –L5 disc level. Disc bulge was common at L3 – L4 & L4 – L5 disc level.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4437133/

Chiu, C.-C., Chuang, T.-Y., Chang, K.-H., Wu, C.-H., Lin, P.-W., & Hsu, W.-Y. (2014). The probability of spontaneous regression of lumbar herniated disc: a systematic review. Clinical Rehabilitation, 29(2), 184–195. The rate of spontaneous regression was found to be 96% for disc sequestration, 70% for disc extrusion, 41% for disc protrusion, and 13% for disc bulging. The rate of complete resolution of disc herniation was 43% for sequestrated discs and 15% for extruded discs.
https://journals.sagepub.com/.../10.1177/0269215514540919

Kermani, H. R., Keykhosravi, E., Mirkazemi, M., & Ehsaei, M. R. (2013). The relationship between morphology of lumbar disc herniation and MRI changes in adjacent vertebral bodies. The Archives of Bone and Joint Surgery, 1(2), 82–85. Extruded discs are associated with increased signal in T1-weighted MRI (short TR/TE) in the upper adjacent vertebrae. Signal changes in T2-weighted MRI (long TR/TE) in upper adjacent vertebrae are significantly more common in extruded discs, in comparison with protruded discs.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4151413/

Kim, J.-H., Rijn, R. M. V., Tulder, M. W. V., Koes, B. W., Boer, M. R. D., Ginai, A. Z., … Verhagen, A. P. (2018). Diagnostic accuracy of diagnostic imaging for lumbar disc herniation in adults with low back pain or sciatica is unknown, a systematic review. Chiropractic & Manual Therapies, 26(1). The diagnostic accuracy of CT, myelography and MRI of today is unknown, as we found no studies evaluating today's more advanced imaging techniques. Concerning the older techniques, we found moderate diagnostic accuracy for all CT, myelography and MRI, indicating a large proportion of false positives and negatives. https://link.springer.com/article/10.1186/s12998-018-0207-x

Chou, R., Deyo, R. A., & Jarvik, J. G. (2012). Appropriate use of lumbar imaging for evaluation of low back pain. Radiologic Clinics of North America, 50(4), 569–585.
Use of lumbar spine imaging, particularly advanced imaging, continues to grow rapidly in the United States. Many lumbar spine imaging tests are obtained in patients who have no clinical symptoms or risk factors suggesting a serious underlying condition, yet evidence shows that this routine imaging is not associated with benefits, exposes patients to unnecessary harms, and increases costs. This article reviews current trends and practice patterns in lumbar spine imaging, direct and downstream costs, benefits and harms, current recommendations, and potential strategies for reducing imaging overuse.
https://www.radiologic.theclinics.com/.../S0033.../abstract

References

Divi, S., Warner, E. D., Makanji, H., Goyal, D. K., Galetta, M. S., Fang, T., … Schroeder, G. D. (2019). 205. Can imaging characteristics on MRI predict the acuity of a lumbar disc herniation? The Spine Journal, 19(9).
This is one of the first studies to assess acuity of symptoms and MRI signal characteristics. Outside of advanced degenerative findings such as Pfirrmann grade 5 or anterior and posterior vertebral body spurring, no other MRI characteristics could be identified that correlate with acuity of symptoms. Therefore, close clinical correlation is important in combination with imaging in treating patients with lumbar disc herniation.
https://www.sciencedirect.com/.../pii/S1529943019307867

Thapa, S., Lakhey, R., Sharma, P., & Pokhrel, R. (2016). Correlation between clinical features and magnetic resonance imaging findings in lumbar disc prolapse. Journal Of Nepal Health Research Council, .
Conclusions: Clinical features and Magnetic resonance imaging findings of lumbar disc prolase had fair correlation, but all imaging abnormalities do not have a clinical significance.
http://jnhrc.com.np/index.php/jnhrc/article/view/794

Extension Exercises Lumbar Disc

Steele, J., Bruce-Low, S., Smith, D., Jessop, D., & Osborne, N. (2017). Isolated lumbar extension resistance training improves strength, pain, and disability, but not spinal height or shrinkage ("creep") in participants with chronic low back pain. Cartilage, 194760351769561.
Significant improvement across the intervention period (T2 to T3) was found for strength (P <0.0001; effect size [ES] = 2.42). Change in pain was not significant for repeated effects (P = 0.064); however, ES for the intervention period (T2 to T3) was moderate (ES = −0.77). Change in disability was significant between time point T1 and T3 (P = 0.037) and ES for the intervention period (T2 to T3) was large (ES = −0.92). Pain and disability achieved minimal clinically important changes. Conclusions. This is apparently the first study to examine disc change in vivo after exercise in CLBP. Results of the present study, though supporting ILEX resistance training to improve strength, pain, and disability, did not find any effect on spinal height.
https://journals.sagepub.com/.../10.1177/1947603517695614

Ebrahimi H., Blaouchi R., Eslami R., & Shahrokhi M. (2014). Effect of 8-week core stabilization exercises on low back pain, abdominal and back muscle endurance in patients with chronic low back pain due to disc herniation. Physical Treatments Journal, 4(1), 25-32.
Results: Results showed that 8-weeks core stabilization exercises caused a significantly low back pain reduction (P=0.001) and a significant increase in abdominal muscle endurance (P=0.001) and back muscles endurance (P=0.001) in the experimental group compared to the control group.
Conclusion: According to the findings of the study, core stabilization exercises in improving low back pain, abdominal and back muscle endurance in patients with chronic low back pain caused by disc herniation have been effective. Hence, cautious prescription of core stabilization exercises for these patients would be beneficial. http://ptj.uswr.ac.ir/browse.php?a_code=A-10-179-1&sid=1...

