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MRI

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Diplomate, American Board of Chiropractic Orthopedists

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Clinician
- DC - NYCC
- Diplomate, American Board of Chiropractic Orthopedists
- Fellow, International Academy of Neuromusculoskeletal Medicine

Educator
- Post-graduate educator since 2000
- NCMIC Speakers' Bureau for>10 years
- Northeast College of Health Sciences
- CEO - PostGradDC.com

Honors
- Academy of Chiropractic Orthopedists Distinguished Service and Fellow Awards
- American College of Chiropractic Orthopedists Outstanding Achievement Award

Publications
- Over 31 Peer-Reviewed chiropractic journal articles.
- Many Contributions to NCMIC Examiner and Chiropractical Podcast

Editorial
- Editorial Reviewer for journals Spine, Annals of Internal Medicine, and Clinical Anatomy
- Former Managing Editor of Journal of Chiropractic Orthopedists

Community
- Lower Cape Fear Hospice, Board Member
- Founder, Past-President Wilmington Autism Society

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Purpose…

“It's not what you look at that matters, it's what you see.”

~Henry David Thoreau

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Instructive Case

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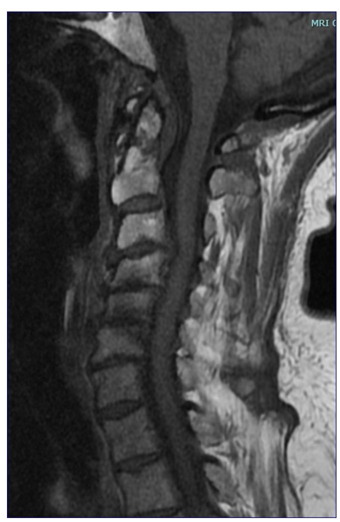

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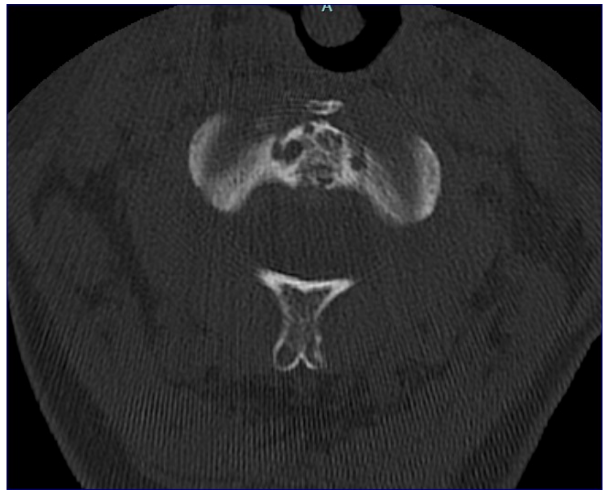

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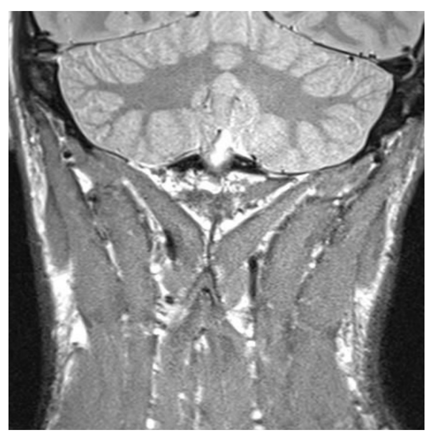
My Goals for you Today…

- **It is my hope to:**
  - Offer chiropractic physicians an assessment tool and flow chart to order and interpret MRI studies that will complement the reports from board-certified radiologists.



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Why, What, Where, When, and How?

- **WHY?**
  - To define the neuroradiologic elements of chiropractic subluxation (a term that I still favor!)
- **WHAT?**
  - To better order and interpret the findings of board-certified radiologists and perform overreads to attain important chiropractic findings on MRI studies.
- **WHERE?**
  - To provide guidance with regard to MRI prescriptions.
- **WHEN?**
  - To offer an evidence-based review of MRI standards of care and appropriateness criteria.
- **How?**
  - By providing a unique MRI spine assessment tool and flowchart.

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Course Outline

- Indications
- Ordering
- Basic Sequences
- IVD
- Vertebral Body
- Endplate Modic ∆'s
- Posterior Joints
- Paraspinal MM
- Canal and Foramina
- Cord/Nerve Roots/ Cauda Equina
- Paraspinal/Extra-Vertebral Findings
- Measurements
- Alignment
- Instability/Hardware

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The PostGradDC MRI Spine Assessment Tool

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Read the Radiologist's Report.
Overread Images for Evidence-Based Neuroradiologic Elements of Chiropractic Subluxation.
Go to PostGradDC.com for Advanced Training.

1. **Indications:**
   a. Consult the ACR/ Appropriateness Criteria.
   b. Clinical need.
2. **Order (if indicated):**
   a. CCJ: Thin slice, axial views from CO-C7, coronal views
   b. Lower C-spine: Sagittal obliques views
   c. Fat-Sat images for edema
   d. Contrast, if prior spinal surgery, suspect infection, or tumor (kidney assessment - involve PCP)
3. **Basic Sequences:**
   a. Water, CSF, Edema: ↑ T2, ↓T 1, ↑ Fat sat.
   b. Fat: ↑ T 1, ↔ T 1/T2
   c. Cortical Bone, Ligament, Tendon: ↓ T 1/T2
   d. Medullary Bone, Cord, Nerve: ↔ T 1 / T2
   e. Contrast: ↑ T 1 post-surgical, tumors, infections
4. **IVD:**
   a. Annular/Ligament Tears: Describe location/size
   b. Desiccation: Describe/list levels-Pfirrmann Scale
   c. Herniations:
      i. Protrusion, Extrusion, Intravertebral
      ii. Containment, continuity, relation to PLL and neural elements
      iii. Volume/Location
5. **Vertebral Body:**
   a. Describe morphology, signal, osteophytes, canal, foraminal intrusion
6. **Endplate Modic Δ's:**
   a. Modic 1: ↑T2, ↓ T 1
   b. Modic 2: ↑T2, ↑ T 1
   c. Modic 3: ↓T2, ↓ T 1
7. **Posterior Joints:**
   a. Describe morphology, canal/foraminal intrusion
   b. Synovitis
   c. Ligaments/capsules: describe tears / thickening, cysts
   d. Pedicle edema: ↑T2, ↓ T 1, ↑ Fat Sat.
   e. Peri-articular edema - Czervionke scale: ↑T2, ↓ T 1, ↑ Fat Sat.
8. **Paraspinal MM:**
   a. Describe atrophy, fatty degeneration, decreased volume/cross sectional area, edema
9. **Canal and Foramina:**
   a. Describe morphology, intrusions,
   b. Volume
   c. Patency
   d. AP canal diameter
10. **Cord/Nerve Roots/Cauda Equina:**
    a. Morphology
    b. Describe signal intensity
    c. Deformation
11. **Paraspinal/Extra-Vertebral Findings:**
    a. Tumors
    b. Phlegmon
12. **Measurements:**
    a. CCJ lines/angles
    b. AP canal diameters
13. **Alignment:**
    a. Translations, subluxations, angulations
14. **Instability/Hardware**

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- **To become more proficient at reading spinal MRI:**
  - Take advanced coursework to be able to read spinal MRI.
  - Spend time and shadow local radiologists.
  - If unsure about how to order an MRI, consult the ACR Appropriateness Criteria, a radiologist, a chiropractic orthopedist, and possibly the patient's medical provider.
  - Read the radiologist's report.
  - Overread images for evidence-based neuroradiologic elements of chiropractic subluxation.

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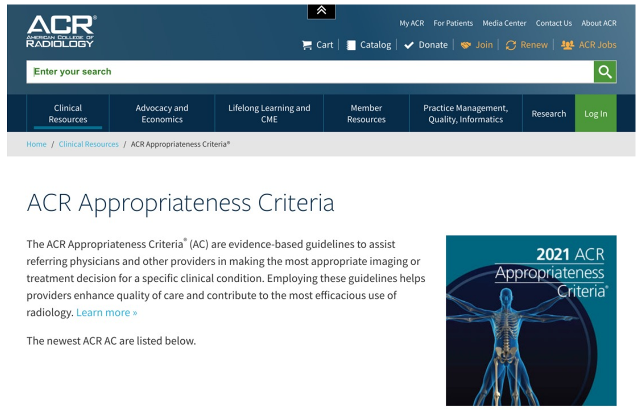
- **Indications:**
  - Consult the ACR/ Appropriateness Criteria.
  - Clinical need.



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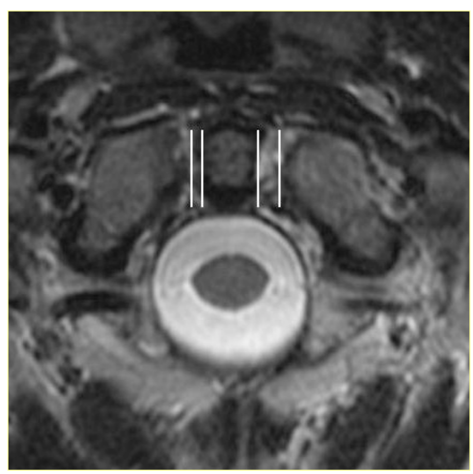
- **Order (if indicated):**
  - CCJ: Thin slice, axial views from CO-C7, coronal views
  - Lower C-spine: Sagittal obliques views
  - Fat-Sat images for edema
  - Contrast, if prior spinal surgery, suspect infection, or tumor (kidney assessment - involve PCP)



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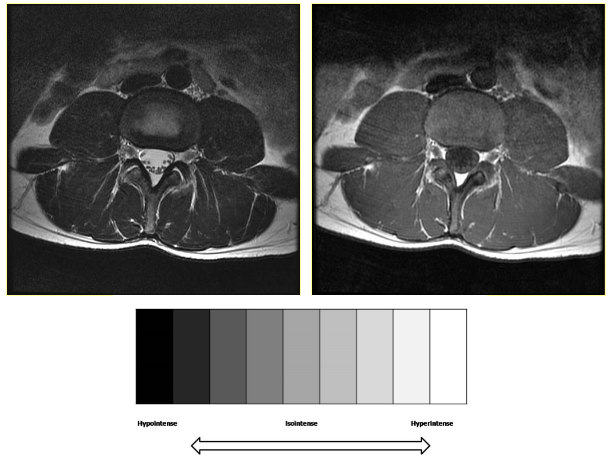
- **Basic Sequences:**
  - Water, CSF, Edema: ↑ T2, ↓T 1, ↑ Fat sat.
  - Fat: ↑ T 1, ↔ T 1/T2
  - Cortical Bone, Ligament, Tendon: ↓ T 1/T2
  - Medullary Bone, Cord, Nerve: ↔ T 1 / T2
  - Contrast: ↑ T 1 post-surgical, tumors, infections



Morgan WE. Modic Changes: Understanding Reactive Vertebral Endplate and Marrow Morphology. Copyright 2015. Bethesda Spine Institute

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- **IVD:**
  - Annular/Ligament Tears: Describe location/size
  - Desiccation: Describe/list levels-Pfirrmann Scale
  - Herniations:
    - Protrusion, Extrusion, Intravertebral
    - Containment, continuity, relation to PLL and neural elements
    - Volume/Location

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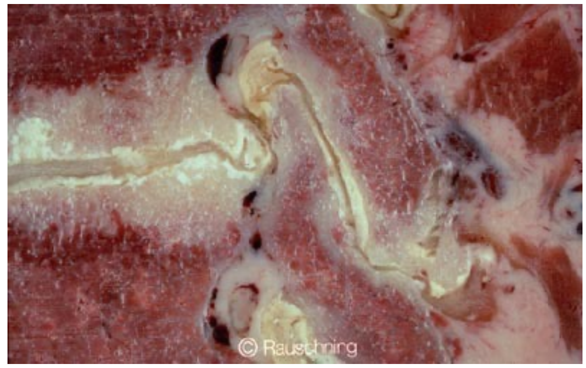
- **Vertebral Body:**
  - Describe morphology,
  - signal,
  - osteophytes,
  - canal,
  - foraminal intrusion



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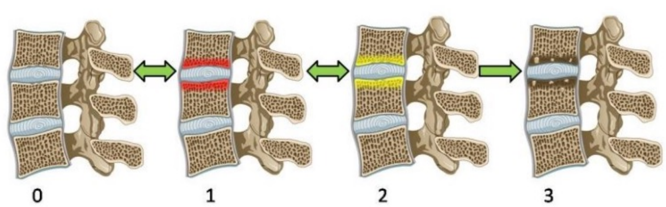
- **Endplate Modic Δ's:**
  - Modic 1: ↑T2, ↓ T 1
  - Modic 2: ↑T2, ↑ T 1
  - Modic 3: ↓T2, ↓ T 1



Morgan WE. Modic Changes: Understanding Reactive Vertebral Endplate and Marrow Morphology. Copyright 2015. Bethesda Spine Institute

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- **Posterior Joints:**
  - Describe morphology, canal/foraminal intrusion
  - Synovitis
  - Ligaments/capsules: describe tears/ thickening, cysts
  - Pedicle edema: ↑T2, ↓ T 1, ↑ Fat Sat.
  - Peri-articular edema - Czervionke scale: ↑T2, ↓ T 1, ↑ Fat Sat.

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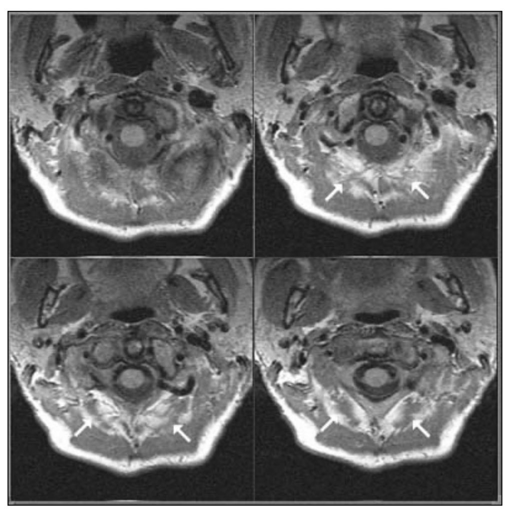
- **Paraspinal MM:**
  - Describe atrophy,
  - fatty degeneration,
  - decreased volume/cross sectional area,
  - edema



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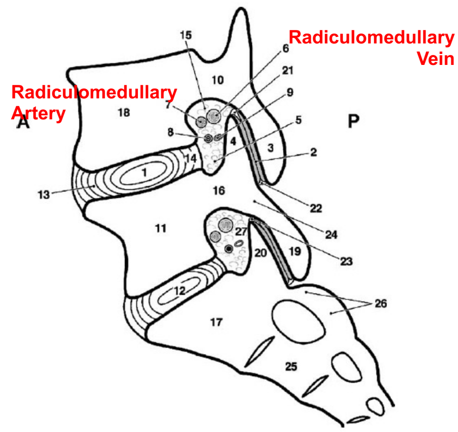
- **Canal and Foramina:**
  - Describe morphology,
  - Intrusions,
  - Volume
  - Patency
  - AP canal diameter



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- **Cord/Nerve Roots/Cauda Equina:**
  - Morphology
  - Describe signal intensity
  - Deformation

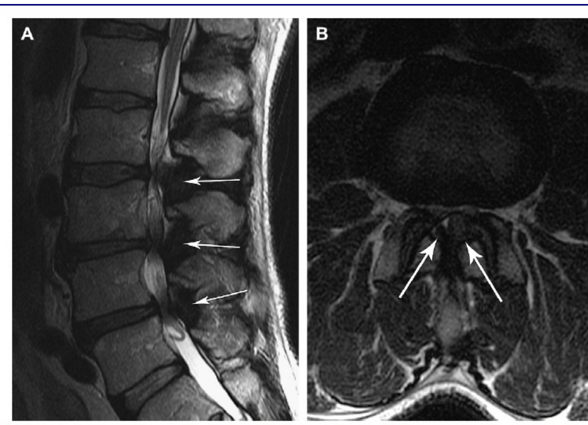

Fig. 7. Facet joint osteoarthrosis and spinal stenosis. A 67-year-old man with low back pain and weakness in both legs exacerbated with walking. Sagittal (*A*) and axial (*B*) FSE T2-weighted MR images demonstrate multilevel loss of disc space height with resultant redundancy of the ligamentum flavum (*arrows*), causing severe spinal stenosis at each level.

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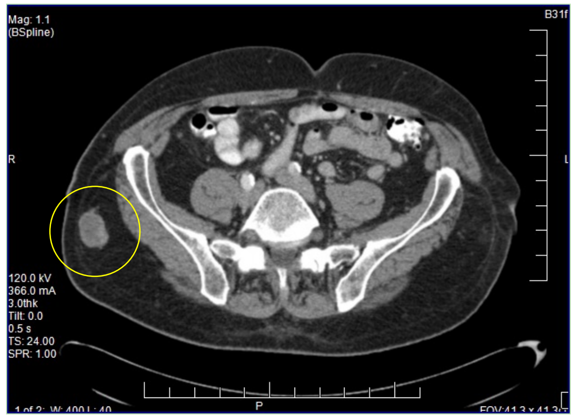
- **Paraspinal/Extra-Vertebral Findings:**
  - Tumors
  - Phlegmon



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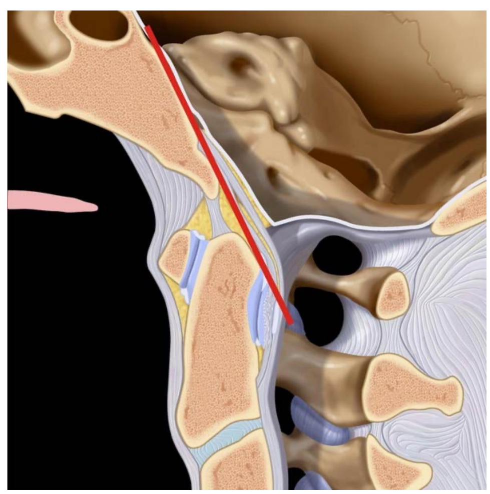
- **Measurements:**
  - CCJ lines/angles
  - AP canal diameters



Syllabus

- **MRI Anatomy**
  - Muscles
  - Myodural Bridges
  - Ligaments
  - MRI of Injured Ligaments
  - Chiropractic Subluxation on Imaging

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Clinical Anatomy – Chiropractic - MM

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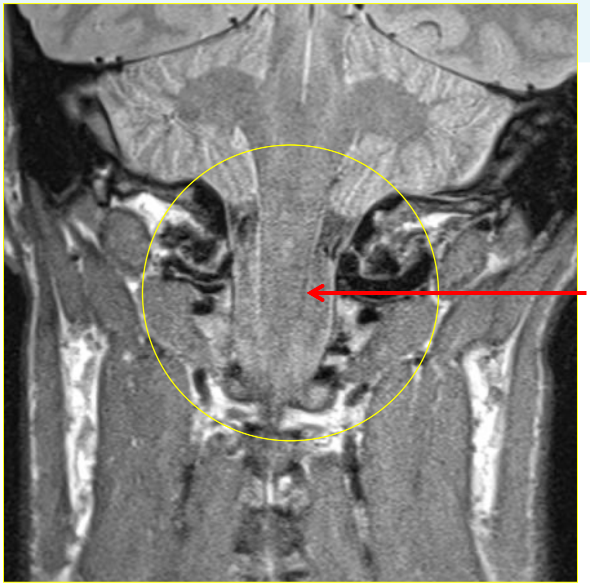

How important is this anatomic region?

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Neurol Res Int. 2015;2015:794829. doi: 10.1155/2015/794829. Epub 2015 Nov 30.

The Role of the Craniocervical Junction in Craniospinal Hydrodynamics and Neurodegenerative Conditions.

Flanagan MF[1].

Author information

Abstract

The craniocervical junction (CCJ) is a potential choke point for craniospinal hydrodynamics and may play a causative or contributory role in the pathogenesis and progression of neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, MS, and ALS, as well as many other neurological conditions including hydrocephalus, idiopathic intracranial hypertension, migraines, seizures, silent-strokes, affective disorders, schizophrenia, and psychosis. The purpose of this paper is to provide an overview of the critical role of the CCJ in craniospinal hydrodynamics and to stimulate further research that may lead to new approaches for the prevention and treatment of the above neurodegenerative and neurological conditions.