References

Ye, C., Ren, J., Zhang, J., Wang, C., Liu, Z., Li, F., & Sun, T. (2015). Comparison of lumbar spine stabilization exercise versus general exercise in young male patients with lumbar disc herniation after 1 year of follow-up. International Journal of Clinical and Experimental Medicine, 8(6), 9869–9875.
Both groups showed a significant reduction in VAS and ODI scores at 3- and 12-months post-exercise compared with before treatment (P<0.001). The LSSE group showed a significant reduction in the average score of the VAS for low back pain (P=0.012) and the ODI (P=0.003) at 12 months post-exercise compared with the GE group. Conclusions: LSSE and GE are considered as effective interventions for young male patients with LDH. Moreover, LSSE is more effective than GE, and physical therapy, such as LPL, is required during acute LDH.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4538120/

Jeon, K., Kim, T., & Lee, S.-H. (2016). Effects of muscle extension strength exercise on trunk muscle strength and stability of patients with lumbar herniated nucleus pulposus. Journal of Physical Therapy Science, 28(5), 1418–1421.
An integrated exercise program aiming to strengthen lumbar spine muscles, reduce pain and stabilize the trunk can help to maintain muscle strength and balance. In addition, improvement in extension strength is expected to be helpful in daily life by securing the range of joint motion and improving the strength and stability. https://www.jstage.jst.go.jp/.../28.../_article/-char/ja/

Jeong, D.-K., Choi, H.-H., Kang, J.-I., & Choi, H. (2017). Effect of lumbar stabilization exercise on disc herniation index, sacral angle, and functional improvement in patients with lumbar disc herniation. Journal of Physical Therapy Science, 29(12), 2121–2125.
There was a significant pre- versus post-intervention difference in disc herniation index, sacral angle, and KODI in experimental group I and a significant difference in disc herniation index and KODI in experimental group II, and each group of disc herniation index and sacral angle had a significant difference. In experimental group I, each disc herniation index and sacral angle had a negative correlation. [Conclusion] The lumbar stabilization exercise, which controls balance using pelvic movements, improves mobility and stability of the sacroiliac joint; therefore, it increases pelvic and back movements. These kinds of movements not only improved proprioception sense, they also had positive effects on lumbar disc function recovery.
https://www.jstage.jst.go.jp/.../29.../_article/-char/ja/

Lifting and Loading Lumbar Disc Herniation

Ahsan, M. K., Matin, T., Mi, A., My, A., Awwal, M. A., & Sakeb, N. (2013). Relationship between physical workload and lumbar disc herniation. Mymensingh Medical Journal, 22(3), 533-540.
There was a statistically significant positive association between cumulative exposure of physical workload and lumbar disc herniation indicating an increased occurrence of herniation in heavy physical work load and occupation requiring harder efforts.
https://europepmc.org/abstract/med/23982545

References

Lumbar Disc Herniation Differential Diagnosis

Kim, K., Isu, T., Morimoto, D., Iwamoto, N., Kokubo, R., Matsumoto, J., … Morita, A. (2017). Common diseases mimicking lumbar disc herniation and their treatment. Mini-Invasive Surgery, 1(2).
This study describes other diseases with symptoms similar to LDH. Patients with paralumbar spine diseases such as superior cluneal nerve entrapment neuropathy (NEN), gluteus medius muscle pain, piriformis syndrome, and sacroiliac joint pain experience low back, buttock, and leg pain. Peripheral nerve diseases of the leg including lateral femoral cutaneous NEN, common and superficial peroneal NEN, and tarsal tunnel syndrome also cause leg symptoms. These diseases can produce intermittent claudication, thought to be specific to lumbar spine disease, and can be misdiagnosed as LDH. They are rather common and can be treated less invasively.
https://misjournal.net/article/view/2036

Nezari, N. H. A., Schneiders, A. G., & Hendrick, P. A. (2013). Neurological examination of the peripheral nervous system to diagnose lumbar spinal disc herniation with suspected radiculopathy: a systematic review and meta-analysis. The Spine Journal, 13(6), 657–674.
This systematic review and meta-analysis demonstrate that neurological testing procedures have limited overall diagnostic accuracy in detecting disc herniation with suspected radiculopathy. Pooled diagnostic accuracy values of the tests were poor, whereby all tests demonstrated low sensitivity, moderate specificity, and limited diagnostic accuracy independent of the disc herniation reference standard or the specific level of herniation.
https://www.sciencedirect.com/.../abs/pii/S1529943013001642

Gerdan, V., Akar, S., Solmaz, D., Pehlivan, Y., Onat, A. M., Kisacik, B., … Akkoc, N. (2012). Initial diagnosis of lumbar disc herniation is associated with a delay in diagnosis of ankylosing spondylitis. The Journal of Rheumatology, 39(10), 1996–1999. The mean diagnostic delay was 8.1 ± 8.6 years in the whole study population. The shortest delay was observed when rheumatologists were the first physicians consulted (2.9 ± 5.3 yrs). An initial diagnosis of LDH was reported by 33% of the patients. The diagnostic delays in patients with an initial diagnosis of LDH and those without were 9.1 ± 8.5 years and 6.2 ± 7.4 years, respectively ($p = 0.002$). In a regression model, predictive factors for delay in diagnosis were age at onset of spondyloarthritic symptoms, back pain, education level, prior diagnosis of LDH, and surgical history for LDH.
http://www.jrheum.org/content/39/10/1996.short

Jeon, C.-H., Chung, N.-S., Lee, Y.-S., Son, K.-H., & Kim, J.-H. (2013). Assessment of hip abductor power in patients with foot drop. Spine, 38(3), 257–263.
There were 44 men and 17 women, with a mean age of 46.8 years (19–77 yr). The final diagnosis was peroneal neuropathy in 28 patients, lumbosacral plexopathy in 9 patients, lumbar radiculopathy in 21 patients, and sciatic nerve disorder in 3 patients. Concomitant hip abductor weakness was found in 85.7% of lumbar radiculopathy and 3.6% of peroneal neuropathy. The sensitivity and specificity of hip abductor power in the differential diagnosis of foot drop due to the lumbar radiculopathy and peroneal neuropathy were 85.7% and 96.4%, respectively. The positive and negative predictive values were 94.7% and 90%, respectively.
https://journals.lww.com/.../Assessment_of_Hip_Abductor...

References

Nutrition Supplements Lumbar Disc Injury

Jacobs, L., Vo, N., Coelho, J. P., Dong, Q., Bechara, B., Woods, B., … Sowa, G. (2013). Glucosamine supplementation demonstrates a negative effect on intervertebral disc matrix in an animal model of disc degeneration. Spine, 38(12), 984–990.
The MRI index and NP area of injured discs of glucosamine treated animals with annular puncture was found to be lower than that of degenerated discs from rabbits not supplemented with glucosamine. Consistent with this, decreased glycosaminoglycan was demonstrated in glucosamine fed animals, as determined by both histological and GAG content. Gene expression was consistent with a detrimental effect on matrix.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3672267/

Illien-Jünger, S., Lu, Y., Qureshi, S. A., Hecht, A. C., Cai, W., Vlassara, H., … Iatridis, J. C. (2015). Chronic ingestion of advanced glycation end products induces degenerative spinal changes and hypertrophy in aging pre-diabetic mice. Plos One, 10(2).
Overall, chronic exposure to dietary AGEs promoted age-accelerated IVD degeneration and vertebral alterations involving ectopic calcification which occurred in parallel with insulin resistance, and which were prevented with dMG- diet. This study described a new mouse model for diet-induced spinal degeneration, and results were in support of the hypothesis that chronic AGE ingestion could be a factor contributing to a pre-diabetic state, ectopic calcifications in spinal tissues, and musculoskeletal complications that are more generally known to occur with chronic diabetic conditions. https://journals.plos.org/plosone/article...

Facet and Disc Herniation

Chadha, M., Sharma, G., Arora, S. S., & Kochar, V. (2012). Association of facet tropism with lumbar disc herniation. European Spine Journal, 22(5), 1045–1052.
The findings of the study suggest that facet tropism is associated with lumbar disc herniation at the L5–S1 motion segment but not at the L4–L5 level.
https://link.springer.com/article/10.1007/s00586-012-2612-5

Wang, H., & Zhou, Y. (2016). Facet tropism: possible role in the pathology of lumbar disc herniation in adolescents. Journal of Neurosurgery: Pediatrics, 18(1), 111–115.
FT was identified in 16 of 39 patients with LDH in L4–5 and in 3 of 30 controls ($p = 0.006$, OR 6.261, 95% CI 1.619–24.217). It was also identified in 12 of 27 patients with LDH in L5–S1 and in 4 of 30 controls ($p = 0.017$, OR 5.200, 95% CI 1.420–19.039). One patient had LDH in both L4–5 and L5–S1. FT is associated with LDH in both L4–5 and L5–S1 levels in adolescents.
https://thejns.org/.../j-neurosurg.../18/1/article-p111.xml

Liu, Z., Duan, Y., Rong, X., Wang, B., Chen, H., & Liu, H. (2017). Variation of facet joint orientation and tropism in lumbar degenerative spondylolisthesis and disc herniation at L4-L5: A systematic review and meta-analysis. Clinical Neurology and Neurosurgery, 161, 41–47.
No significant correlation was observed between facet joint angle with LDH.
https://www.sciencedirect.com/.../pii/S030384671730224X

References

Mohanty, S. P., Kanhangad, M. P., Kamath, S., & Kamath, A. (2018). Zygapophyseal joint orientation and facet tropism and their association with lumbar disc prolapse. Asian Spine Journal, 12(5), 902–909.
Our results confirm the existence of a significant association between lumbar IVDP and FT; however, a causal relationship could not be ascertained.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6147874/

Zhou, Q., Teng, D., Zhang, T., Lei, X., & Jiang, W. (2018). Association of facet tropism and orientation with lumbar disc herniation in young patients. Neurological Sciences, 39(5), 841–846.
The results showed that LDH was significantly associated with more coronal facet joint orientation at L1–2 (p = 0.009), L2–3 (p = 0.004), and L3–4 (p = 0.004). No association was established between facet tropism and LDH. This study revealed that facet joint orientation was associated with LDH in young patients (18–35 years); they were more of coronal facing at upper levels. Also, the facet tropism was not associated with LDH.
https://link.springer.com/article/10.1007/s10072-018-3270-0