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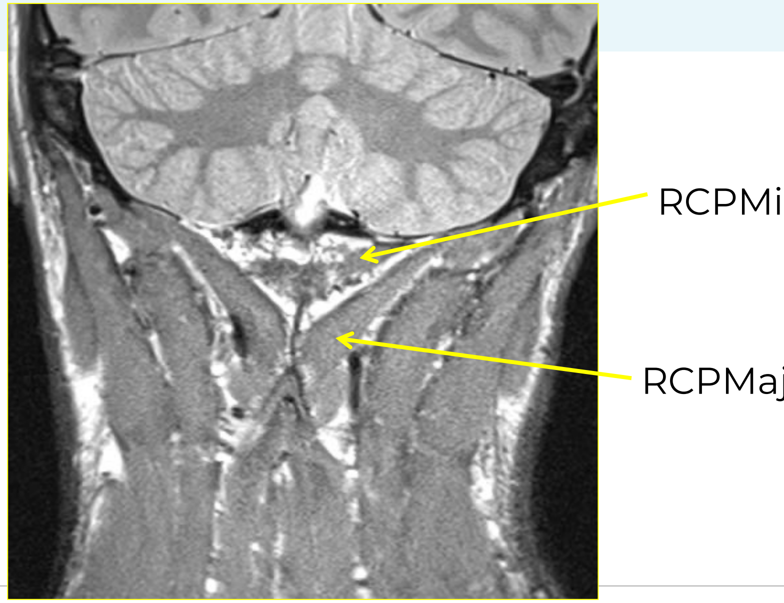
RCPMi
RCPMaj

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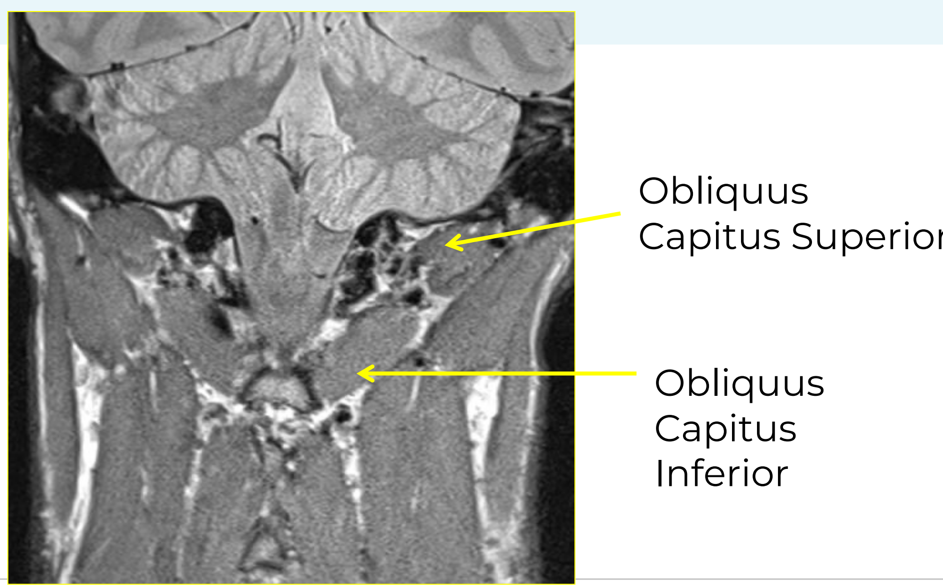
Obliquus
Capitus Superior
Obliquus
Capitus
Inferior

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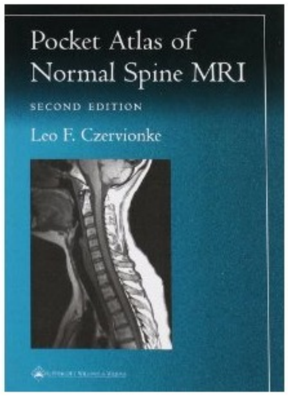

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Leo F. Czervionke (Author)
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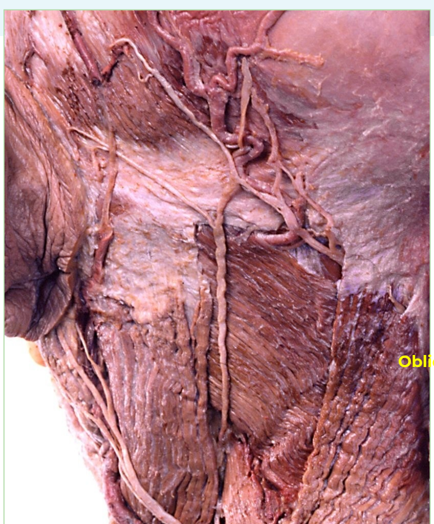
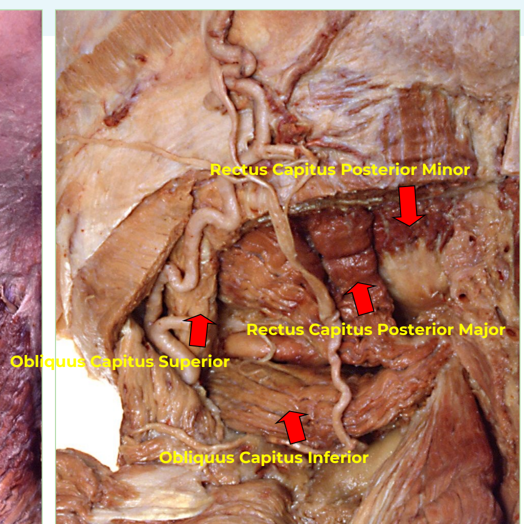


Interactive Spine - Chiropractic edition © 2001 Primal Pictures Ltd



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Cruveilhier plexus: an anatomical study and a potential cause of failed treatments for occipital neuralgia and muscular and facet denervation procedures

Laboratory investigation

R. Shane Tubbs, Ph.D.,[1] Martin M. Mortazavi, M.D.,[1] Marios Loukas, M.D., Ph.D.,[2] Anthony V. D'Antoni, Ph.D.,[3] Mohammadali M. Shoja, M.D.,[4] and Aaron A. Cohen-Gadol, M.D., M.Sc.[5]

[1]Pediatric Neurosurgery, Children's Hospital, Birmingham, Alabama; [2]Department of Anatomical Sciences, St. George's University, Grenada, West Indies; [3]Department of Physical Therapy, Dominican College, Orangeburg, New York; [4]Neuroscience Research Center, Tabriz University of Medical Sciences, Tabriz, Iran; and [5]Goodman Campbell Brain and Spine, Indiana University Department of Neurological Surgery, Indianapolis, Indiana

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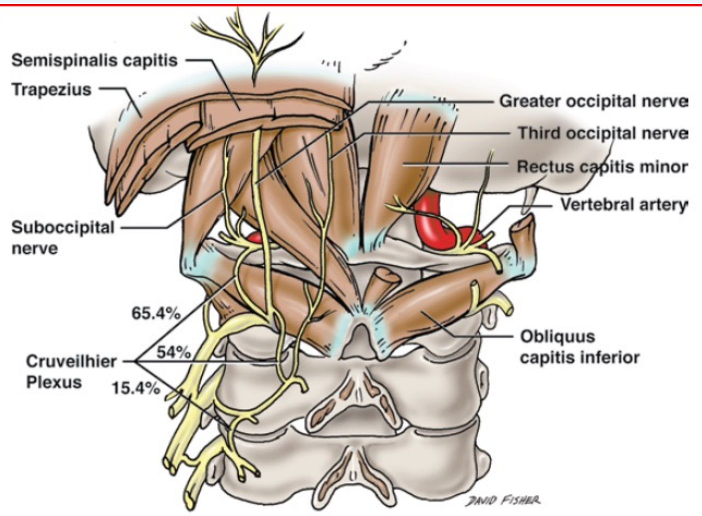

Fig. 1. Schematic drawing showing the communicating neural loops between the upper cervical dorsal rami (Cruveilhier plexus). Note the position of the plexus between the overlying semispinalis capitis muscle (cut) and deeper suboccipital triangle muscles (for example, obliquus capitis inferior muscle). Also note the incidence of neural loops, as found in the present study. Printed with the permission of R. S. Tubbs, 2011.

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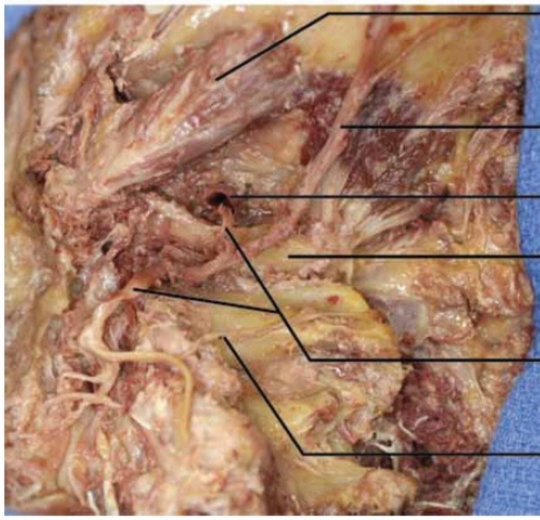

FIG. 2. Cadaveric (left side from a male cadaver) example of communicating branches between adjacent dorsal rami (C-1 to C-2 and C-2 to C-3). Note that the obliquus capitis inferior muscle has been removed.

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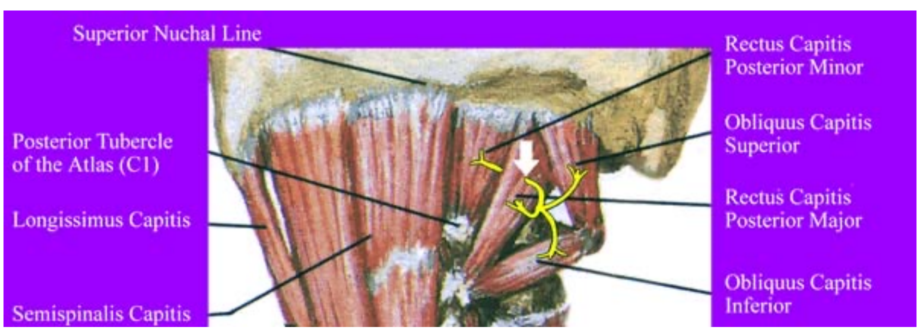
Richard Halgren, Ph.D.



"We hypothesize that entrapment and traction of the C1 dorsal ramus during whiplash-type cervical distortions, results in denervation atrophy, characterized by fatty infiltration, of the RCPMI muscles."

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Richard Halgren, Ph.D.

Michigan State University
Department of Physical Medicine & Rehabilitation
Department of Osteopathic Manipulative Medicine

- The presence of positive sharp waves in EMG recordings strongly suggests that there are dennervated muscle cells in the RCPMI muscle.
- These findings give support to the hypothesis that neck trauma can cause peripheral mononeuropathy resulting in dennervation atrophy in skeletal muscle and associated clinical symptoms of chronic pain.

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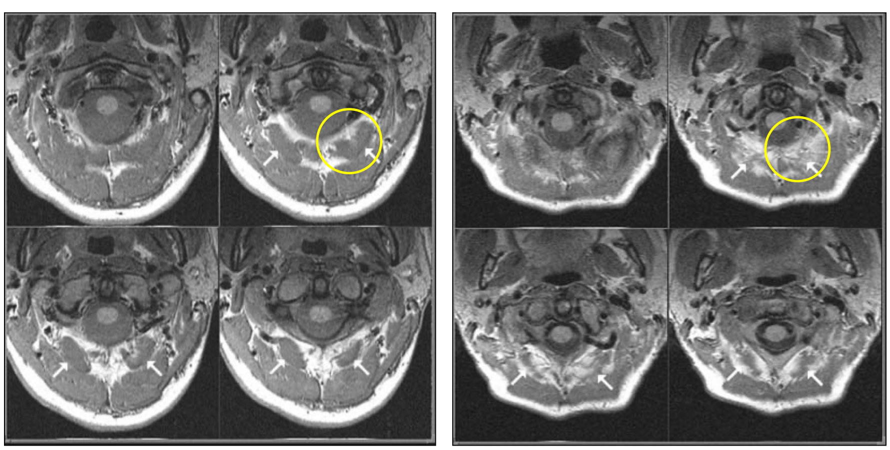
Richard Hallgren, PhD.



Control

Headache Patient

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Fatty Infiltration in the Cervical Extensor Muscles in Persistent Whiplash-Associated Disorders: A Magnetic Resonance Imaging Analysis.

Elliott et al. Spine. 31(22):E847-E855, October 15, 2006.

Conclusion. There is significantly greater fatty infiltration in the neck extensor muscles, especially in the deeper muscles in the upper cervical spine, in subjects with persistent WAD when compared with healthy controls. Future studies are required to investigate the relationships between muscular alterations and symptoms in patients suffering from persistent WAD.

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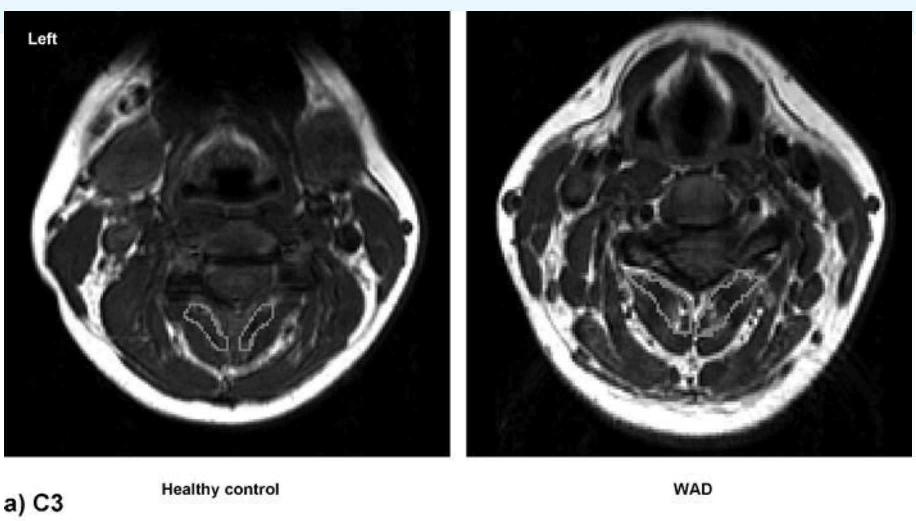

From: Elliott: Spine, Volume 31(22).October 15, 2006.E847-E855

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Clinical Anatomy – Chiropractic – Myodural Bridges

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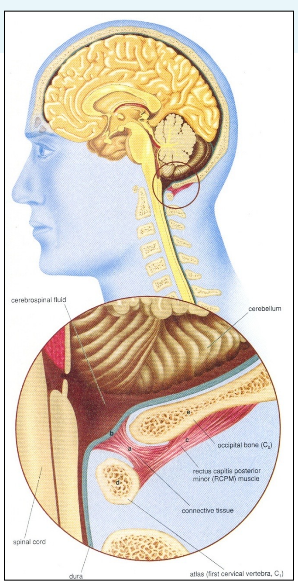
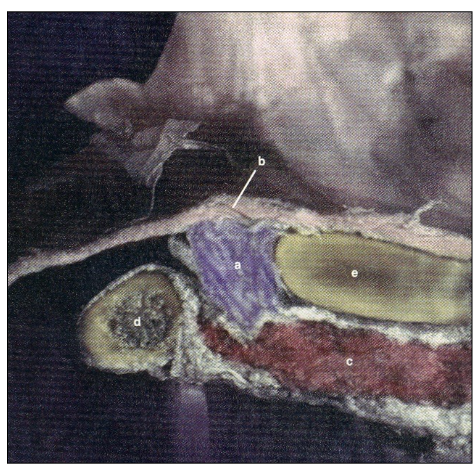
From "The Anatomist's New Tools"





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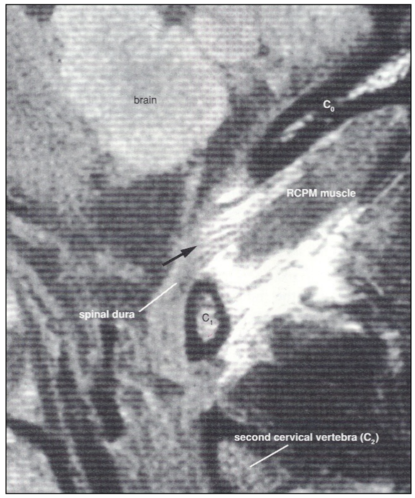
Myodural Bridge



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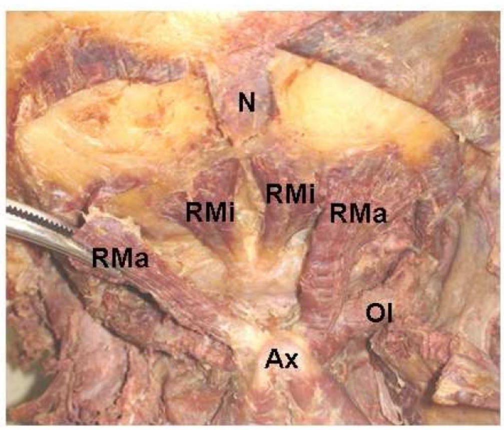

Fig. 1: Detaching left rectus capitis posterior major muscle from occipital bone. Ax, Axis; N, remnant of nuchal ligament; OI, obliquus capitis inferior; RMa, rectus capitis superior major; RMi, rectus capitis posterior minor.
117x99mm (96 x 96 DPI)

Ward P. *Clinical Anatomy.* Submitted June, 2009.

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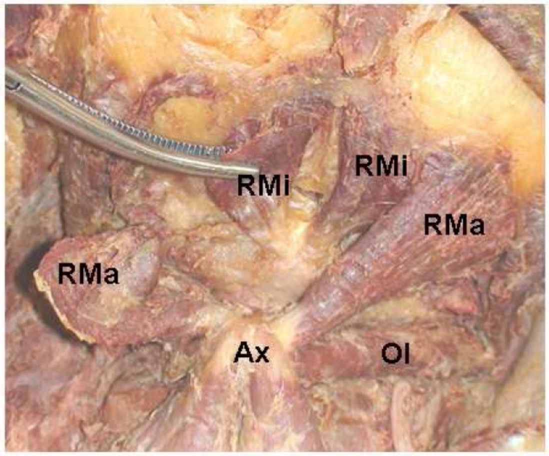

Fig. 2: Detaching the left rectus capitis posterior minor muscle from the occipital bone. Ax, Axis; OI, obliquus capitis inferior; RMa, rectus capitis superior major; RMi, rectus capitis posterior minor.

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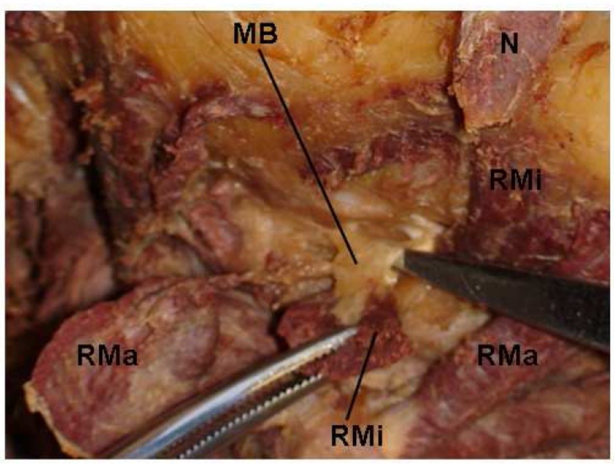

Fig. 3: Demonstrating the myodural bridge originating from the left rectus capitis posterior minor muscle. MB, myodural bridge; N, remnant of nuchal ligament; RMa, rectus capitis superior major; RMi, rectus capitis posterior minor.