Ghandhari, H., Ameri, E., Hasani, H., Safari, M. B., & Tabrizi, A. (2018). Is facet tropism associated with increased risk of disc herniation in the lumbar spine? Asian Spine Journal, 12(3), 428–433.
FT is associated with increased risk of L4/L5 intervertebral disc herniation, but not at the L5/S1 level. In addition, disc herniation occurred toward the more sagittally oriented facet joint.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6002178/

Risk Factors Disc Herniation

Sadat, B., Habibi, B., Habibzadeh, A., Shimia, M., & Babaei-Ghazani, A. (2013). Risk factors of recurrent lumbar disk herniation. Asian Journal of Neurosurgery, 8(2), 93.
There was significant difference between groups with and without LDH in sex (P = 0.003), smoking habit (P = 0.004), height (P = 0.04), weight (P = 0.006) and occupational characteristic (P < 0.001). By putting these differences in logistic regression analysis, it showed that gender (male), taller height, heavy works and being smoker could predict lumbar disc herniation recurrence. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775189/

Huang, W., Qian, Y., Zheng, K., Yu, L., & Yu, X. (2015). Is smoking a risk factor for lumbar disc herniation? European Spine Journal, 25(1), 168–176.
This systematic review included 12 studies—six each of cohort and case–control studies. The combined reported values showed that the relative risk of the association between smoking and LDH was 1.27 [95 % confidence interval (CI), 1.15–1.40] overall, 1.48 (95 % CI, 1.27–1.73) for case–control studies, and 1.17 (95 % CI, 1.05–1.30) for cohort studies.
https://link.springer.com/article/10.1007/s00586-015-4103-y

References

Zhang, Y.-G., Zhang, F., Sun, Z., Guo, W., Liu, J., Liu, M., & Guo, X. (2013). A controlled case study of the relationship between environmental risk factors and apoptotic gene polymorphism and lumbar disc herniation. The American Journal of Pathology, 182(1), 56–63.
Therefore, the risk of LDH was determined by both environmental and genetic risk factors, and the mechanisms of interactions between different genotypes and environmental factors also differed. https://www.sciencedirect.com/.../pii/S0002944012007262

Schoenfeld, A. J., Laughlin, M., Bader, J. O., & Bono, C. M. (2012). Characterization of the incidence and risk factors for the development of lumbar radiculopathy. Journal of Spinal Disorders & Techniques, 25(3), 163–167.
Conclusions The incidence of lumbar radiculopathy in this young, racially diverse, and physically active population is higher than many other degenerative conditions. In this study female sex and white race increased the risk of developing lumbar radiculopathy. However, increasing age seems to be one of the most significant independent factors for developing this disorder.
https://journals.lww.com/.../Characterization_of_the...

Shiri, R., Lallukka, T., Karppinen, J., & Viikari-Juntura, E. (2014). Obesity as a risk factor for sciatica: A meta-analysis. American Journal of Epidemiology, 179(8), 929–937.
Overweight (OR = 1.16, 95% CI: 1.09, 1.24; n = 358,328) and obesity (OR = 1.38, 95% CI: 1.23, 1.54; n = 358,328) were associated with increased risk of hospitalization for sciatica, and overweight/obesity was associated with increased risk of surgery for lumbar disc herniation (OR = 1.89, 95% CI: 1.25, 2.86; n = 73,982).
https://academic.oup.com/aje/article/179/8/929/108237/

Schroeder, G. D., Guyre, C. A., & Vaccaro, A. R. (2016). The epidemiology and pathophysiology of lumbar disc herniations. Seminars in Spine Surgery, 28(1), 2–7.
Patients with a family history of disc disease or are in physically demanding jobs, or who have certain medical comorbidities such as obesity, are at an increased risk of developing a lumbar disc herniation. Symptomatic herniations present as lumbar radiculopathy from both a mechanical compression and chemical irritation of the nerve root.
https://www.sciencedirect.com/.../pii/S1040738315000957

Tao, S., Jin, L., Hou, Z., Zhang, W., Chen, T., & Zhang, Y. (2017). A New radiographic feature of lower lumbar disc herniation in young patients. International Orthopaedics, 42(3), 583–586.
Laminae defects of L5 may be a congenitally potential risk factor leading to lower LDH in the young and this radiographic clue could be used for the diagnosis of symptomatic lower LDH patients. https://link.springer.com/article/10.1007/s00264-017-3723-8

References

Brain Disc Herniation

Luchtmann, M., Steinecke, Y., Baecke, S., Lützkendorf, R., Bernarding, J., Kohl, J., … Firsching, R. (2014). Structural brain alterations in patients with lumbar disc herniation: A preliminary study. PLoS ONE, 9(3).
LDH patients showed significantly reduced gray matter volume in the right anterolateral prefrontal cortex, the right temporal lobe, the left premotor cortex, the right caudate nucleus, and the right cerebellum as compared to healthy controls. Increased gray matter volume, however, was found in the right dorsal anterior cingulate cortex, the left precuneal cortex, the left fusiform gyrus, and the right brainstem. Additionally, small subcortical decreases of the white matter were found adjacent to the left prefrontal cortex, the right premotor cortex and in the anterior limb of the left internal capsule. We conclude that the lumbar disk herniation can lead to specific local alterations of the gray and white matter in the human brain.
https://journals.plos.org/plosone/article...

Dolman, A. J., Loggia, M. L., Edwards, R. R., Gollub, R. L., Kong, J., Napadow, V., & Wasan, A. D. (2014). Phenotype Matters. The Clinical Journal of Pain, 30(10), 839–845.
MANOVA showed a trend toward cortical thickening in the right paracentral lobule in cLBP subjects ($F(1,17)=3.667$, $p<0.067$), and significant thickening in the right rostral middle frontal gyrus ($F(1,17)=6.880$, $p<0.014$). These clusters were non-significant after including age as a covariate ($p<0.891$; $p<0.279$). A whole-brain cortical thickness and VBM analysis also did not identify significant clusters of thinning or thickening.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4103969/

Muscles Disc Herniation

Altinkaya, N., & Cekinmez, M. (2015). Lumbar multifidus muscle changes in unilateral lumbar disc herniation using magnetic resonance imaging. Skeletal Radiology, 45(1), 73–77.
In groups A, B, and C, the median MLD differed significantly between the diseased and normal sides ($P < 0.05$). The MLD increased on the diseased side with symptom duration by lumbar disc herniation. The diseased side MLD was 5.1, 6.7, and 7.6 mm in groups A, B, and C, respectively ($P < 0.05$). The cut-off values for the MLD measurements were 5.3 mm (sensitivity = 62.3 %, specificity = 55.5 %; $P < 0.05$). In groups A, B, and C, the median CSA of the multifidus muscle was not significantly different between the diseased and the normal side ($P > 0.05$).
https://link.springer.com/article/10.1007/s00256-015-2252-z

References

Battié, M. C., Niemelainen, R., Gibbons, L. E., & Dhillon, S. (2012). Is level- and side-specific multifidus asymmetry a marker for lumbar disc pathology? The Spine Journal, 12(10), 932–939. Forty-three subjects met the inclusion criteria. The ratio of functional CSA to total muscle CSA was smaller on the side of the herniation than on the unaffected side, both below (mean 0.69 vs. 0.72, p=.007) and at the level of herniation (mean 0.78 vs. 0.80, p=.031). Multifidus signal intensity (fat infiltration) was greater on the side of the herniation at the level below the herniation (p=.014). Contrary to expectation, greater total multifidus CSA was found ipsilateral to the pathology at the level of herniation (p=.033). No asymmetries were found at the level above the herniation or in any other paraspinal muscles, with the exception of higher signal in the erector spinae at the level and side of herniation.
https://www.sciencedirect.com/.../abs/pii/S1529943012005542

Fortin, M., Lazáry, À., Varga, P. P., Mccall, I., & Battié, M. C. (2016). Paraspinal muscle asymmetry and fat infiltration in patients with symptomatic disc herniation. European Spine Journal, 25(5), 1452–1459.
There was no significant asymmetry of the multifidus at spinal level above, same or level below the disc herniation. Instead, variations in muscle composition were observed, with greater fat infiltration on the side and at spinal levels adjacent to the disc herniation. Muscle asymmetry was not correlated with symptom duration. https://link.springer.com/article/10.1007/s00586-016-4503-7

Sun, D., Liu, P., Cheng, J., Ma, Z., Liu, J., & Qin, T. (2017). Correlation between intervertebral disc degeneration, paraspinal muscle atrophy, and lumbar facet joints degeneration in patients with lumbar disc herniation. BMC Musculoskeletal Disorders, 18(1).
In the herniated group, most LMA at L3-L4 level was grade 1 (42, 70.0%); grade 2 (33, 55.0%) at L4-L5 level; and grade 3 (27, 45.0%) at L5-S1 level. LMA and LDD grading were significantly different between L3-L4 and L5-S1 levels ($P < 0.05$). In the herniation group, the Spearman value for LDD and LMA grading were 0.352 ($P < 0.01$) at L3-L4 and 0.036 ($P > 0.05$) at the L5-S1 level. The differences in LMA between the herniated and control groups at the three levels were significant ($P < 0.05$). https://bmcmusculoskeletdisord.biomedcentral.com/.../s128...

Ramos, L. A. V., França, F. J. R., Callegari, B., Burke, T. N., Magalhães, M. O., & Marques, A. P. (2016). Are lumbar multifidus fatigue and transversus abdominis activation similar in patients with lumbar disc herniation and healthy controls? A case control study. European Spine Journal, 25(5), 1435–1442.
Fatigue was significantly more intense and the TrA activation was insufficient ($p < 0.01$) in individuals with disc herniation relative to the control group. The LHG had mild functional disability and moderate pain. There were differences in the initial exertion self-evaluation between groups, which were not observed in the final exertion evaluation.
https://link.springer.com/article/10.1007/s00586-015-4375-2

References

Farshad, M., Gerber, C., Farshad-Amacker, N. A., Dietrich, T. J., Laufer-Molnar, V., & Min, K. (2013). Asymmetry of the multifidus muscle in lumbar radicular nerve compression. Skeletal Radiology, 43(1), 49–53. Asymmetry of the multifidus muscle correlates with neither the severity nor the duration of nerve root compression in the lumbar spine. https://link.springer.com/article/10.1007/s00256-013-1748-7