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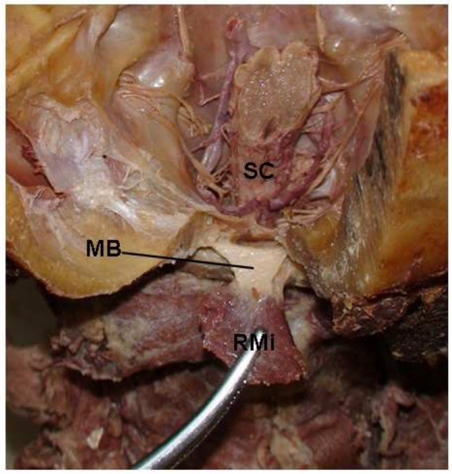

Fig. 4: Removal of a wedge of occipital bone to demonstrate the myodural bridge between the rectus capitis posterior minor and the dura mater near the foramen magnum. MB, myodural bridge; RMi, rectus capitis posterior minor; SC, spinal cord.

Ward P. *Clinical Anatomy*. Submitted June, 2009.

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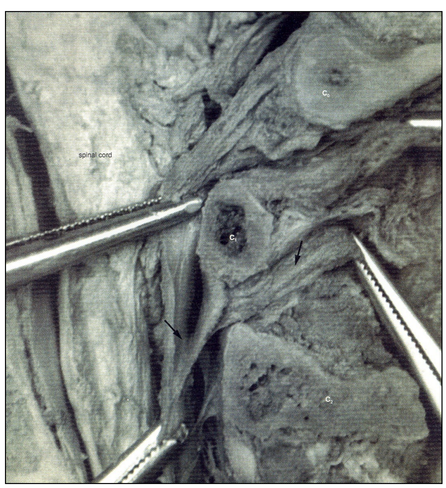
Myodural Bridge



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Spine
ANATOMY
SPINE Volume 36, Number 25, pp E1612–E1614
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Anatomical Connection Between the Rectus Capitis Posterior Major and the Dura Mater

Frank Scali, DC,* Eric S. Marsili, DC,† and Matthew E. Pontell, BSc*

➢ Key Points

- ❑ The rectus capitis posterior major communicates with the cervical dura mater.
- ❑ Aside from its attachment on the spinous process of the axis, this muscle also exhibited a fibrous connection to the dura mater.
- ❑ Manual traction of this muscle resulted in movement of the dura mater, thus validating a substantial connection between the two structures.

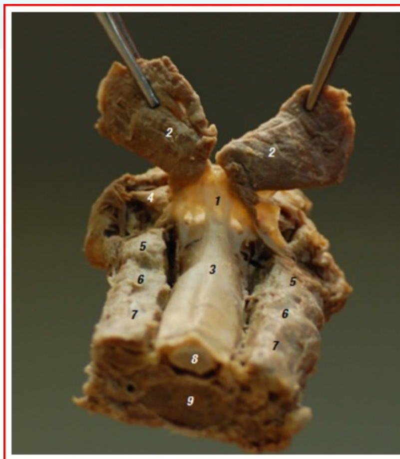
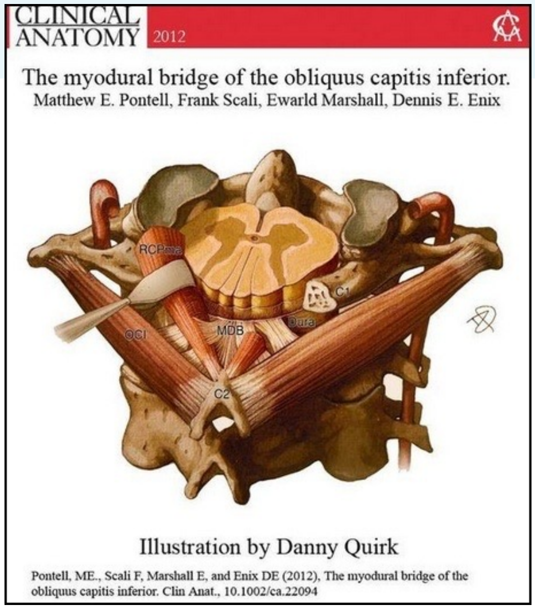


Figure 2. Photograph of dural attachment between rectus capitis posterior major (RCPma) and cervical dura mater. (1) Attachment between RCPma and cervical dura mater; (2) RCPma; (3) cervical dura mater; (4) lamina of axis; (5) transverse process of atlas; (6) third cervical vertebra; (7) fourth cervical vertebra; (8) spinal cord; and (9) body of fourth cervical vertebra.



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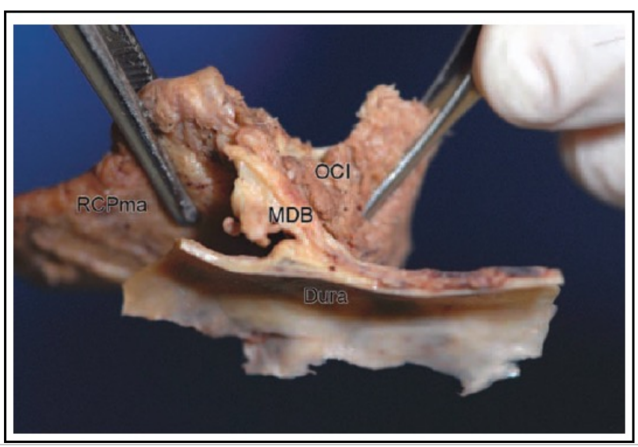
Clinical Anatomy 00:000–000 (2012)

ORIGINAL COMMUNICATION

The Obliquus Capitis Inferior Myodural Bridge

MATTHEW E. PONTELL,[1*] FRANK SCALI,[2] EWARLD MARSHALL,[1] AND DENNIS ENIX[3]
[1]Department of Anatomical Sciences, School of Medicine, St. George's University, Grenada, West Indies
[2]Independent Investigator, Valley Stream, New York
[3]Division of Research, Logan University, Chesterfield, Missouri



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Clinical Anatomy 00:000–000 (2012)

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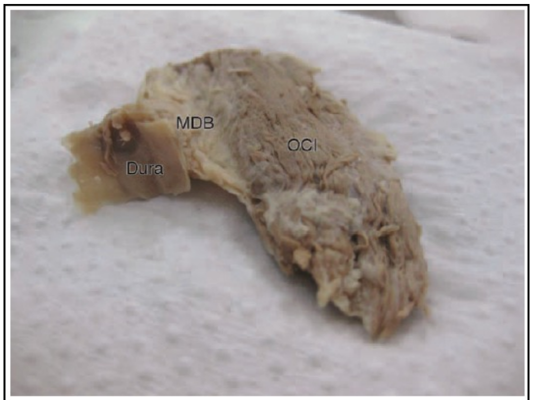

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Clinical Anatomy 00:000–000 (2012)

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Clinical Anatomy 00:000–000 (2012)

ORIGINAL COMMUNICATION

Magnetic Resonance Imaging Investigation of the Atlanto-Axial Interspace

FRANK SCALI,[1*] MATTHEW E. PONTELL,[2] AARON B. WELK,[3] THEODORE K. MALMSTROM,[4] EWARLD MARSHALL,[2] AND NORMAN W. KETTNER[3]
[1]Independent Investigator, Valley Stream, New York
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[3]Department of Radiology, Logan College of Chiropractic, Chesterfield, Missouri
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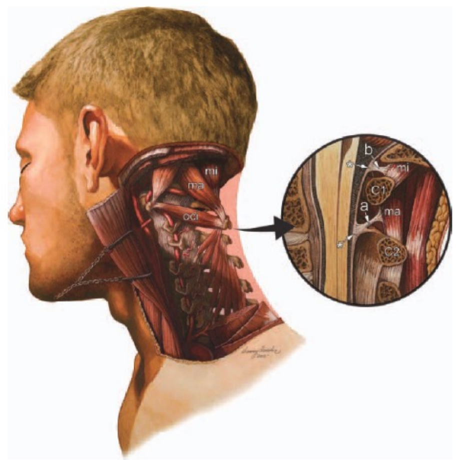

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Clinical Anatomy 00:000–000 (2012)

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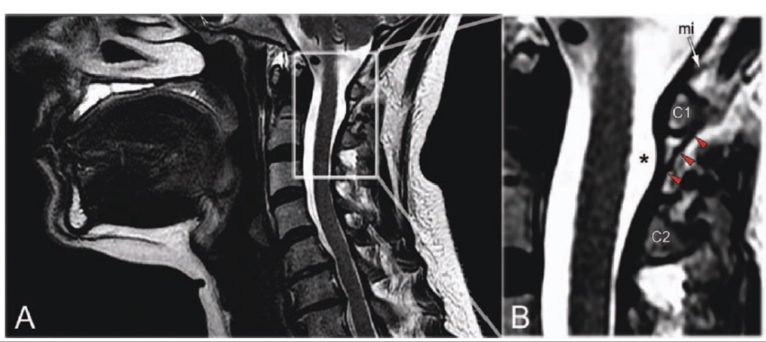
Scali et al.



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Clinical Anatomy – Chiropractic - Ligaments

J Neurosurg Spine 14:697–709, 2011

Ligaments of the craniocervical junction

A review

R. Shane Tubbs, M.S., P.A.-C., Ph.D.,[1] Justin D. Hallock, M.D.,[2] Virginia Radcliff, M.D.,[1] Robert P. Naftel, M.D.,[1] Martin Mortazavi, M.D.,[1] Mohammadali M. Shoja, M.D.,[3] Marios Loukas, M.D., Ph.D.,[4] and Aaron A. Cohen-Gadol, M.D., M.Sc.[3]

[1]*Section of Pediatric Neurosurgery, Children's Hospital, Birmingham, Alabama;* [2]*University of Tennessee College of Medicine, Memphis, Tennessee;* [3]*Clarian Neuroscience, Goodman Campbell Brain and Spine, Department of Neurological Surgery, Indiana University, Indianapolis, Indiana; and* [4]*Department of Anatomical Sciences, St. George's University, Grenada*

Conclusions

The ligaments of the CCJ play a vital role in maintaining structural stability in this region. A thorough working knowledge of this anatomy is, therefore, important for clinicians and surgeons who treat patients with conditions affecting this area.

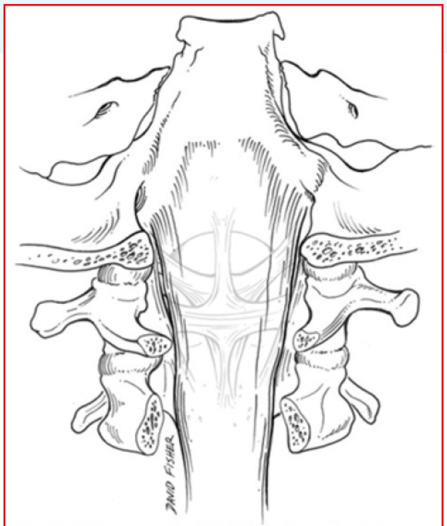

Fig. 8. Posterior view of the CCJ illustrating the relationship between the tectorial membrane *(shadowed)* and the more anterior-lying ligaments.

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Craniocervical junction ligaments

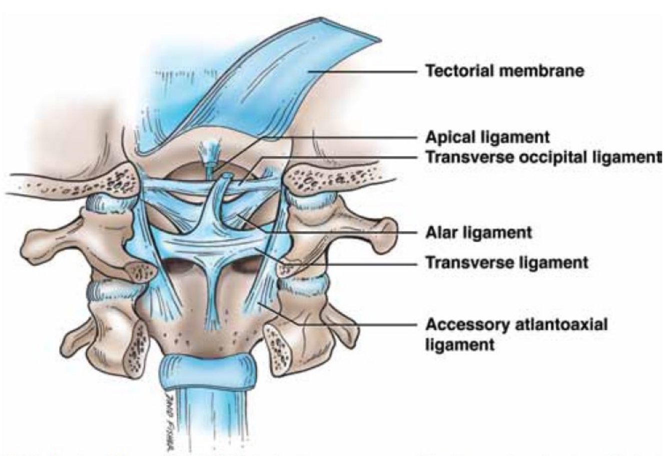

Fig. 1. Artist's drawing of the posterior CCJ illustrating its numerous specialized ligamentous structures. The tectorial membrane is reflected up and down in this drawing.

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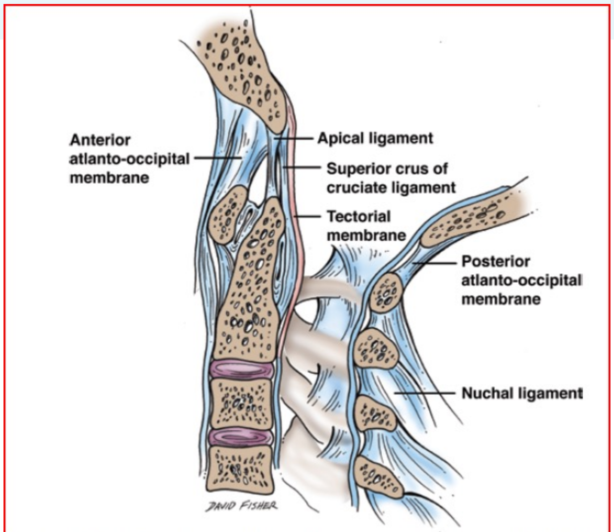

Fig. 9. Sagittal drawing of the neck and cranial base depicting the various specialized ligaments of the CCJ region.

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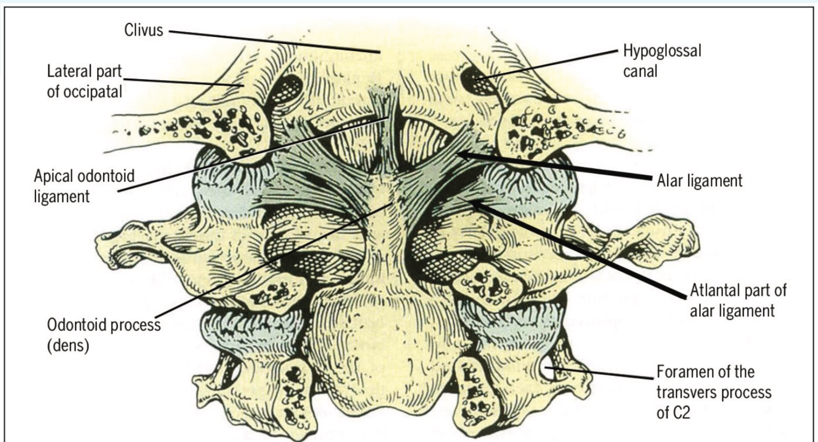

FIGURE 2. Posterior view with transverse ligament removed, showing the alar ligaments. Note that the atlantal part of the alar ligaments blends into an attachment with the C1-2 joint capsule. From Cramer GD, Darby SA. *Basic and Clinical Anatomy of the Spine, Spinal Cord, and ANS*. 2nd ed. 2005. St Louis, MO: Mosby; 2005. Used with permission from Elsevier Ltd.

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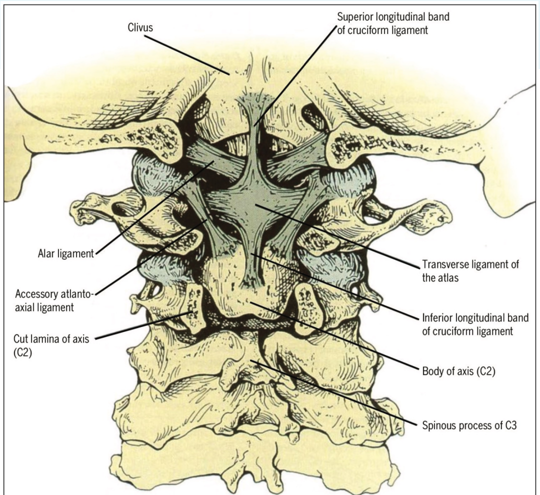

FIGURE 1. Posterior view of the upper cervical region depicting the anatomy of the transverse ligament. Also note the superior portion of the alar ligaments. From Cramer GD, Darby SA. *Basic and Clinical Anatomy of the Spine, Spinal Cord, and ANS*. 2nd ed. St Louis, MO: Mosby; 2005. Used with permission from Elsevier Ltd.

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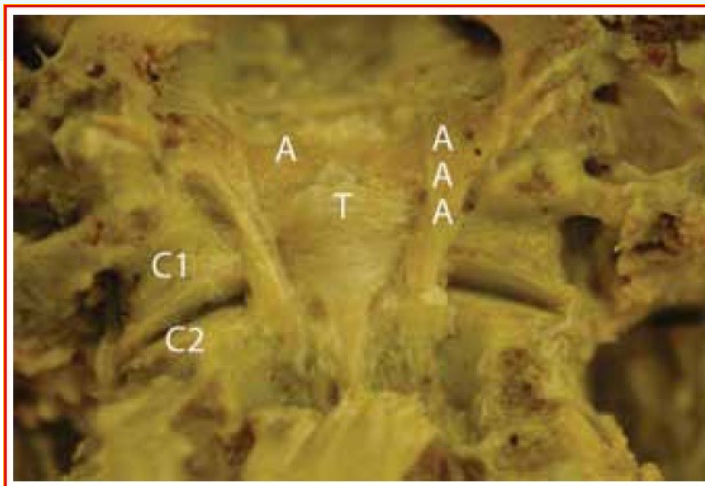

Fig. 2. Cadaveric dissection illustrating the view of Fig. 1. Note the transverse ligament (T), alar ligament (A), accessory atlantooccipital membrane (AAA), and the atlas (C1) and axis (C2).

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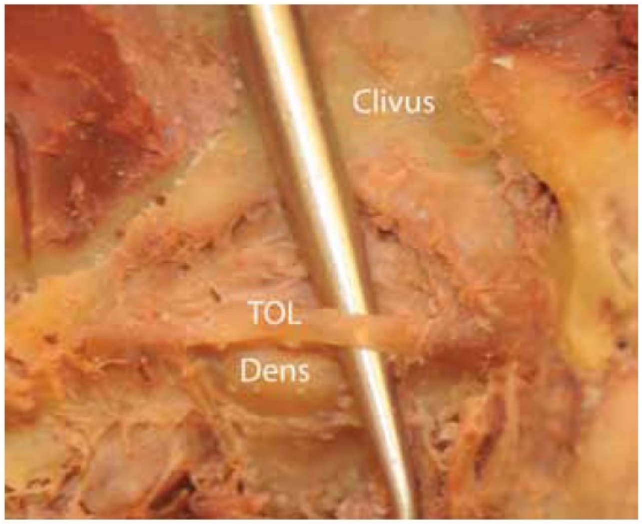

FIG. 3. Cadaveric dissection noting the transverse occipital ligament (TOL).

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Craniocervical junction ligaments

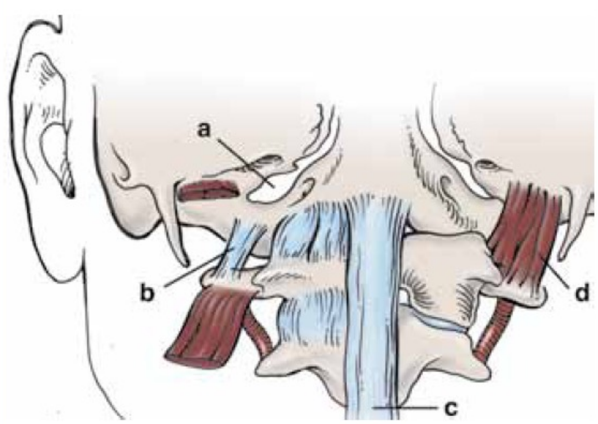

FIG. 4. Anterior drawing noting the jugular foramen **(a)** and its relationship to the lateral atlantooccipital ligament **(b)**. For reference, note the anterior longitudinal ligament **(c)** and the rectus capitis lateralis **(d)**.

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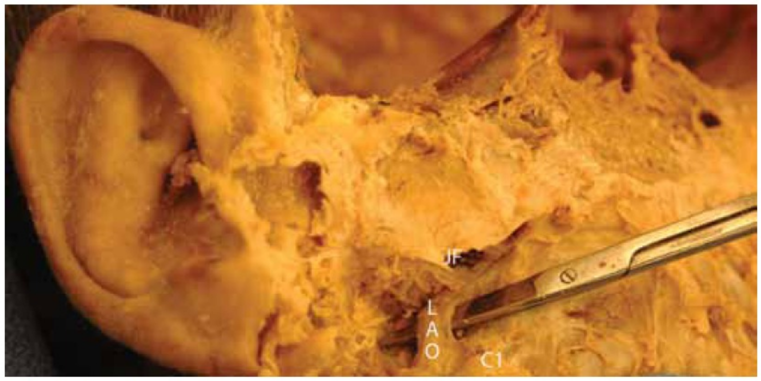

FIG. 5. Cadaveric dissection noting the right lateral atlantooccipital (LAO) ligament. Note the jugular foramen (JF) and atlas (C1).

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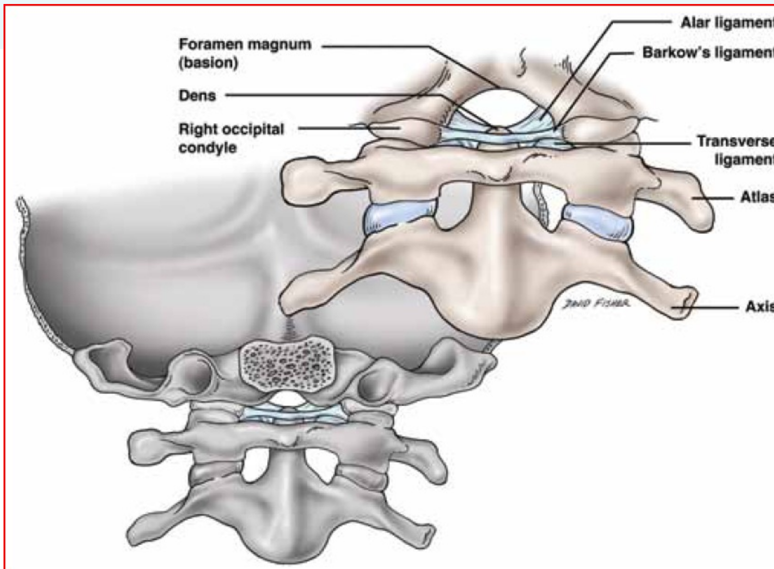

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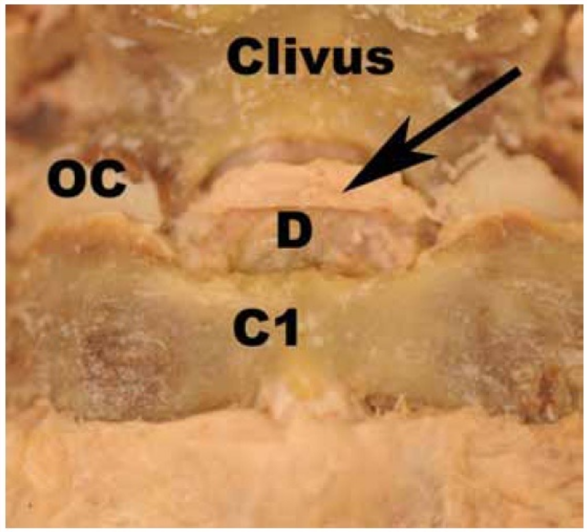

FIG. 7. Cadaveric dissection noting the Barkow ligament *(arrow)*. For reference, note the right occipital condyle (OC) and dens (D).

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Clinical Anatomy – MRI of Injured Ligaments

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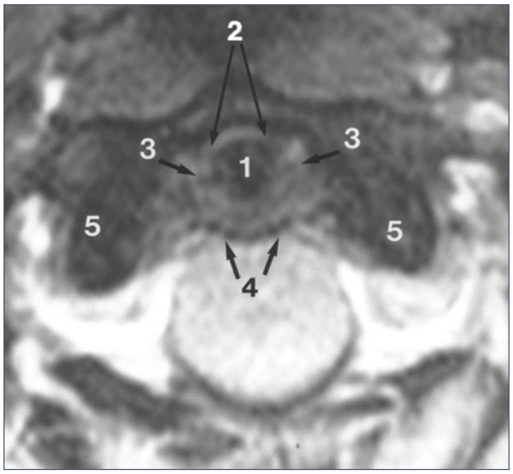

Dens (1), presumed anterior atlantodental ligaments (2), alar ligaments (3), transverse ligament (4), and lateral masses of C1 (5).

MR Imaging Findings in Spinal Ligamentous Injury Benedetti et al. *AJR 2000; 175:661-665*

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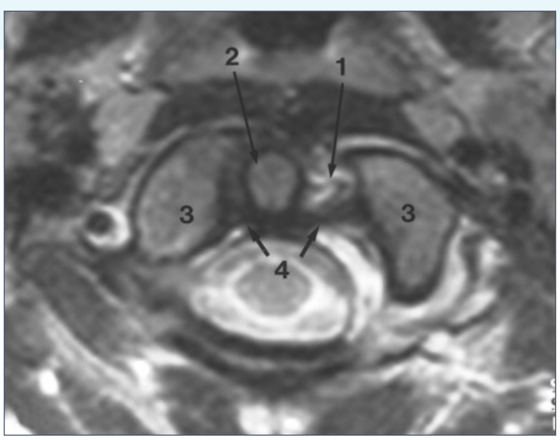

MR Imaging Findings in Spinal Ligamentous Injury Benedetti et al. *AJR 2000; 175:661-665*

Left alar ligament tear in 19-year-old woman with severe neck pain after fall on her head while snowboarding. Fixed deviation of dens to right was seen on radiograph (not shown):

- C1-2 rotatory subluxation was suspected.
- Isolated tear of left alar ligament (1) and deviation of dens (2) toward right with respect to lateral masses of C2 (3).
- Transverse ligament (4) is intact.

Sagittal images (not shown) depict normal alignment of occipital condyles with C2, thus no rotatory subluxation is present.

CT performed before MR imaging was negative for fracture and fixed rotatory subluxation.

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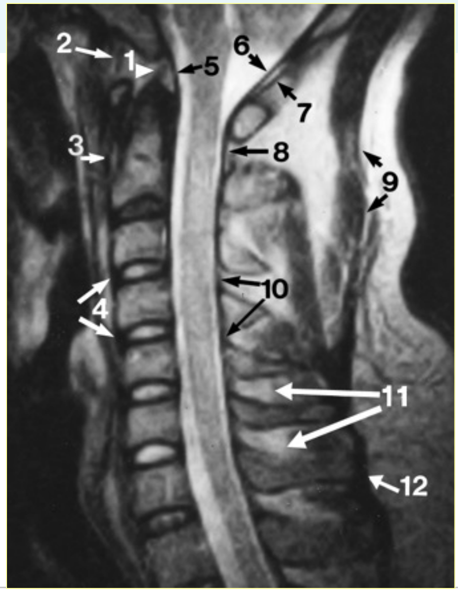

Normal apical ligament (1), anterior occipitoatlantal membrane (2), anterior atlantoaxial membrane (3), anterior longitudinal ligament (4), tectorial membrane (5), dural reflection (6), posterior occipitoatlantal membrane (7), posterior atlantoaxial membrane (8), nuchal ligament (9), flaval ligaments (10), area of interspinous ligaments (11), and supraspinous ligament (12).

MR Imaging Findings in Spinal Ligamentous Injury
Benedetti et al. *AJR 2000; 175:661-665*

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Occipitoatlantal dislocation in 11-year-old boy who was neurologically intact after motor vehicle crash. Intact (1) and torn (2) portions of anterior occipitoatlantal membrane, anterior arch of C1 (3), intact anterior atlantoaxial membrane (4), prevertebral edema or hemorrhage (5), torn tectorial membrane (6), torn posterior occipitoatlantal membrane (7), torn posterior atlantoaxial membrane (8), intact dural reflection (9), and intact nuchal ligament (10). Before MR imaging, full extent of injury and degree of instability were not appreciated either clinically or from results of radiographs or CT scans. Patient underwent surgical fusion shortly thereafter.

MR Imaging Findings in Spinal Ligamentous Injury
Benedetti et al. *AJR 2000; 175:661-665*

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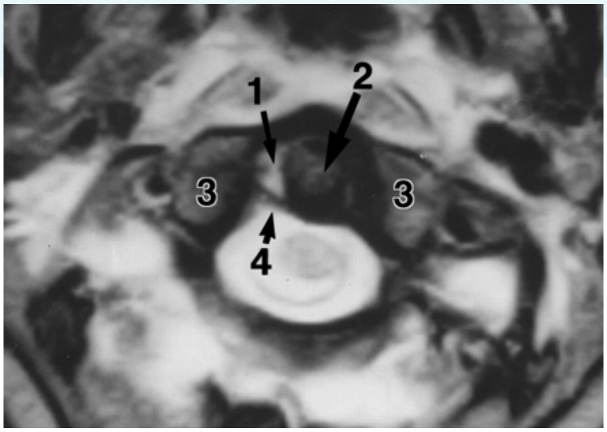

Occipitoatlantal dislocation in 11-year-old boy who was neurologically intact after motor vehicle crash. Torn right alar ligament (1), displacement of dens (2) to left with respect to lateral masses of C2 (3), and intact transverse ligament (4).

MR Imaging Findings in Spinal Ligamentous Injury
Benedetti et al. *AJR 2000; 175:661-665*

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Teardrop fracture of C7 in 27-year-old man involved in motor vehicle crash. Extensive posterior paravertebral edema or hemorrhage and probable tearing of interspinous ligaments (1), partial tear of nuchal ligament (2), flaval ligament tear (3), partial tear of posterior longitudinal ligament (4), anterior superior corner fracture of C7 vertebral body (5), stripping of anterior longitudinal ligament from anterior surface of C7 vertebral body (6), and prevertebral edema or hemorrhage (7).

MR Imaging Findings in Spinal Ligamentous Injury
Benedetti et al. *AJR 2000; 175:661-665*

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Instructive Case…

A 30 year old female was involved in a MVC. Despite 6-months of chiropractic care, she reports persistent symptoms.

The MRI was interpreted as normal.

What do you see that refutes that reading?

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Magnetic Resonance Imaging Assessment of Craniovertebral Ligaments and Membranes After Whiplash Trauma

Krakenes, Jostein MD, PhD*; Kaale, Bertel R. MT *Spine*. Volume 31(24), 15 November 2006, pp 2820-2826

- By use of high-resolution MRI, it is possible to assess ligaments and membranes in the craniovertebral junction with reasonable reliability.
- Significantly more high-grade lesions in a whiplash injured than in a noninjured population.
- There is association between high-grade changes in the alar ligaments and clinical impairment.
- There is association between specific lesions and specific trauma mechanisms.

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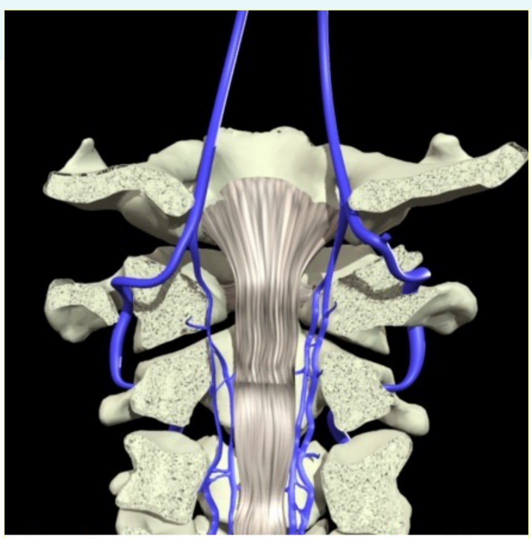

Interactive Spine - Chiropractic edition © 2001 Primal Pictures Ltd

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A, Normal anatomy. The tectorial membrane (arrows) is fused with the dura mater and extends from the C2 body to the clivus. The posterior atlanto-occipital membrane (arrowheads), also fused with the dura mater, extends from the posterior arch of the atlas to the occipital bone.
From: **Krakenes: Spine, Volume 31(24).November 15, 2006. 2820-2826**

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B, A 40-year-old woman sustaining frontal collision 4 years previously. Upper part of the tectorial membrane (arrows) is absent; only the dura is shown.
From: **Krakenes: Spine, Volume 31(24).November 15, 2006. 2820-2826**

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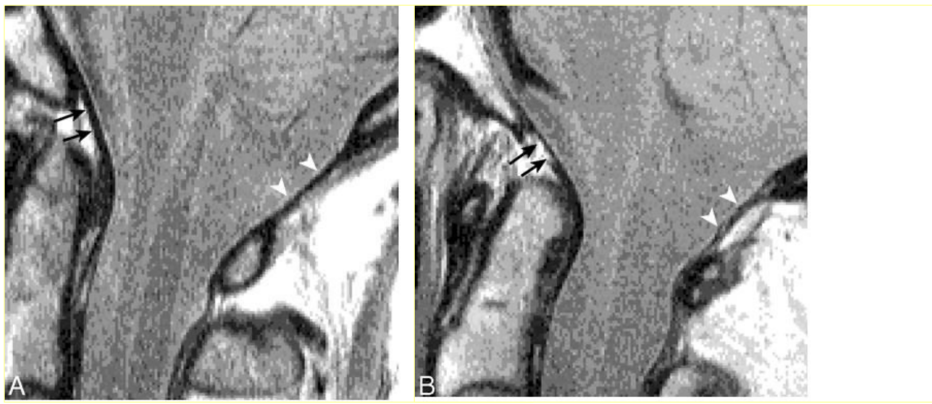

From: **Krakenes: Spine, Volume 31(24).November 15, 2006. 2820-2826**

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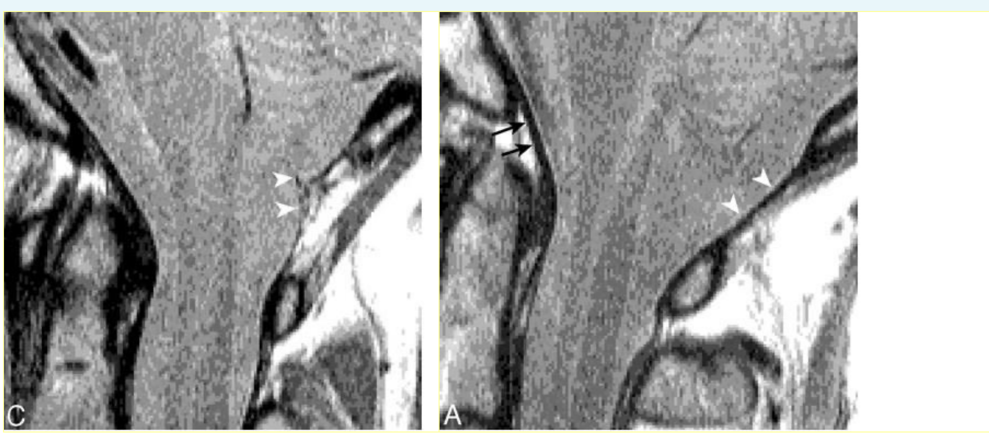

C, A 46-year-old woman sustaining rear-end collision 11 years previously. The flap combined with thinning of the atlanto-occipital membrane/dura complex was classified as Grade 3 (arrowheads).

From: **Krakenes: Spine, Volume 31(24).November 15, 2006. 2820-2826**

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Table 2. Grading Criteria for the Tectorial and the Posterior Atlanto-Occipital Membranes

Grade	Criteria
Tectorial membrane	
0	A membrane/dura complex thicker than the dura alone in all sagittal sections
1	Only the dura seen in one third or less of transverse width
2	Only the dura seen in one third to two thirds of transverse width
3	Only the dura seen in two thirds or more of transverse width
Posterior atlanto-occipital membrane	
0	Smooth and well-defined membrane/dura complex
1	A dural hump traversing the membrane/dura complex
2	A tent-shaped dural ridge traversing the membrane/dura complex
3	A dural flap traversing the membrane/dura complex

From: **Krakenes: Spine, Volume 31(24).November 15, 2006. 2820-2826**

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Acta Neurochirurgica
July 2012, Volume 154, Issue 7, pp 1229-1234

The denticulate ligament: anatomical properties, functional and clinical significance

Davut Ceylan, Necati Tatarlı, Tuychiboy Abdullaev, Aşkın Şeker, Sercan D. Yıldız, Evren Keleş, Deniz Konya, Yaşar Bayri, Türker Kılıç, Safiye Çavdar

- The main findings were:
  - (1) each DL is composed of a single narrow fibrous strip that extends from the craniovertebral junction to T12, and each also features 18–20 triangular extensions that attach to the dura at their apices;
  - (2) the triangular extensions are smaller and more numerous at the cervical levels, and are larger and less numerous at the thoracic levels;
  - (3) the apices of the extensions attach to the dura via fibrous bands at cervical levels (each band 3-5 mm long) and lower thoracic levels (21-26 mm long), whereas they attach directly to the dura at upper thoracic levels;
  - (4) the narrow fibrous strip of the DL features longitudinally oriented collagen fibers, whereas the triangular extensions are composed of transverse and obliquely oriented collagen fibers. The collagen fibers are thicker and more abundant at the cervical than at the thoracic levels.

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Denticulate Ligaments

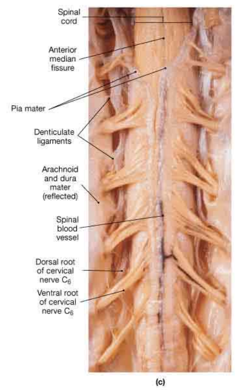

FIGURE 13-2 The Spinal Cord and Spinal Meninges. **(c)** Anterior view of the spinal cord and spinal nerve roots within the vertebral canal. The dura mater and arachnoid membrane have been cut and reflected; note the blood vessels in the delicate pia mater.

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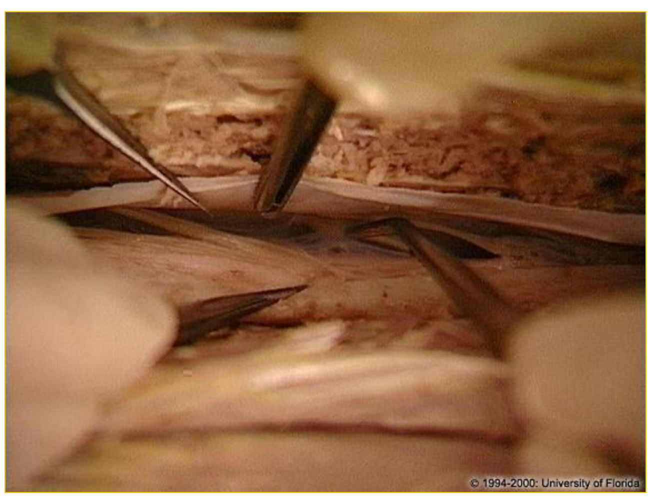
Denticulate Ligaments



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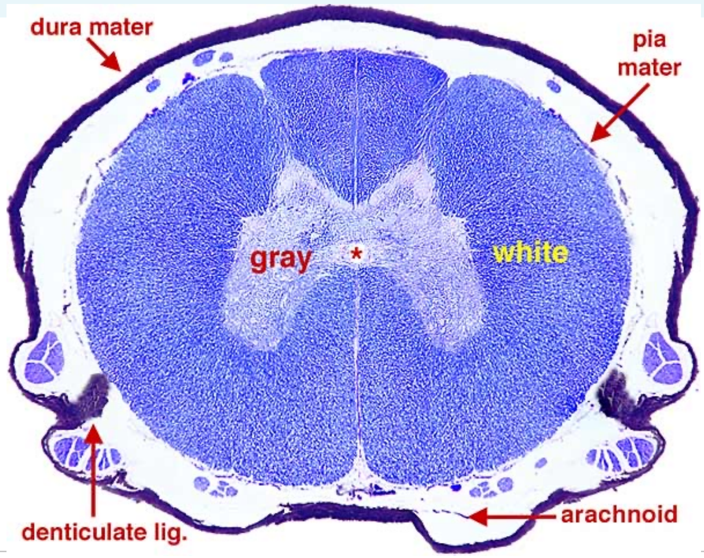

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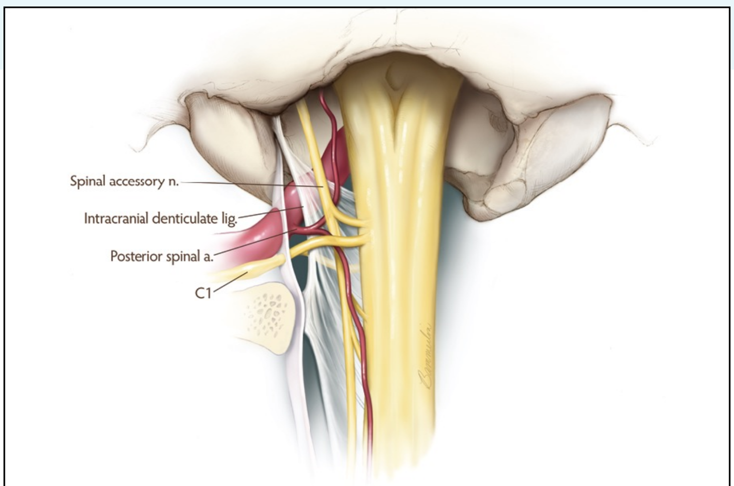

Fig. 1. Schematic drawing illustrating the relationships of the left intracranial denticulate ligament (lig). Note the relationship between the course of the vertebral artery and its branches and the spinal accessory nerve (n) and first cervical rootlets to this ligament. a = artery. Used with permission from Clarian Health.