Evidence Based Guidelines Disc Herniation

Kreiner, D. S., Hwang, S. W., Easa, J. E., Resnick, D. K., Baisden, J. L., Bess, S., …Toton, J. F. (2014). An evidence-based clinical guideline for the diagnosis and treatment of lumbar disc herniation with radiculopathy. The Spine Journal, 14(1), 180 – 191.
The clinical guideline has been created using the techniques of evidence-based medicine and best available evidence to aid practitioners in the care of patients with symptomatic lumbar disc herniation with radiculopathy. https://www.sciencedirect.com/.../abs/pii/S1529943013014502

Creep Lumbar Disc

Mörl, F., & Bradl, I. (2013). Lumbar posture and muscular activity while sitting during office work. Journal of Electromyography and Kinesiology, 23(2), 362–368.
Because of very low activation of lumbar muscles while sitting, the load is transmitted by passive structures like ligaments and intervertebral discs. Due to the viscoelasticity of passive structures and low activation of lumbar muscles, the lumbar spine may incline into de-conditioning. This may be a reason for low back pain.
https://www.sciencedirect.com/.../abs/pii/S1050641112001721

Pei, B.-Q., Li, H., Li, D.-Y., Fan, Y.-B., Wang, C., & Wu, S.-Q. (2014). Creep bulging deformation of intervertebral disc under axial compression. Bio-Medical Materials and Engineering, 24(1), 191–198.
Methods: Fifteen motion segment specimens of ovine IVD were used to analyze axial creep, and disc bulging deformations of 5 markers on the surface were measured and analyzed. Findings: The maximum radial bulging rate was 2.78%±1.09% and the position at which the maximum radial deformation occurred was found to be below the midline of the disc during all levels of loading. The results showed that deformations occurred in the order vertical, radial, circumferential. https://content.iospress.com/.../bio-medical.../bme799

Jamison, D., & Marcolongo, M. S. (2014). The effect of creep on human lumbar intervertebral disk impact mechanics. Journal of Biomechanical Engineering, 136(3).
The data suggest that the IVD mechanical response to impact loading conditions is altered by fluid content and may result in a disk that exhibits less clinical stability and transfers more load to the AF. This could have implications for risk of diskogenic pain as a function of time of day or tissue hydration. https://asmedigitalcollection.asme.org/.../The-Effect-of...

References

Stefanakis, M., Luo, J., Pollintine, P., Dolan, P., & Adams, M. A. (2014). ISSLS Prize Winner. Mechanical influences in progressive intervertebral disc degeneration. Spine, 39(17), 1365–1372.
Results. As grade of disc degeneration increased from 2 to 4, nucleus pressure decreased by an average 68%, and maximum compressive stress in the annulus decreased by 48% to 64%, depending on location and posture. In contrast, stress gradients in the annulus increased by an average 75% in the anterior annulus (in flexed posture) and by 108% in the posterior annulus (in erect posture). Spearman rank correlation showed that these increases were statistically significant. https://journals.lww.com/.../ISSLS_Prize_Winner...

Vergroesen, P.-P. A., Veen, A. J. V. D., Royen, B. J. V., Kingma, I., & Smit, T. H. (2014). Intradiscal pressure depends on recent loading and correlates with disc height and compressive stiffness. European Spine Journal, 23(11), 2359–2368.Each disc showed a linear relationship between axial compression and intradiscal pressure (R 2 > 0.91). The intercept of linear regression analysis declined over time, but the gradient remained constant. Disc height changes were correlated to intradiscal pressure changes (R 2 > 0.98): both decreased during High loading, and increased during Low loading. In contrast, compressive stiffness increased during High loading, and was inversely related to intradiscal pressure and disc height.
https://link.springer.com/article/10.1007/s00586-014-3450-4

Kemper, A., Mcnally, C., Manoogian, S.J., McNeely, D., & Duma, S.M. (2007). Stiffness properties of human lumbar intervertebral discs in compression and the influence of strain rate.
The results show that the compressive stiffness of lumbar intervertebral discs is dependent on the loading rate. There was no significant correlation (p > 0.05) between functional spinal unit compressive stiffness and vertebral level at any of the three loading rates. Therefore, a linear relationship between loading rate and vertebral disc compressive stiffness was developed by curve fitting the stiffness data from the current study along with static compressive stiffness data reported by previous studies. https://www.semanticscholar.org/paper/Stiffness-Properties-of-Human-Lumbar-Intervertebral-Kemper-Mcnally/0e44d898bf044126e2a59357ffa453ead7ed8d2a

Classification Annular Tears Lumbar Disc

Fardon, D. F., Williams, A. L., Dohring, E. J., Murtagh, F. R., Rothman, S. L. G., & Sze, G. K. (2014). Lumbar disc nomenclature: version 2.0. The Spine Journal, 14(11), 2525–2545.
The article provides a discussion of the recommended diagnostic categories pertaining to the lumbar disc: normal; congenital/developmental variation; degeneration; trauma; infection/inflammation; neoplasia; and/or morphologic variant of uncertain significance. The article provides a glossary of terms pertaining to the lumbar disc, a detailed discussion of these terms, and their recommended usage. Terms are described as preferred, nonpreferred, nonstandard, and colloquial. Updated illustrations pictorially portray certain key terms. Literature references that provided the basis for the task force recommendations are included.
https://www.sciencedirect.com/.../pii/S1529943014004094