J Neurosurg / Volume 114 / February 2011

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NMR Biomed. 2012 July ; 25(7): 891–899.

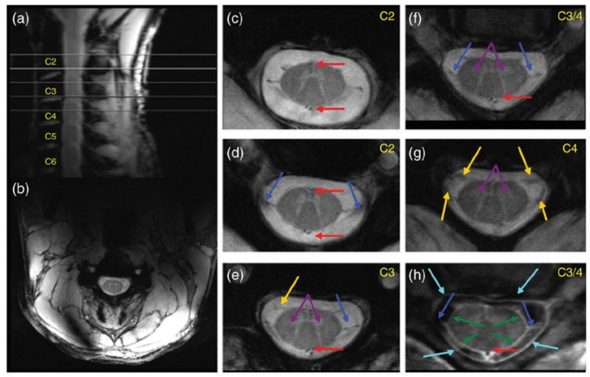

Figure 4.
Cervical spine T_2-weighted MRI at 7 T (four-channel array). (a) Sagittal localizer view showing slice and vertebra locations. (b) Full field of view axial gradient echo (GRE) image. Enlarged view of spinal cord area in GRE (c–g) and turbo spin echo (TSE) (h) sequences. Labeled structures: dorsal/ ventral nerve roots (yellow), gray matter anterior horn (purple), denticulate ligament (blue), dorsal/ventral blood vessels (red), dura mater (cyan), pia mater (green).

Clinical Anatomy – Chiropractic - Subluxations

Instructive Case…

Chiropractic & Osteopathy BioMed Central

Case report **Open Access**

Post-traumatic upper cervical subluxation visualized by MRI: a case report

James Demetrious[1,2]

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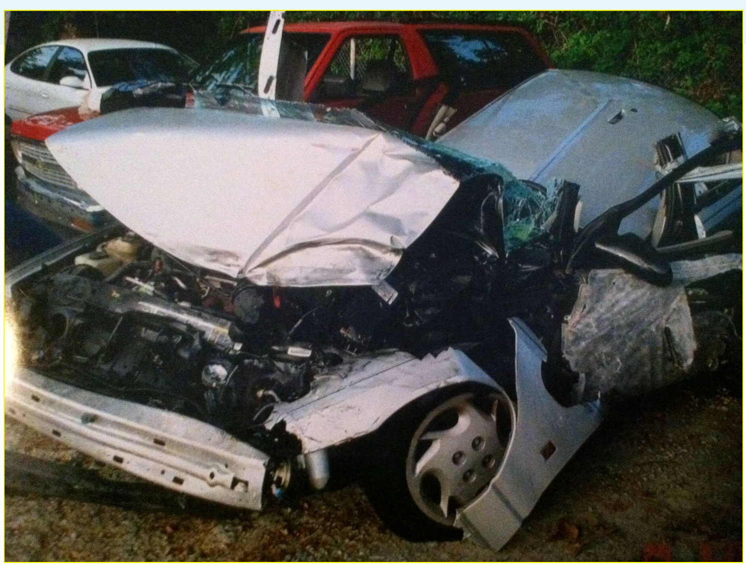
This article is available from: http://www.chiroandosteo.com/content/15/1/20

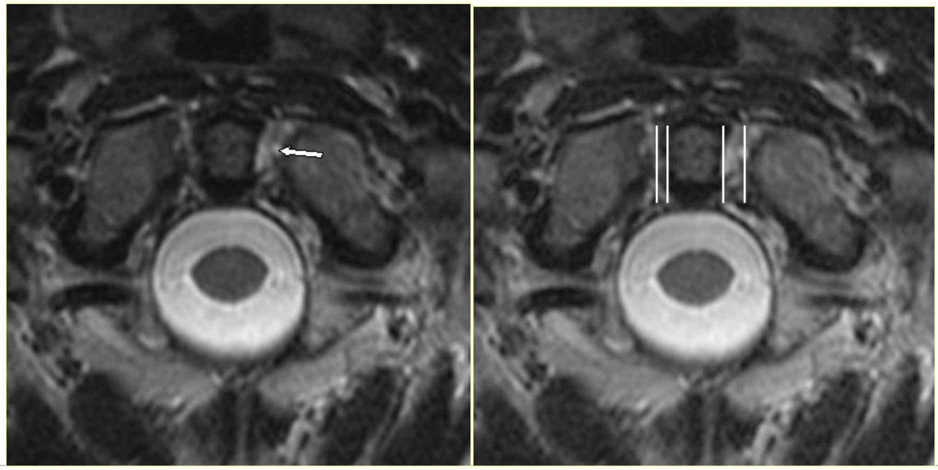


Case report

Open Access

Post-traumatic upper cervical subluxation visualized by MRI: a case report

James Demetrious[1,2]



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John Grostic, DC, FICR

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Volume 1 • Number 1 • Spring 1988
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DENTATE LIGAMENT — CORD DISTORTION HYPOTHESIS

by John D. Grostic, D.C., F.I.C.R.

DENTATE LIGAMENT - CORD DISTORTION HYPOTHESIS

By John D. Grostic, D.C., F.I.C.R.
Director of Research
Sid E. Williams Research Center
Life Chiropractic College

ABSTRACT

The mechanism of nerve irritation resulting from upper cervical misalignments has usually involved either the nerve compression hypothesis or the proprioceptive insult hypothesis. Because of the diameter of the canal and the space between the cord and the wall of the canal, compression of the cord at the upper cervical area would require much larger displacements than are encountered in typical patients.

The proprioceptive insult hypothesis does not adequately explain the sensory phenomena experienced by some upper cervical patients and is cumbersome to use in explaining the mechanism behind an upper cervical subluxation causing sciatica.

- First -

IS THE DENTATE LIGAMENT MECHANICALLY LINKED TO THE OSSEOUS STRUCTURES OF THE UPPER CERVICAL SPINE?

- Second -

IS THE DENTATE LIGAMENT STRONG ENOUGH TO DEFORM THE SPINAL CORD?

- Third -

ARE THE OSSEOUS MISALIGNMENTS LARGE ENOUGH TO CAUSE MECHANICAL IRRITATION TO THE CORD?

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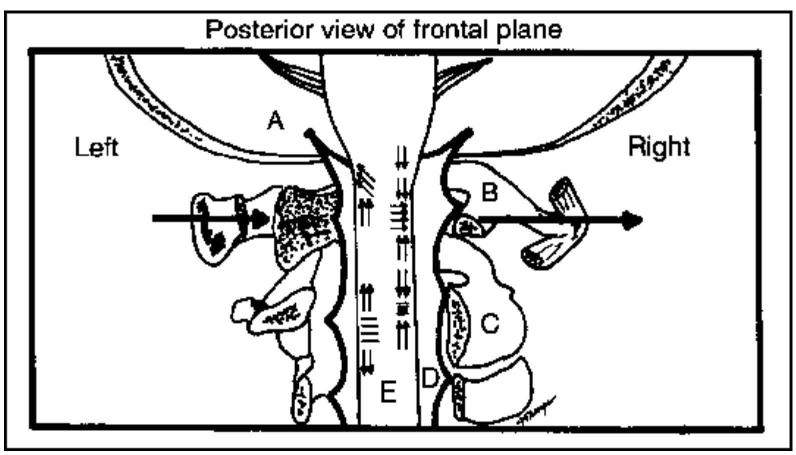
- The significance of Grostic's findings is that any subluxation of the atlas, by virtue of dural attachment, could transfer the forces of eccentric motion into the cord via the stronger cervical denticulate ligaments.



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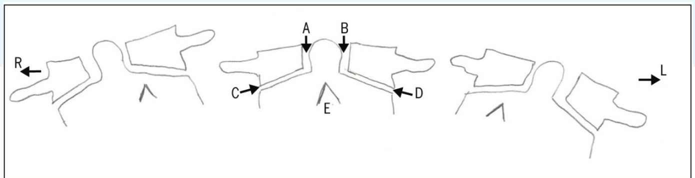

FIGURE 3. Normal. The CCJ is coupled with rotation. In neutral (the center figure), during neutral the C2 spinous process (E) is in midline and the spaces between the dens and the lateral masses (A and B) are symmetrical. During lateral flexion, counterrotation of the C2 spinous process occurs due to the posterior insertion of the alar ligaments on the odontoid and occiput and the symmetry of the lateral masses (C and D) over the body of C2 is maintained. Compare to actual radiographic images in **FIGURES 5** and **7**.

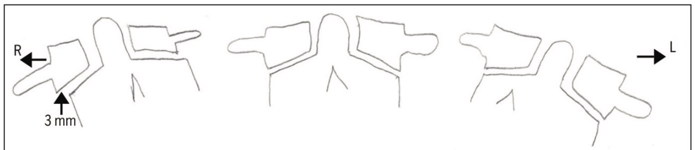

FIGURE 4. Abnormal lateral flexion mechanics of the CCJ. The normal biomechanics are disrupted. In this example, during right lateral flexion, there is no counterrotation of the C2 spinous process, and note the right translation of the right lateral mass over the body of C2, due to the failure of the left alar ligament. Compare to radiographic image in **FIGURE 6**.

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Hariharan *et al. Chiropractic & Manual Therapies* (2020) 28:32 Page 4 of 9

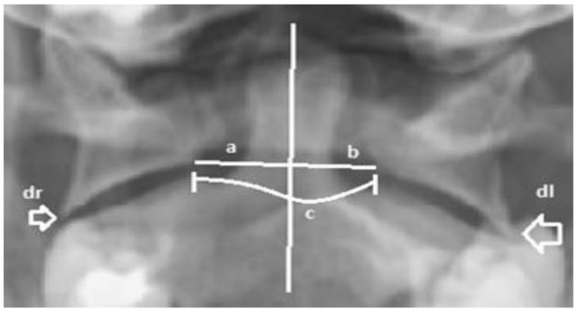

Fig. 2 Open Mouth Lateral bending cervical spine radiographs with measures recorded. **a** midline of Dens to right lateral mass; **b** midline of Dens to left lateral mass; **c** width between lateral mass; dr: Right lateral mass step-off; dl: left lateral mass step-off

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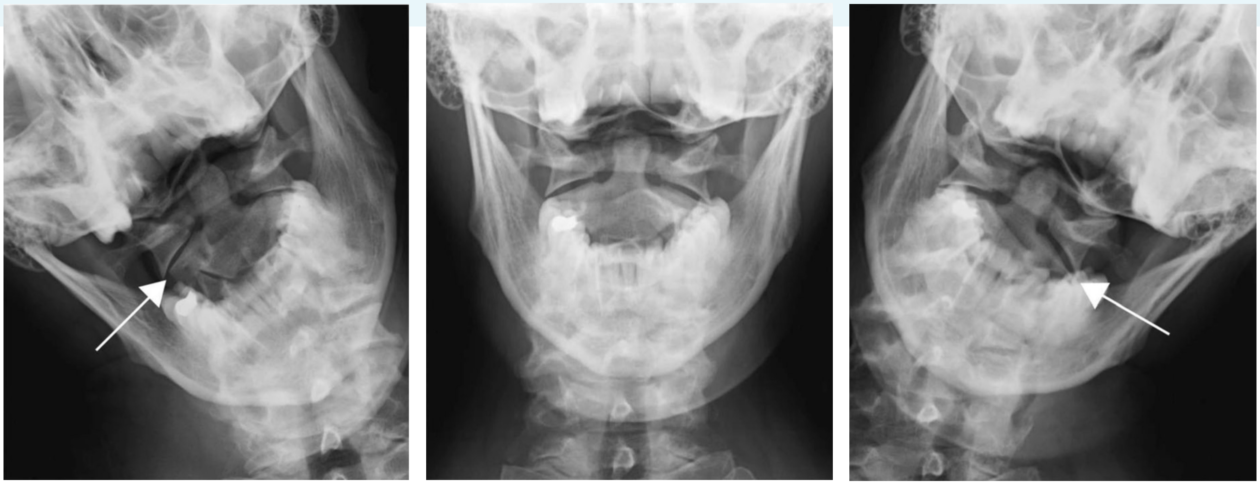

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Class Outline

- Guidelines and useful resources
- Epidemiology of IVD/Stenosis
- Cases for Consideration
- Prevalence in the Asymptomatic Population
- IVD Anatomy/Physiology
- Causative Factors
- Imaging Insight
- IVD Herniation
- Dynamic stenosis
- Cervical Degenerative Myelopathy
- Tandem Spinal Stenosis
- CES
- Chiropractic Care
- Iatragenic Nightmares

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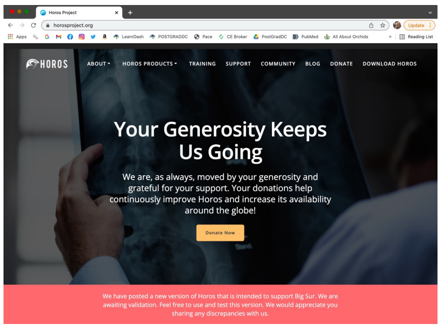
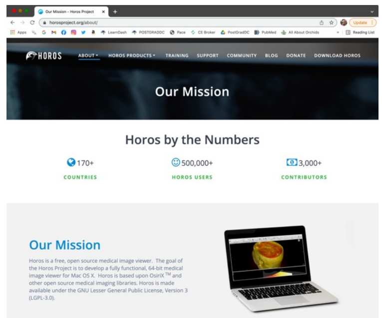
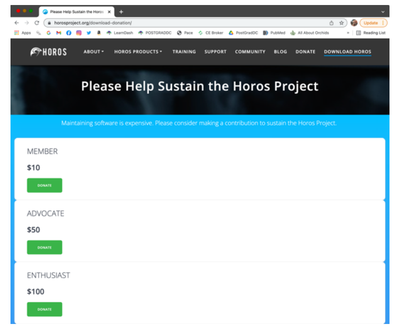
Tools – Horos DICOM Viewer







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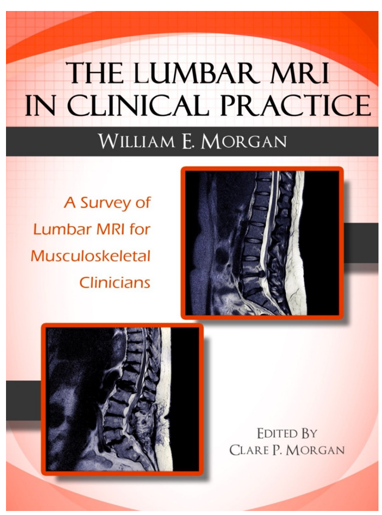
Mandatory Reading



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Some Cases to Consider

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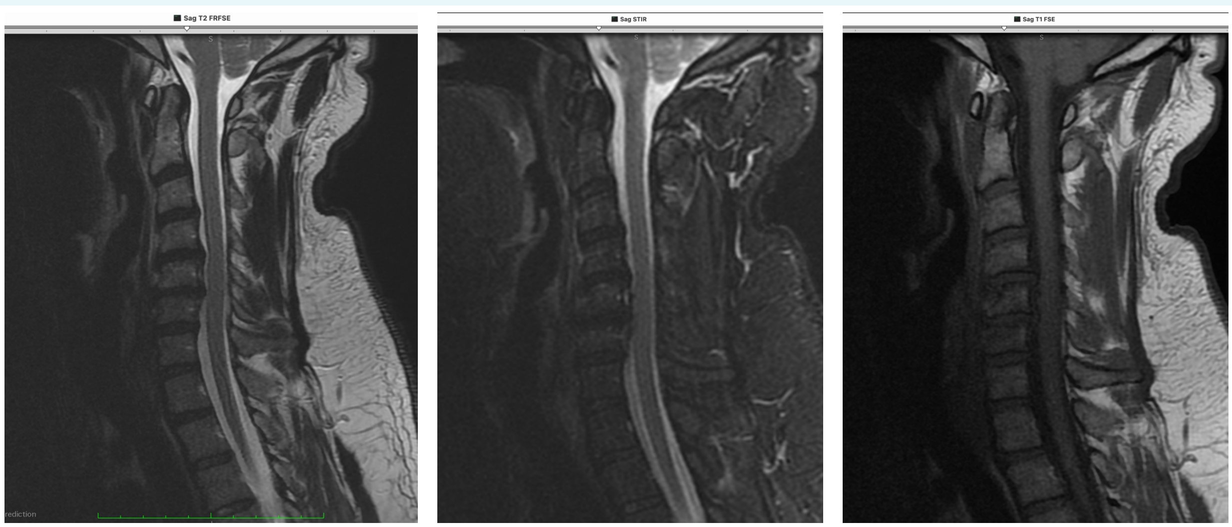
Instructive Case: 35-year-old male, right radiculopathy…



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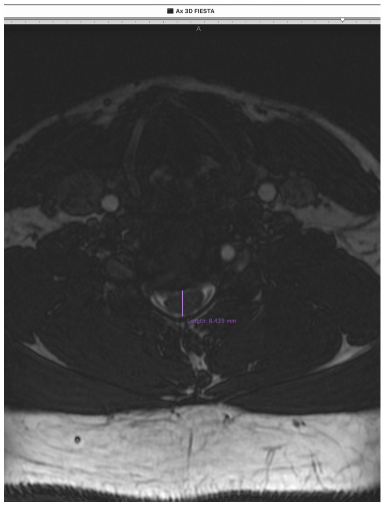
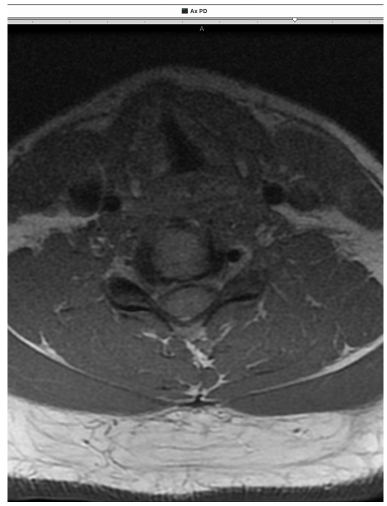
Instructive Case: 35-year-old male, right radiculopathy…





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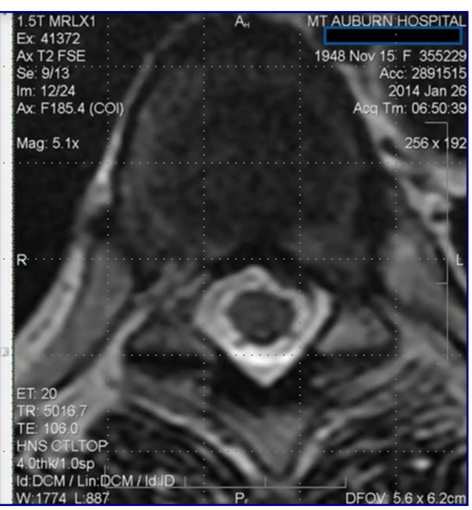
Instructive Case: 70 year old female…



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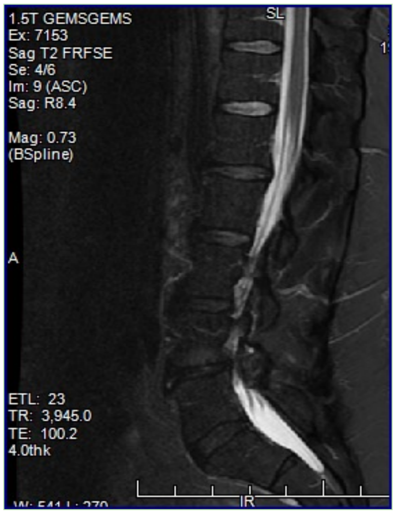
Instructive Case: 50-year old fireman…



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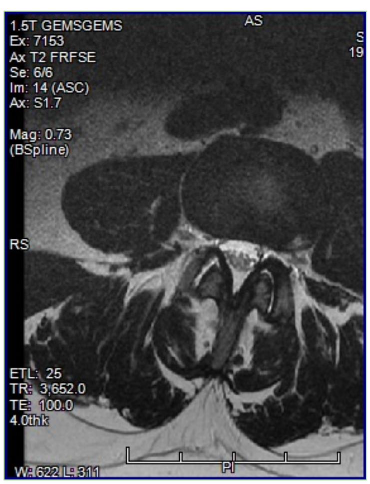
Instructive Case: 50-year old fireman…



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Prevalence in the Asymptomatic Population

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The New England
Journal of Medicine

Volume 331 | JULY 14, 1994 | Number 2

MAGNETIC RESONANCE IMAGING OF THE LUMBAR SPINE
IN PEOPLE WITHOUT BACK PAIN

Maureen C. Jensen, M.D., Michael N. Brant-Zawadzki, M.D., Nancy Obuchowski, Ph.D.,
Michael T. Modic, M.D., Dennis Malkasian, M.D., Ph.D., and Jeffrey S. Ross, M.D.