References

Fields, A. J., Liebenberg, E. C., & Lotz, J. C. (2014). Innervation of pathologies in the lumbar vertebral end plate and intervertebral disc. The Spine Journal, 14(3), 513–521.
In the disc, nerves were observed in only 35% of the annular tears; in particular, innervation in radial tears tended to be higher than in normal discs (p=.07). Of the discs with radial tears, less than 13% had HIZ on T2 MRI. Innervation was significantly less in radial tears than in fibrovascular end-plate marrow (p=.05) and end-plate defects (p=.02).
https://www.sciencedirect.com/.../abs/pii/S1529943013011972

Hoppe, S., Quirbach, S., Mamisch, T. C., Krause, F. G., Werlen, S., & Benneker, L. M. (2012). Axial T2* mapping in intervertebral discs: a new technique for assessment of intervertebral disc degeneration. European Radiology, 22(9), 2013–2019.
Healthy intervertebral discs revealed a distinct cross-sectional T2* value profile: T2* values were significantly lower in the annulus fibrosus compared with the nucleus pulposus (P = 0.01). In abnormal IVDs, T2* values were significantly lower, especially towards the centre of the disc representing the expected decreased water content of the nucleus (P = 0.01). In herniated discs, ROIs within the nucleus pulposus and ROIs covering the annulus fibrosus showed decreased T2* values. https://link.springer.com/article/10.1007/s00330-012-2448-8

Rajasekaran, S., Kanna, R. M., Senthil, N., Raveendran, M., Cheung, K. M., Chan, D., … Shetty, A. P. (2013). Phenotype variations affect genetic association studies of degenerative disc disease: conclusions of analysis of genetic association of 58 single nucleotide polymorphisms with highly specific phenotypes for disc degeneration in 332 subjects. The Spine Journal, 13(10), 1309–1320.
For annular tears, rs1042631 SNP of AGC1 and rs467691 SNP of ADAMTS5 were highly significantly associated (p<.01) and SNPs in NGFB, IL1B, IL18RAP, and MMP10 were also significantly associated (p<.05). https://www.sciencedirect.com/.../abs/pii/S1529943013005287

Farshad-Amacker, N. A., Hughes, A. P., Aichmair, A., Herzog, R. J., & Farshad, M. (2014). Is an annular tear a predictor for accelerated disc degeneration? European Spine Journal, 23(9), 1825–1829.
One-fourth (25 %) of the 36 discs with an AT on the initial MRI exam progressed in degeneration. This was similar to the rate of the matched control discs with no AT, in which also around one-fourth (22 %) showed a progression of degeneration (p = 1.00), also without any difference in the degree of degeneration. https://link.springer.com/article/10.1007/s00586-014-3260-8

Zhou, Z., Chen, Z., Zheng, Y., Cao, P., Liang, Y., Zhang, X., … Qiu, S. (2015). Relationship between annular tear and presence of Propionibacterium acnes in lumbar intervertebral disc. European Spine Journal, 24(11), 2496–2502.
P. acnes is significantly more likely to be present in herniated discs with an annular tear than in herniated discs without such a tear. Since in the vast majority of these cases, no P. acnes was found in control muscle samples, a true infection with P. acnes is far more likely than a contamination.https://link.springer.com/article/10.1007/s00586-015-4180-y

References

Yang, H., Liu, H., Li, Z., Zhang, K., Wang, J., Wang, H., & Zheng, Z. (2015). Low back pain associated with lumbar disc herniation: role of moderately degenerative disc and annulus fibrous tears. International journal of clinical and Experimental Medicine, 8(2), 1634–1644. Low back pain associated with lumbar disc herniation: role of moderately degenerative disc and annulus fibrous tears. In conclusion, the high expression of inflammatory mediators with AF tears causes LBP associated with disc herniation.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4402739/

Sharma, A., Lancaster, S., Bagade, S., & Hildebolt, C. (2014). Early pattern of degenerative changes in individual components of intervertebral discs in stressed and nonstressed segments of lumbar spine. Spine, 39(13), 1084–1090. Results. Burden of annular tears, radial tears, herniations, and nuclear degeneration was significantly higher in stressed discs (0.70 ± 0.34, 0.48 ± 0.39, 0.07 ± 0.19, and 0.17± 0.31, respectively) than control (0.29 ± 0.25, 0.09 ± 0.17, 0.01 ± 0.04, and 0.02 ± 0.08, respectively) or loading-matched control discs (0.44 ± 0.47, 0.16 ± 0.36, 0.01 ± 0.04, and 0.01 ± 0.11, respectively) (P < 0.01 for all). Stressed segments did not show any significant increase in endplate degeneration. Conclusion. Intervertebral discs in stressed spinal segments show an increased burden of disc degeneration involving annulus fibrosus and nucleus pulposus, but not the endplates.
https://cdn.journals.lww.com/.../Early_Pattern_of...

Galbusera, F., Rijsbergen, M. V., Ito, K., Huyghe, J. M., Brayda-Bruno, M., & Wilke, H.-J. (2014). Ageing and degenerative changes of the intervertebral disc and their impact on spinal flexibility. European Spine Journal. Despite some disagreement in the findings, a trend toward spinal stiffening with the increasing degeneration was observed in most studies. Tests about tears and fissures showed inconsistent results, as well as for disc collapse and dehydration.
https://link.springer.com/article/10.1007/s00586-014-3203-4

Kim, S.-Y., Lee, I.-S., Kim, B.-R., Lim, J.-H., Lee, J., Koh, S.-E., … Park, S. L. (2012). Magnetic resonance findings of acute severe lower back pain. Annals of Rehabilitation Medicine, 36(1), 47. Patients with acute severe axial LBP were more likely to have disc herniation, LDD, annular tear, HIZ. Among LBP groups, there was a significant association of HIZ on MRI with acute severe axial LBP. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309311/

Rajasekaran, S., Bajaj, N., Tubaki, V., Kanna, R. M., & Shetty, A. P. (2013). ISSLS Prize Winner. An in vivo, multimodal, prospective study of 181 subjects. Spine, 38(17), 1491–1500. Conclusion. Our study provides the first in vivo evidence that LDH in humans is more commonly the result of EPJF than AF rupture and offers clinical validation of previous in vitro mechanical disruption studies. https://cdn.journals.lww.com/.../ISSLS_Prize_Winner___The...

William E. Morgan

Chiropractor to Congress, Supreme Court, and the White House, Parker University's Seventh President, Active Texas Chiropractic Association Member, and proud Texan

Dr. Morgan has a long history of serving in military health care. Joining the Navy at 17, he served with an elite Marine Recon company as a hospital corpsman. While in the Navy, he was qualified in parachuting, military diving, submarine insertion, jungle warfare, combat swimming, explosives, mountaineering, winter warfare and Arctic survival. Additionally, he attended anti-terrorist training at the FBI Academy. After leaving active military service and transferring to the Navy Reserves, Dr. Morgan began his educational journey to becoming a doctor of chiropractic. While at Palmer College of Chiropractic, he transferred to a Naval Special Warfare platoon as the unit's primary hospital corpsman. He was sent to Special Operations Technician training to learn the principles of dive medicine. For the next eight years, he served as a dive medicine corpsman/combat swimmer for a platoon of Navy frogmen in Navy Special Warfare Unit One.

In 1985, Dr. Morgan received his Doctorate of Chiropractic from Palmer College of Chiropractic – West Campus and soon after, married fellow Palmer graduate, Clare Pelkey. They practiced for thirteen years in California. He has completed a 2,000 hour fellowship program in Integrated Medicine. Dr. Morgan served on the Board of Trustees for Palmer College of Chiropractic for ten years. He is also a Diplomate of the American Academy of Pain Management and held adjunct faculty positions at F. Edward Hébert School of Medicine, Uniformed Services University of the Health Sciences and New York Chiropractic College. Additionally, Dr. Morgan has served as a consultant for the U.S. Department of Veterans Affairs (VA), helping to implement the VA's chiropractic benefit and advocate for chiropractic research.

In 1998, Dr. Morgan was chosen to establish the first chiropractic clinic at the National Naval Medical Center in Bethesda, Maryland, which later became Walter Reed National Military Medical Center. In 2015, Walter Reed recognized Dr. Morgan with its highest honor for clinical excellence, the Master Clinician's Award. During the last 18 years at the military's most prestigious medical centers, he practiced in an integrative setting providing chiropractic care to the injured troops returning from the wars in Iraq and Afghanistan.

Dr. Morgan was appointed as the Chiropractor Congress at the U.S. Capitol in 2000. At the OAP, doctors of many specialties care for members of Congress and the Supreme Court. In 2007, Dr. Morgan began serving as the White House Chiropractor. He was appointed chiropractor for the United States Naval Academy football team in 2009, which never lost to Army while under his care).

William E. Morgan

Dr. Morgan was appointed as the Chiropractor Congress at the U.S. Capitol in 2000. At the OAP, doctors of many specialties care for members of Congress and the Supreme Court. In 2007, Dr. Morgan began serving as the White House Chiropractor. He was appointed chiropractor for the United States Naval Academy football team in 2009, which never lost to Army while under his care).

In 2011, Dr. Morgan was appointed to the United States Navy Musculoskeletal Continuum of Care Advisory Board – an entity created to address the prevalent injuries sustained by U.S. Armed Forces Personnel during active-duty operations. Dr. Morgan also served on the Spine Subcommittee, which helps develop care algorithms for treating spinal conditions and determining the future of musculoskeletal management in the U.S. Armed Forces.

Parker University inaugurated him as their seventh President in 2016. Upon arriving in Texas he organized a leadership summit to establish a legislative agenda strategy for the chiropractors in Texas. Texas Chiropractors had not won a significant legislative victory in two decades, but in 2016 four bills advantageous to the chiropractic profession passed.

As part of his vision to integrate chiropractic care with neurological conditions and treatment, Dr. Morgan's brainchild, Synapse: Human Performance Centers, Inc., a Texas non-profit corporation certified by the Texas Medical Board as a non-profit healthcare organization (NPHO) was established. The first prototype center was launched November 2019 on Parker's campus and will be the first of many in the region and nationally.

Dr. Morgan became an active member and supporter of the Texas Chiropractic Association from the moment he arrived in Texas. He has aided in fund raising, membership recruitment, and awareness. A lifetime member of the American Chiropractic Association (ACA), he has held several leadership positions in the ACA.

Dr. Morgan is the recipient of many prestigious awards, namely:

- The American Chiropractic Association Chairman's Award of Valor, 2003
- Chiropractor of the Year from the American Chiropractic Association, 2003
- Doctor of Laws, L.L.D. (honoris causa), National University of Health Sciences, 2004
- Master Clinician Award, Walter Reed National Military Medical Center, 2015
- The Keeler Plaque "Chiropractor of the Year" awarded by the Texas Chiropractic Association in 2018.