- 36% of 98 asymptomatic subjects had normal discs at all levels.
- 52% of the subjects have a bulge at at least one level.
- 27% had a protrusion.
- 1% had an extrusion.
- 38% had one abnormality at more than one intervertebral disc.

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Spine
SPINE Volume 40, Number 6, pp 392-398

DIAGNOSTICS

Abnormal Findings on Magnetic Resonance Images of the Cervical Spines in 1211 Asymptomatic Subjects

Hiroaki Nakashima, MD,* Yasutsugu Yukawa, MD,† Kota Suda, MD,‡ Masatsune Yamagata, MD,§ Takayoshi Ueta, MD,¶ and Fumihiko Kato, MD†

Study Design. Cross-sectional study.
Objective. The purpose of this study was to determine the prevalence and distribution of abnormal findings on cervical spine magnetic resonance image (MRI).
Summary of Background Data. Neurological symptoms and abnormal findings on MR images are keys to diagnose the spinal diseases. To determine the significance of MRI abnormalities, we must take into account the (1) frequency and (2) spectrum of structural abnormalities, which may be asymptomatic. However, no large-scale study has documented abnormal findings of the cervical spine on MR image in asymptomatic subjects.
Methods. MR images were analyzed for the anteroposterior spinal cord diameter, disc bulging diameter, and axial cross-sectional area of the spinal cord in 1211 healthy volunteers. The age of healthy volunteers prospectively enrolled in this study ranged from 20 to 70 years, with approximately 100 individuals per decade, per sex. These data were used to determine the spectrum and degree of disc bulging, spinal cord compression (SCC), and increased signal intensity changes in the spinal cord.
Results. Most subjects presented with disc bulging (87.6%), which significantly increased with age in terms of frequency, severity, and number of levels. Even most subjects in their 20s had bulging discs, with 73.3% and 78.0% of males and females, respectively. In contrast, few asymptomatic subjects were diagnosed with SCC (5.3%) or increased signal intensity (2.3%). These numbers increased with age, particularly after age 50 years. SCC mainly involved 1 level (58%) or 2 levels (38%), and predominantly occurred at C5–C6 (41%) and C6–C7 (27%).
Conclusion. Disc bulging was frequently observed in asymptomatic subjects, even including those in their 20s. The number of patients with minor disc bulging increased from age 20 to 50 years. In contrast, the frequency of SCC and increased signal intensity increased after age 50 years, and this was accompanied by increased severity of disc bulging.
Key words: magnetic resonance image (MRI), abnormal findings, asymptomatic, cervical, disc degeneration, disc bulging, spinal cord compression, increased signal intensity, cervical myelopathy, aging, cross-sectional study.
Level of Evidence: 2
Spine 2015;40:392–398

Magnetic resonance image (MRI) is a useful tool for

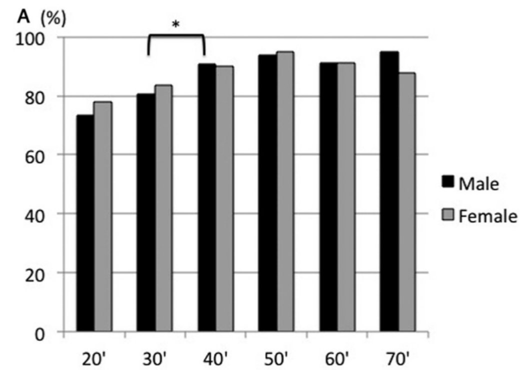

Figure 2. Frequency distribution of disc bulging in asymptomatic subjects. A, Frequency distribution of disc bulging with age and sex. B, Frequency distribution of the number of levels involved in disc bulging. C, Impact of age and sex on disc displacement (mm). Values are mean + SD. *$P < 0.05$, †$P < 0.001$. SD indicates standard deviation.

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DIAGNOSTICS

Abnormal Findings on Magnetic Resonance Images of the Cervical Spines in 1211 Asymptomatic Subjects

Hiroaki Nakashima, MD,* Yasutsugu Yukawa, MD,† Kota Suda, MD,‡ Masatsune Yamagata, MD,§ Takayoshi Ueta, MD,¶ and Fumihiko Kato, MD†

Figure 4. Spine magnetic resonance imaging T2-weighted sagittal image of a 77-year-old asymptomatic male. There is fusion of the C5 and C6 vertebrae, and local kyphosis at C4–C6. Spinal cord compression detected at C4–C5 and C5–C6, with high-signal intensity change at C5–C6.

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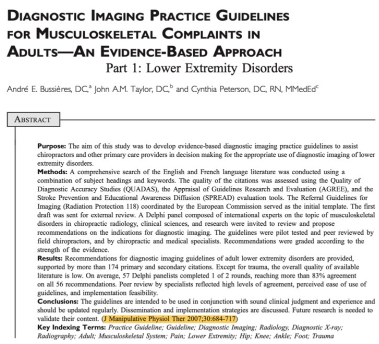
Guidelines and Standards of Care



Diagnostic Imaging Practice Guidelines for Musculoskeletal Complaints in Adults—An Evidence-Based Approach
Part 1: Lower Extremity Disorders

André E. Bussières, DC,[a] John A.M. Taylor, DC,[b] and Cynthia Peterson, DC, RN, MMedEd[c]

Abstract

Purpose: The aim of this study was to develop evidence-based diagnostic imaging practice guidelines to assist chiropractors and other primary care providers in decision making for the appropriate use of diagnostic imaging of lower extremity disorders.
Methods: A comprehensive search of the English and French language literature was conducted using a combination of subject headings and keywords. The quality of the citations was assessed using the Quality of Diagnostic Accuracy Studies (QUADAS), the Appraisal of Guidelines Research and Evaluation (AGREE), and the Stroke Prevention and Educational Awareness Diffusion (SPREAD) evaluation tools. The Referral Guidelines for Imaging (Radiation Protection 118) coordinated by the European Commission served as the initial template. The first draft was sent for external review. A Delphi panel composed of international experts on the topic of musculoskeletal disorders in chiropractic radiology, clinical sciences, and research were invited to review and propose recommendations on the indications for diagnostic imaging. The guidelines were pilot tested and peer reviewed by field chiropractors, and by chiropractic and medical specialists. Recommendations were graded according to the strength of the evidence.
Results: Recommendations for diagnostic imaging guidelines of adult lower extremity disorders are provided, supported by more than 174 primary and secondary citations. Except for trauma, the overall quality of available literature is low. On average, 57 Delphi panelists completed 1 of 2 rounds, reaching more than 83% agreement on all 56 recommendations. Peer review by specialists reflected high levels of agreement, perceived ease of use of guidelines, and implementation feasibility.
Conclusions: The guidelines are intended to be used in conjunction with sound clinical judgment and experience and should be updated regularly. Dissemination and implementation strategies are discussed. Future research is needed to validate their content. (J Manipulative Physiol Ther 2007;30:684-717)
Key Indexing Terms: *Practice Guideline; Guideline; Diagnostic Imaging; Radiology, Diagnostic X-ray; Radiography; Adult; Musculoskeletal System; Pain; Lower Extremity; Hip; Knee; Ankle; Foot; Trauma*

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ACR Appropriateness Criteria®

- These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment.
- Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments.
- The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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American College of Radiology
ACR Appropriateness Criteria®
Myelopathy

Variant 1: **Acute onset myelopathy. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
CT myelography spine area of interest	May Be Appropriate	Varies
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies
Arteriography spine area of interest	Usually Not Appropriate	Varies
Radiography spine area of interest	Usually Not Appropriate	Varies
MRA spine area of interest with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without and with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without IV contrast	Usually Not Appropriate	O
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies
CTA spine area of interest with IV contrast	Usually Not Appropriate	Varies

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Variant 2: **Chronic or progressive myelopathy. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without and with IV contrast	Usually Appropriate	O
MRI spine area of interest without IV contrast	Usually Appropriate	O
CT myelography spine area of interest	May Be Appropriate	Varies
CT spine area of interest with IV contrast	May Be Appropriate	Varies
CT spine area of interest without IV contrast	May Be Appropriate	Varies
Arteriography spine area of interest	Usually Not Appropriate	Varies
Radiography spine area of interest	Usually Not Appropriate	Varies
MRA spine area of interest with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without and with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without IV contrast	Usually Not Appropriate	O
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies
CTA spine area of interest with IV contrast	Usually Not Appropriate	Varies

ACR Appropriateness Criteria® 1 Myelopathy

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Revised 2021

American College of Radiology
ACR Appropriateness Criteria®
Low Back Pain

Variant 1: **Acute low back pain with or without radiculopathy. No red flags. No prior management. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Not Appropriate	☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without and with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
CT lumbar spine without IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT myelography lumbar spine	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Variant 2: **Subacute or chronic low back pain with or without radiculopathy. No red flags. No prior management. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Not Appropriate	☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without and with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
CT lumbar spine without IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT myelography lumbar spine	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Variant 3: **Subacute or chronic low back pain with or without radiculopathy. Surgery or intervention candidate with persistent or progressive symptoms during or following 6 weeks of optimal medical management. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI lumbar spine without IV contrast	Usually Appropriate	O
Radiography lumbar spine	May Be Appropriate	☢☢☢
MRI lumbar spine without and with IV contrast	May Be Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	May Be Appropriate	☢☢☢
CT lumbar spine without IV contrast	May Be Appropriate	☢☢☢
CT myelography lumbar spine	May Be Appropriate	☢☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Table 1. Red Flags: Indications of a more complicated status include back pain/radiculopathy in the following settings (adapted from Bigos et al [8]).

Red Flag	Potential Underlying Condition as Cause of LBP
• History of cancer • Unexplained weight loss • Immunosuppression • Urinary infection • Intravenous drug use • Prolonged use of corticosteroids • Back pain not improved with conservative management	• Cancer or infection
• History of significant trauma • Minor fall or heavy lift in a potentially osteoporotic or elderly individual • Prolonged use of steroids	• Spinal fracture
• Acute onset of urinary retention or overflow incontinence • Loss of anal sphincter tone or fecal incontinence • Saddle anesthesia • Bilateral or progressive weakness in the lower limbs	• Cauda equina syndrome or other severe neurologic condition

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Variant 4: **Low back pain with suspected cauda equina syndrome. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI lumbar spine without and with IV contrast	Usually Appropriate	O
MRI lumbar spine without IV contrast	Usually Appropriate	O
CT lumbar spine without IV contrast	May Be Appropriate	☢☢☢
CT myelography lumbar spine	May Be Appropriate	☢☢☢☢
Radiography lumbar spine	Usually Not Appropriate	☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Variant 5: **Low back pain with history of prior lumbar surgery and with or without radiculopathy. New or progressing symptoms or clinical findings. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Appropriate	☢☢☢
MRI lumbar spine without and with IV contrast	Usually Appropriate	O
MRI lumbar spine without IV contrast	Usually Appropriate	O
CT lumbar spine without IV contrast	May Be Appropriate	☢☢☢
CT myelography lumbar spine	May Be Appropriate	☢☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Variant 6: **Low back pain with or without radiculopathy. One or more of the following: low-velocity trauma, osteoporosis, elderly individual, or chronic steroid use. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Appropriate	☢☢☢
MRI lumbar spine without IV contrast	Usually Appropriate	O
CT lumbar spine without IV contrast	Usually Appropriate	☢☢☢
MRI lumbar spine without and with IV contrast	May Be Appropriate	O
CT myelography lumbar spine	May Be Appropriate	☢☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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Variant 7: **Low back pain with or without radiculopathy. One or more of the following: suspicion of cancer, infection, or immunosuppression. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI lumbar spine without and with IV contrast	Usually Appropriate	O
MRI lumbar spine without IV contrast	Usually Appropriate	O
Radiography lumbar spine	May Be Appropriate (Disagreement)	☢☢☢
CT lumbar spine with IV contrast	May Be Appropriate	☢☢☢
CT lumbar spine without IV contrast	May Be Appropriate	☢☢☢
CT myelography lumbar spine	May Be Appropriate	☢☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

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IVD Anatomy and Physiology

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THE JOURNAL OF BONE & JOINT SURGERY

JB&JS

This is an enhanced PDF from The Journal of Bone and Joint Surgery

The PDF of the article you requested follows this cover page.

Histology and Pathology of the Human Intervertebral Disc

Sally Roberts, Helena Evans, Jayesh Trivedi and Janis Menage
J Bone Joint Surg Am. 88:10-14, 2006. doi:10.2106/JBJS.F.00019

- Hyaline endplate at adulthood – 90% of disc body interface at .6 mm thick
- Large amounts of extracellular matrix with small amount of cells
- Various glycoaminoglycans and collagen types located in preferential regions.
- AF and cartilage elongated and fibroblast like.
- NP cells oval and chondrocyte like.
- Cells often have long thin cell processes that may be involved in sensing mechanical strain
- AF – 15-25 lamellae
- Nerves and blood vessels limited degree in adults, restricted to outer few mm. of AF.
- Small number of mechanoreceptors GTO, Ruffini receptors and pacinian corpuscles.
- Elastin localized between layers of lamellae with a few fibers crossing perpendicularly

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Pathomechanism and Biomechanics of Degenerative Disc Disease: Features of Healthy and Degenerated Discs

Sertac Kirnaz, Charisse Capadona, Marianne Lintz, Byumsu Kim, Rachel Yerden, Jacob L. Goldberg, Branden Medary, Fabian Sommer, Lynn B. McGrath, JR, Lawrence J. Bonassar and Roger Härtl

Int J Spine Surg 2021, 15 (s1) 10-25
doi: https://doi.org/10.14444/8052
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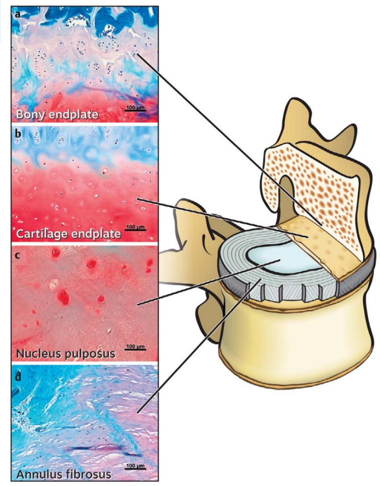

Figure 4. Histology images of human intervertebral disc. (a) and (b) Bony and cartilaginous endplates of a young healthy patient. The bony endplate is distinct and contains hypertrophic cartilage. (c) and (d) The nucleus pulpous (NP) and annulus fibrosus (AF). Histology stains were Safranin-O, fast green FCF, and Weigert's hematoxylin. Printed with permission from *Biological Approaches to Spinal Disc Repair and Regeneration for Clinicians.*[15]

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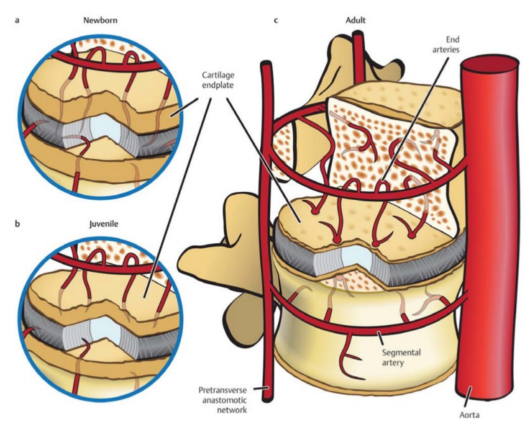

Figure 3. (a) Neonate's vertebral body and disc vascular network; blood supply can extend into the innermost regions of the annulus fibrosis (AF). (b) Vessels retract further from the disc to the outer region of the AF during adolescence. (c) Vessels are regressed further away from the AF and fix themselves within and surrounding the end plate and connective tissues in adult spines. Printed with permission from *Biological Approaches to Spinal Disc Repair and Regeneration for Clinicians.*[15]

IVD Nutrition

Nutrition of the Intervertebral Disc.
Spine. 29(23):2700-2709, December 1, 2004.
Urban, Jill P.G. PhD et al.

Results. Small nutrients such as oxygen and glucose are supplied to the disc's cells virtually entirely by diffusion; convective transport, arising from load-induced fluid movement in and out of the disc, has virtually no direct influence on transport of these nutrients. Consequently, there are steep concentration gradients of oxygen, glucose, and lactic acid across the disc; oxygen and glucose concentrations are lowest in the center of the nucleus where lactic acid concentrations are greatest. The actual levels of concentration depend on the balance between diffusive transport and cellular demand and can fall to critical levels if the endplate calcifies or nutritional demand increases.

Conclusions. Loss of nutrient supply can lead to cell death, loss of matrix production, and increase in matrix degradation and hence to disc degeneration.

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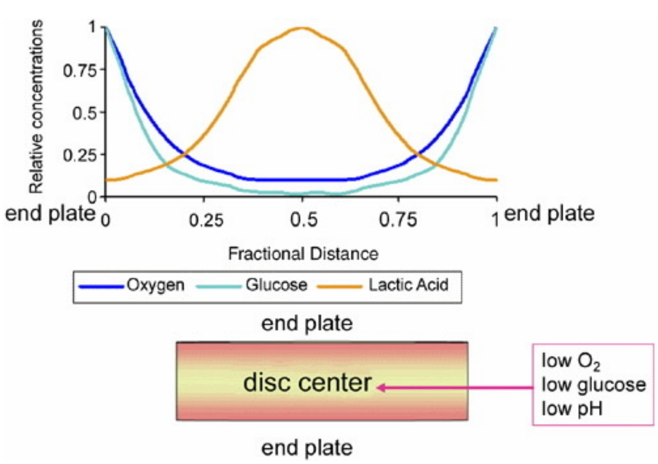
NUTRIENT SUPPLY AND INTERVERTEBRAL DISC METABOLISM

Grunhagen et al. JBJS. Volume 88 Supplement 2, April 2006, p 30–35.



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NUTRIENT SUPPLY AND INTERVERTEBRAL DISC METABOLISM

Grunhagen et al. JBJS. Volume 88 Supplement 2, April 2006, p 30–35.

- The capillaries are protected by a dense hyaline cartilage end plate that is lower in hydration than that of articular cartilage 30,31; it limits transport of large molecules into and out of the disc 32.
- In aging, degeneration, or disorders such as scoliosis, this end plate tends to calcify by unknown mechanisms; severe calcification acts as a barrier to nutrient transport and is thought to be a major factor in the development of disc degeneration 33.
- In scoliotic discs at least, cell death correlates with loss of nutrient supply and end-plate calcification 34,35.

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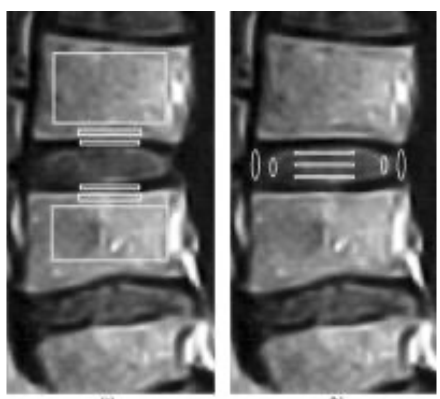
ISSLS Prize Winner: A Study of Diffusion in Human Lumbar Discs: A Serial Magnetic Resonance Imaging Study Documenting the Influence of the Endplate on Diffusion in Normal and Degenerate Discs.

Rajasekaran et al. Spine. 29(23):2654-2667, December 1, 2004.

Objectives. To document the temporal pattern of diffusion in normal human lumbar discs and to study the influence of the vascularity of bone and the status of endplate on diffusion in the normal and degenerate discs.

Methods. The diffusion pattern over 24 hours following gadodiamide injection was studied in 150 discs (96 normal and 54 degenerate). Signal intensity values for three regions of interest in bone (i.e., vertebral body, subchondral bone, and endplate zone) and seven in the disc were calculated, and normal percentiles of diffusion were derived for these regions.

Conclusions. Serial postcontrast magnetic resonance imaging studies offer a reliable method of assessing the diffusion of the discs and the functional status of the endplate cartilage. Endplate cartilage damage increases with age and produces considerable changes in diffusion. The present study has described reliable signs by which these damages can be identified in vivo. Aging and degeneration have been shown to be two separate processes by documenting clear-cut differences in diffusion.



(a) (b)

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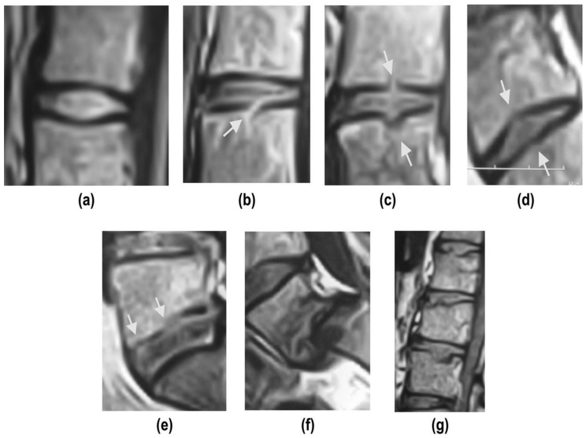
Various alterations in the MRI appearance of the Endplate zone.



The EPZ defect may be widespread centrally (**d**) and may extend to the periphery also (**e**). **e**, Disc of a L5-S1 sacralized segment. There are wide alterations in the superior EPZ, but the inferior EPZ is well maintained, probably protected because of lack of movements. In listhesis (**f**), the EPZ is sometimes lost completely. G, MRI of a 27-year-old untrained weight lifter with back pain showing EPZ change of different degrees in various levels. **e to g, The findings suggest that endplate damage is strongly influenced by movements and mechanical loading.**

From: Rajasekaran: Spine, Volume 29(23).December 1, 2004.2654-2667

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Causative Factors

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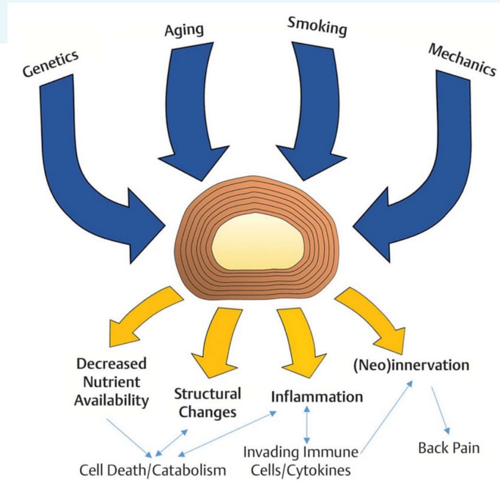

Figure 7. Degenerative disc disease (DDD) in a cascading multifactorial process involving the interaction of risk factors and pathophysiology. Printed with permission from *Biological Approaches to Spinal Disc Repair and Regeneration for Clinicians.*[186]

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Pathomechanism and Biomechanics of Degenerative Disc Disease: Features of Healthy and Degenerated Discs

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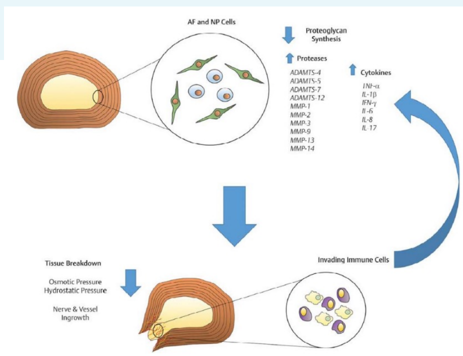

Figure 8. The physiological alterations to the disc are controlled directly by cells within the disc, which are caught in a closed degenerative cycle. These cells increase production of cytokines and proteases while decreasing production of proteoglycans, both of which are essential to the retaining the disc's height as well as maintaining the basic physical function of the intervertebral disc. The increase of proteases expedites the tissue degeneration process. The proteases also alter the extracellular environment, which incurs catabolic reaction and inflammation. This process results in the activation of nearby immune cells that exacerbates the inflammatory processes by continuing to increase cytokine production. The increase in cytokines enhances neovascularization and neoinnervation in the disc. Printed with permission from *Biological Approaches to Spinal Disc Repair and Regeneration for Clinicians.*[186]

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Rim Lesions

Acute Injuries to Cervical Joints. An Autopsy Study of Neck Sprain

Taylor JR, Twomey LT. *Spine* 1993

- 15/16 subjects who died of major trauma showed IVD endplate clefts or “Rim Lesions”
- MRI did not visualize all of these lesions.
- Suggested a source of pain.

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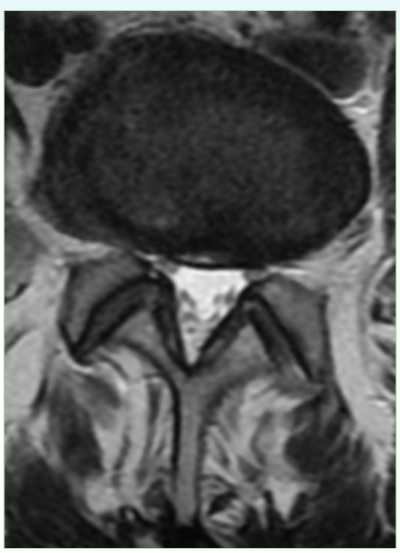

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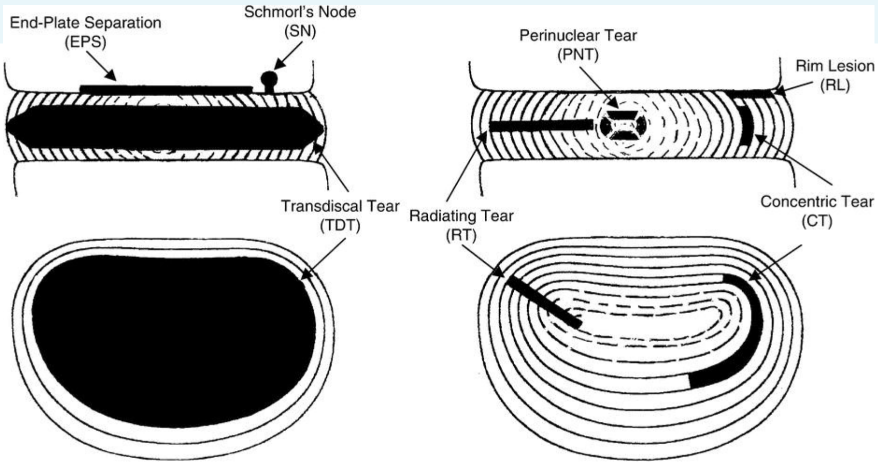

Perinuclear tears (PNT) and a radiating tear (RT).
Vernon Roberts: Spine, Volume 32(25).December 1, 2007.2797-2804

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Vernon Roberts: Spine, Volume 32(25).December 1, 2007.2797-2804

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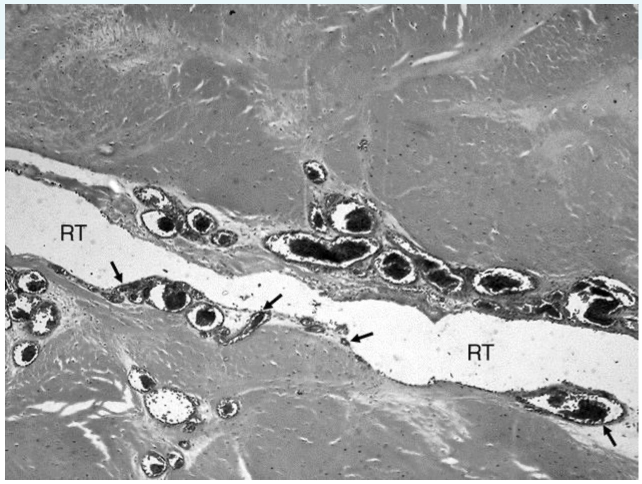

Neovascularization of a radiating tear (RT) in the L4–L5 disc showing that some vessels attached to the inner surface have walls composed only of a single layer of endothelial cells (arrows).

Vernon Roberts: Spine, Volume 32(25).December 1, 2007.2797-2804

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Possible Pathogenesis of Painful Intervertebral Disc Degeneration

Peng, Baogan MD, PhD et al. *Spine*, Volume 31(5), 1 March 2006, pp 560-56

To study the pathogenesis of disc degeneration, meanwhile discriminating between common disc degeneration and painful disc degeneration .

Results. The distinct histologic characteristic of the disc from the patient with discogenic low back pain was the ingrowth of vascularized granulation tissue along torn fissures, extending from the external layer of the anulus fibrosus into the nucleus pulposus.

Conclusions. The findings indicated that degeneration of the painful disc might originate from the injury and subsequent repair of anulus fibrosus. Growth factors, such as bFGF and TGF-[beta]1, macrophages and mast cells might play a key role in the repair of the injured anulus fibrosus and subsequent disc degeneration.

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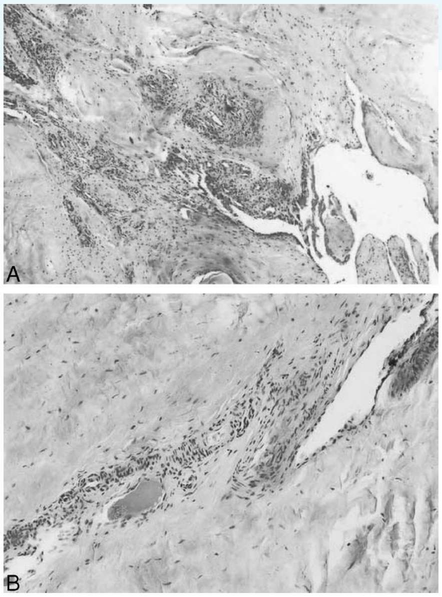

A, The ingrowth of vascularized granulation tissue into anulus along tear in painful disc.

B, A strip of granulation tissue and surrounding tissue in anulus showing fibrosis in surrounding tissue.

From: Peng: Spine, Volume 31(5).March 1, 2006.560-566

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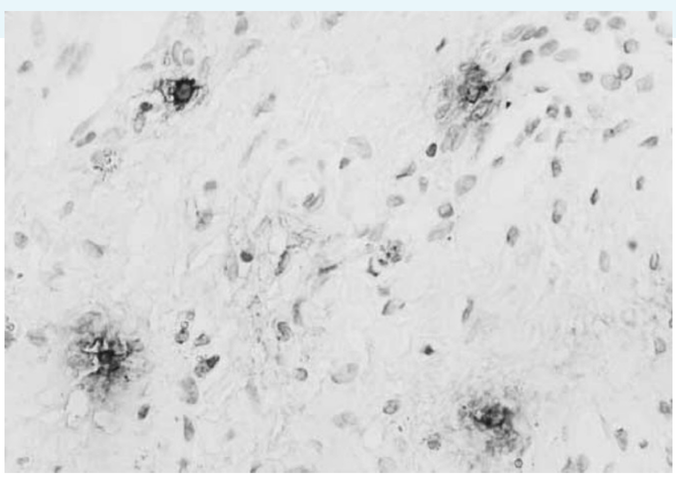

Mast cells in granulation tissue in painful disc.
From: Peng: Spine, Volume 31(5).March 1, 2006.560-566

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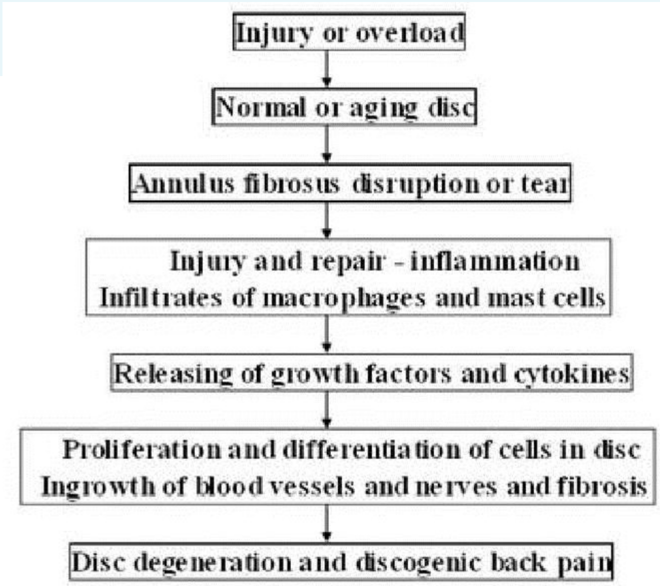

From: Peng: Spine, Volume 31(5).March 1, 2006.560-566

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What is Intervertebral Disc Degeneration, and What Causes It?
Adams et al. *Spine*. Volume 31(18), 15 August 2006, pp 2151-2161

- In adult discs, blood vessels are normally restricted to the outmost layers of the anulus. Metabolite transport is by diffusion, which is important for small molecules, and by bulk fluid flow, which is important for large molecules.
- Low oxygen tension in the center of a disc leads to anaerobic metabolism, resulting in a high concentration of lactic acid and low pH.
- *In vitro* experiments show that a chronic lack of oxygen causes nucleus cells to become quiescent, whereas a chronic lack of glucose can kill them.

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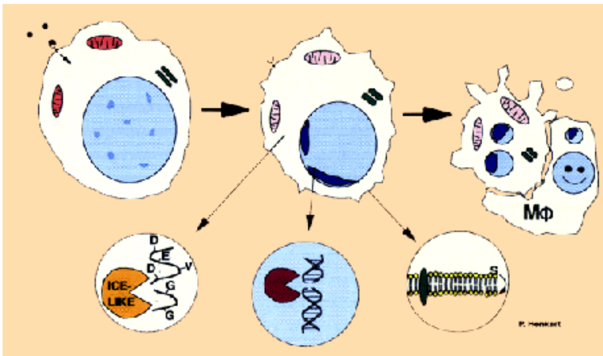
Apoptosis and Necrosis



- The term apoptosis was coined in a now-classic paper by Kerr, Wyllie, and Currie (*Brit J. Cancer* 26:239) in 1972 as a means of distinguishing a morphologically distinctive form of cell death which was associated with normal physiology.
- Apoptosis was distinguished from necrosis, which was associated with acute injury to cells.

From: NIH Special Interest Groups - Apoptosis Interest Group: http://www.nih.gov/sigs/aig/index.html

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IVD Nutrition-Pump Mechanism

- Intervertebral discs make up about one-third of the length of the spine and constitute the largest organ in the body without its own blood supply.
- The discs receive their blood supply through movement as they soak up nutrients.
- When this movement process is inhibited through injury or poor posture, the discs gradually degenerate over time.

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Imaging Clues

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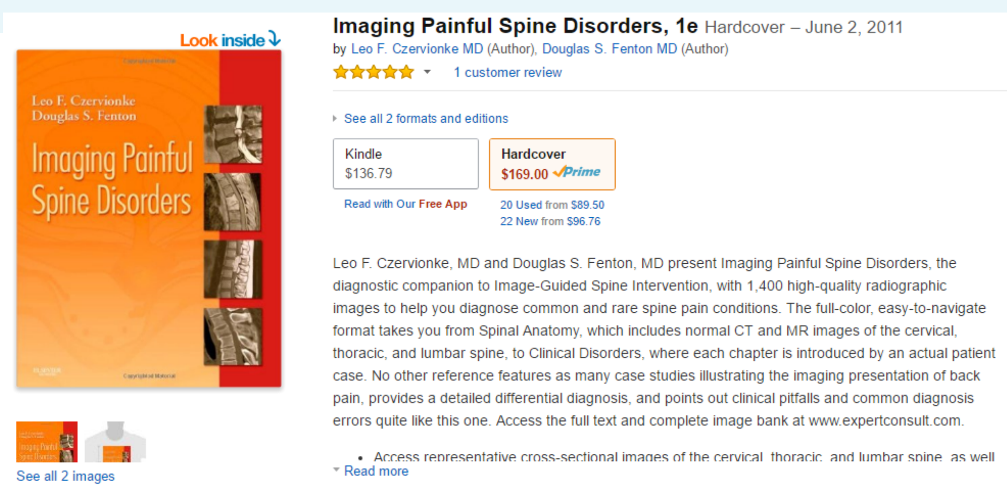

Czervionke LF, Fenton DS. Imaging Painful Spine Disorders.

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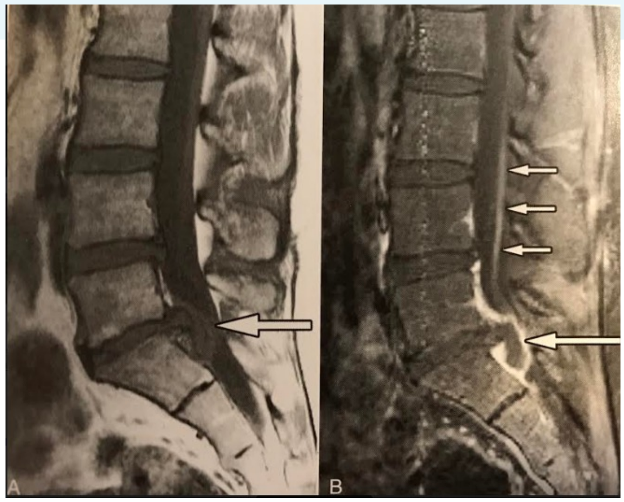

Czervionke LF, Fenton DS. Imaging Painful Spine Disorders.

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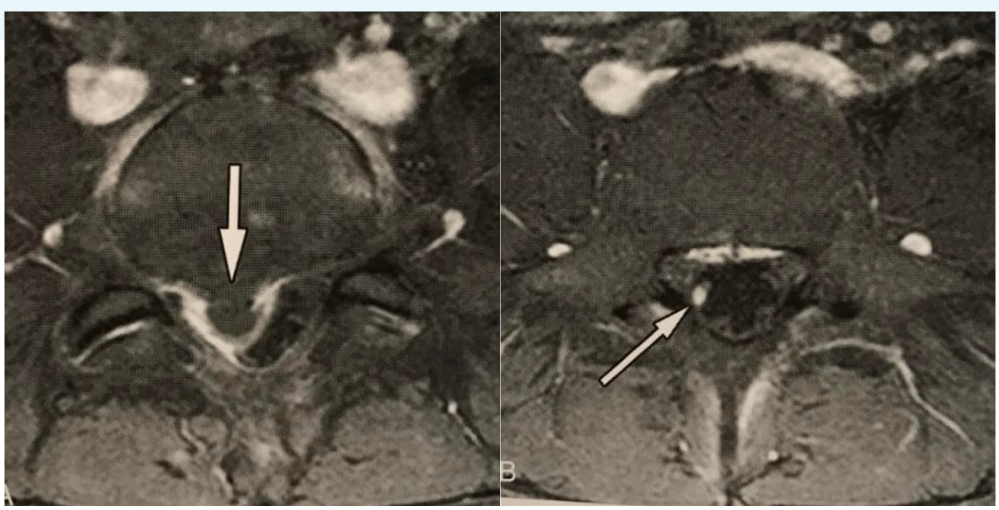

Czervionke LF, Fenton DS. Imaging Painful Spine Disorders.

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The Cleveland Clinic

Michael T. Modic, M.D.
Chairman, Division of Radiology

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Modic Classification

Vertebral body marrow changes (Modic's classification)

Reactive vertebral body modifications associated with disc inflammation and degenerative disc disease, as seen on MR images.

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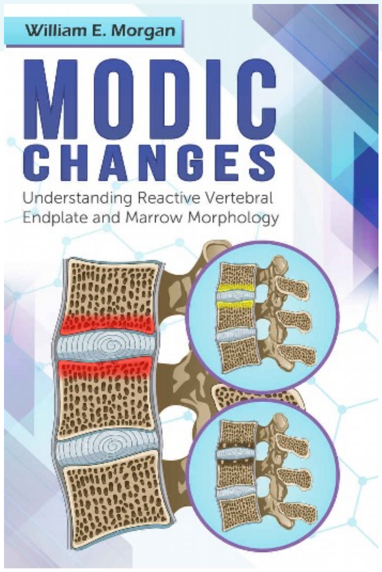

Morgan WE. Modic Changes: Understanding Reactive Vertebral Endplate and Marrow Morphology. Copyright 2015. Bethesda Spine Institute

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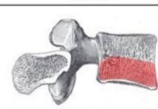
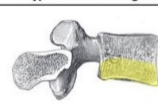
Normal bone is spongy and uniform in appearance. The vertebral endplates are a thin dense margin of bone.	 Normal
Bony edema has been connected with acute endplate or disc disruption. This edema is visible on MRI and is classified as Type 1 Modic change. It has been associated with pain and inflammation.	 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

Morgan WE. Modic Changes: Understanding Reactive Vertebral Endplate and Marrow Morphology. Copyright 2015. Bethesda Spine Institute

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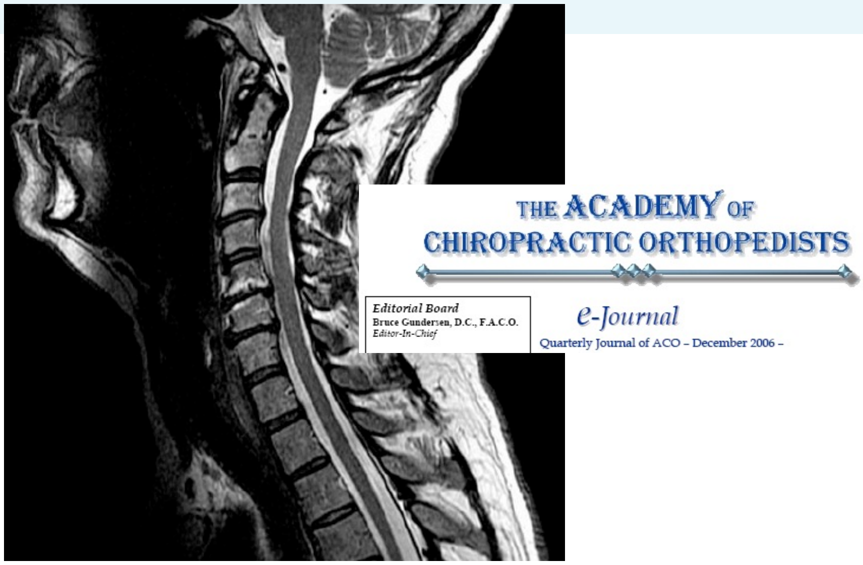

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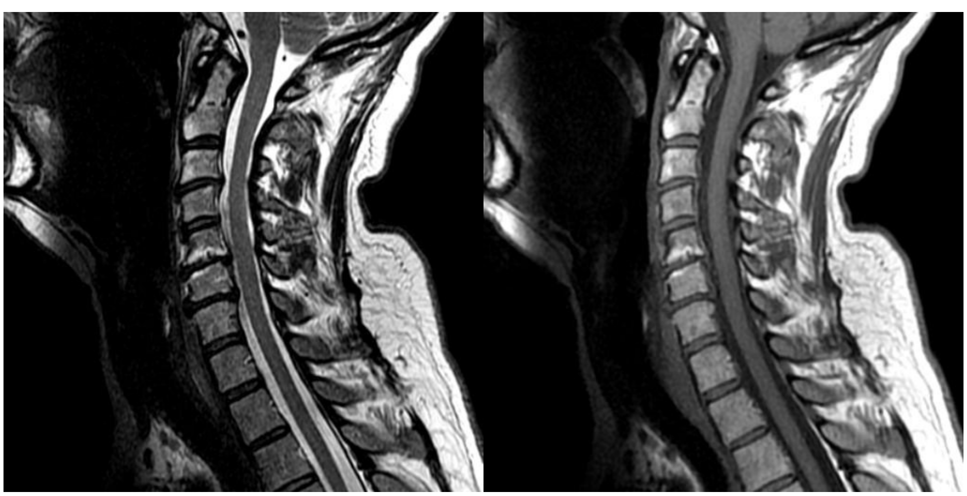

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Prevalence of Modic Degenerative Marrow Changes in the Cervical Spine

Cynthia K. Peterson, RN, DC, M Med Ed,[a] B. Kim Humphreys, DC, PhD,[b] and Tania C. Pringle, DC[c]

Abstract

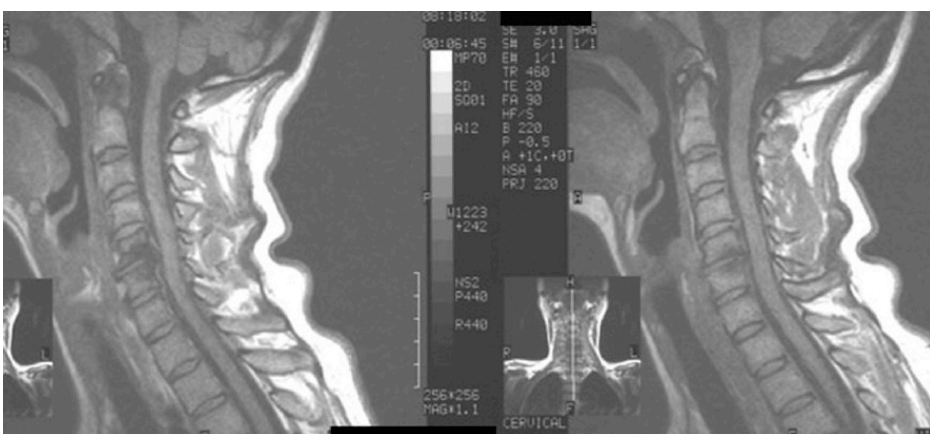
Objective: The prevalence and distribution of Modic degenerative marrow changes as seen on magnetic resonance imaging scans have been reported for the lumbar spine, and research suggests that type 1 Modic changes are linked to low back pain. The purpose of this study was to report on the prevalence, types, and distribution of the changes found for the cervical spine.

Methods: One hundred thirty-three cervical spine T_1-weighted and T_2-weighted sagittal magnetic resonance imaging scans were viewed retrospectively by two radiologists. Data were recorded for patient age, patient sex, and the presence or absence of Modic changes. If Modic changes were present, then the precise vertebral levels of these changes and the specific Modic type were recorded. Descriptive statistics were calculated for the prevalence of Modic changes overall, the prevalence of types 1, 2, and 3 changes, and the prevalence in male vs female patients. The frequency of these changes by spinal level was also determined.

Results: One hundred eighteen patients met the inclusion criteria. Modic changes were seen in 19 patients (16%), with 4 showing changes in more than one segmental level. The most common Modic change observed was type 1. Type 3 marrow changes were the second most common category to be noted. Only 3 patients had Modic type 2 marrow changes. The most common cervical spinal level to show Modic changes was C5-6.

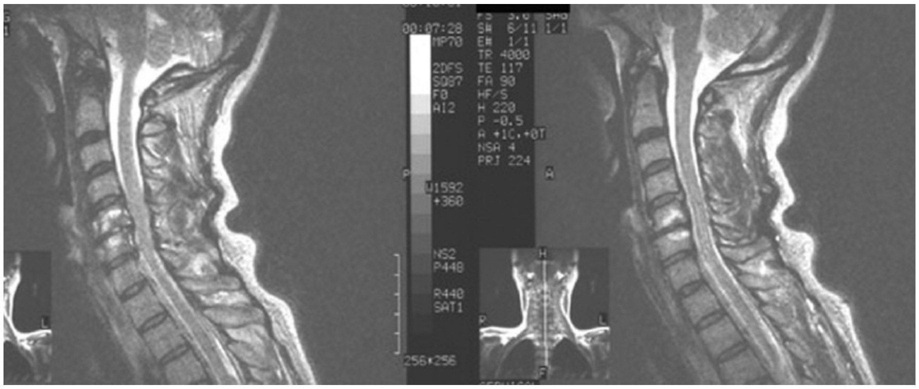
Conclusions: Modic degenerative bone marrow changes are observed in the cervical spine, with the C5-6 level being the most commonly involved. Unlike in the lumbar spine in which Modic type 2 changes predominate, type 1 marrow changes were far more common in the cervical spine. Further studies should focus on the clinical relevance of these findings. (J Manipulative Physiol Ther 2007;30:5-10)

Key Indexing Terms: *Magnetic Resonance Imaging; Intervertebral Disk; Cervical Vertebrae; Bone Marrow*



Journal of Manipulative and Physiological Therapeutics
Volume 30, Number 1

Peterson et al
Prevalence of Modic Degenerative Marrow



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Prevalence of Modic Degenerative Marrow

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Practical Applications

- Modic degenerative marrow changes are common in the cervical spine.
- Type 1 changes appear to be more common in the neck, whereas type 2 changes predominate in the lumbar spine.
- The C5-6 level is most commonly involved.
- There is no sex difference in the prevalence of Modic changes in the cervical spine.

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Prevalence of Modic Degenerative Marrow

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Modified Pfirrmann Grading System for Lumbar Intervertebral Disc Degeneration
Griffith: *Spine*, Volume 32(24).November 15, 2007.E708-E712

Key Points

- An 8-level modified MR-based grading system for lumbar disc degeneration is presented.
- This system, applied to elderly subjects, is easy to understand, easy to use, reliable, and discriminatory.
- It will help in assignment of lumbar disc degeneration severity for clinical or research purposes.

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Table 1. Modified Grading System for Lumbar Disc Degeneration*

Grade	Signal From Nucleus and Inner Fibers of Anulus	Distinction Between Inner and Outer Fibers of Anulus at Posterior Aspect of Disc	Height of Disc
1	Uniformly hyperintense, equal to CSF	Distinct	Normal
2	Hyperintense (>presacral fat and <CSF) ± hypointense intranuclear cleft	Distinct	Normal
3	Hyperintense though <presacral fat	Distinct	Normal
4	Mildly hyperintense (slightly >outer fibers of anulus)	Indistinct	Normal
5	Hypointense (= outer fibers of anulus)	Indistinct	Normal
6	Hypointense	Indistinct	<30% reduction in disc height
7	Hypointense	Indistinct	30%–60% reduction in disc height
8	Hypointense	Indistinct	>60% reduction in disc height

*Grades 1, 2, and 3 are based on the signal intensity of the nucleus and inner fibers of anulus. For Grade 4, the margins between the inner and other fibers of the anulus at the posterior margin of the disc are indistinct. For Grade 5, the disc is uniformly hypointense, although there is no loss of disc space height. For Grades, 6, 7, and 8, there is progressive loss of disc space height. These could be broadly classified as mild, moderate, to severe loss of disc space height. Very occasionally, although obvious disc collapse is present, hyperintense signal from the nucleus and inner fibers of the anulus is preserved. This is referred to by a double entry, *e.g.*, 4/7, with the former reporting the disc signal and the latter the degree of collapse.

Modified Grading System for Lumbar Disc Degeneration
From: Griffith: Spine, Volume 32(24).November 15, 2007.E708-E712

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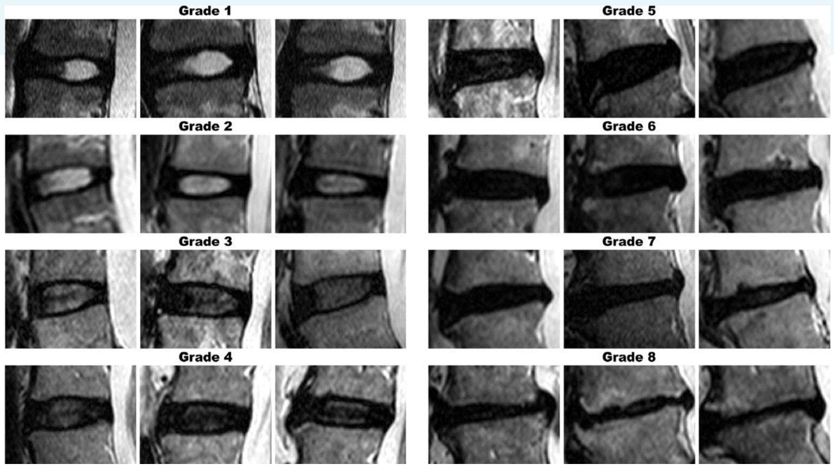

Modified Grading System for Lumbar Disc Degeneration
From: Griffith: Spine, Volume 32(24).November 15, 2007.E708-E712

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Jinkins. ***Hong Kong Coll Radiology*** 2003; 6: 55-74.

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PLOS | ONE

RESEARCH ARTICLE

Classification of High Intensity Zones of the Lumbar Spine and Their Association with Other Spinal MRI Phenotypes: The Wakayama Spine Study

Masatoshi Teraguchi[1], Dino Samartzis[2]*, Hiroshi Hashizume[1]*, Hiroshi Yamada[1], Shigeyuki Muraki[3], Hiroyuki Oka[4], Jason Pui Yin Cheung[2], Ryohei Kagotani[1], Hiroki Iwahashi[1], Sakae Tanaka[5], Hiroshi Kawaguchi[6], Kozo Nakamura[7], Toru Akune[7], Kenneth Man-Chee Cheung[2], Noriko Yoshimura[3], Munehito Yoshida[1]

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Abstract

PLOS ONE | DOI:10.1371/journal.pone.0160111 September 20, 2016

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Table 1. Assessment of lumbar High Intensity Zones on MRI.

Variables	Definition
Shape	
Round	Concentric or oval cavity
Fissure	Parallel and transverse layer to the adjacent endplate
Vertical	Vertical layer to the adjacent endplate
Rim	Oblique radiating layer from the adajacent endplate
Enlarged	Greater concentric area than typical round HIZ
Horizontal location within disc	
Posterior	HIZ located in the posterior annulus fibrosus
Anteriror	HIZ located in the anterior annulus fibrosus
Signal type on T1W and T2W HIZ image	
T1W low-intensity type of HIZ	Decreased signal than the bone marrow on T1W sagittal MRI
T1W high-intensity type of HIZ	Increased signal than the bone marrow on T1W sagittal MRI
T1W iso-intensity type of HIZ	Same signal than the bone marrow on T1W sagittal MRI

HIZ: high intensity zones, MRI: magnetic resonance imaging, T1W: T1-weighted, T2W: T2-weighted, MRI: magnetic resonance imaging

doi:10.1371/journal.pone.0160111.t001

PLOS ONE | DOI:10.1371/journal.pone.0160111 September 20, 2016

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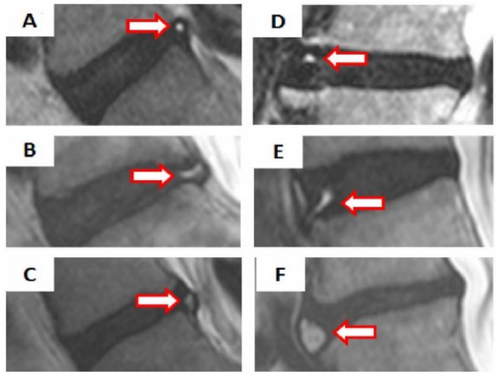

Fig 1. Classification of High Intensity Zones based on morphology and topography. High Intensity Zones (HIZ) were defined as a high intensity signal (white) surrounded by low intensity (black) located in the annulus fibrosus on T2-weighted sagittal MRI. Six types of HIZs were created based on the shape (round type, fissure type, vertical type, rim type, and giant type), and location within the disc (posterior or anterior). The images represent **(A)** posterior round type, **(B)** posterior fissure type, **(C)** posterior vertical type, **(D)** anterior round type, **(E)** anterior rim type, and **(F)** anterior enlarged type.

doi:10.1371/journal.pone.0160111.g001

PLOS ONE | DOI:10.1371/journal.pone.0160111 September 20, 2016

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IVD Herniation

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SPINE Volume 39, Number 24, pp E1448-E1465

Spine

EPIDEMIOLOGY

Lumbar Disc Nomenclature: Version 2.0

Recommendations of the Combined Task Forces of the North American Spine Society, the American Society of Spine Radiology, and the American Society of Neuroradiology

David F. Fardon, MD,* Alan L. Williams, MD,† Edward J. Dohring, MD,‡§ F. Reed Murtagh, MD,¶
Stephen L. Gabriel Rothman, MD,‖ and Gordon K. Sze, MD**
This article is being simultaneously published in The *Spine Journal*.

SPINE Volume 39, Number 2 4, pp E 1448- E 1465

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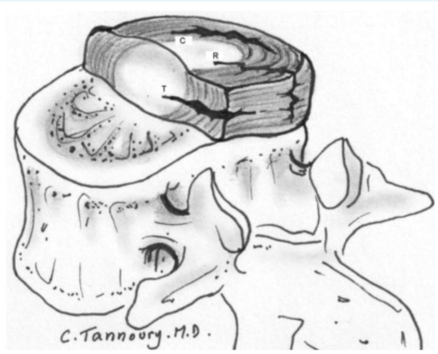

Figure 2. Fissures of the annulus fibrosus. Fissures of the annulus fibrosus occur as radial (R), transverse (T), and/or concentric (C) separations of fibers of the annulus. The transverse fissure depicted is a fully developed, horizontally oriented radial fissure; the term "transverse fissure" is often applied to a less extensive separation limited to the peripheral annulus and its bony attachments.

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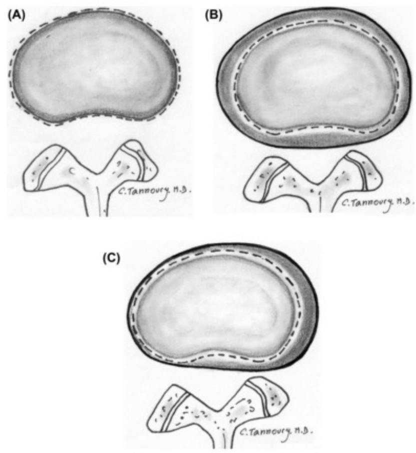

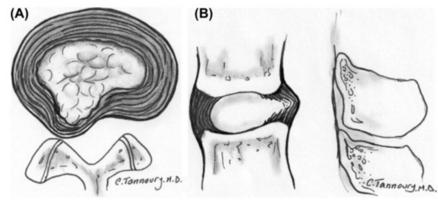

Figure 4. Herniated disc: protrusion. Axial (**A**) and sagittal (**B**) images demonstrate displaced disc material extending beyond less than 25% of the disc space, with the greatest measure, in any plane, of the displaced disc material being less than the measure of the base of displaced disc material at the disc space of origin, measured in the same plane.

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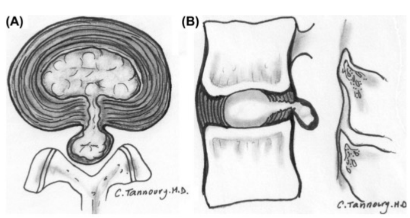

Figure 5. Herniated disc: extrusion. Axial (**A**) and sagittal (**B**) images demonstrate that the greatest measure of the displaced disc material is greater than the base of the displaced disc material at the disc space of origin, when measured in the same plane.

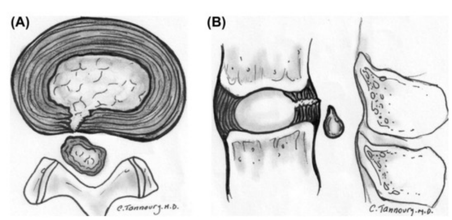

Figure 6. Herniated disc: sequestration. Axial (**A**) and sagittal (**B**) images show that a sequestrated disc is an extruded disc in which the displaced disc material has lost all connection with the disc of origin.

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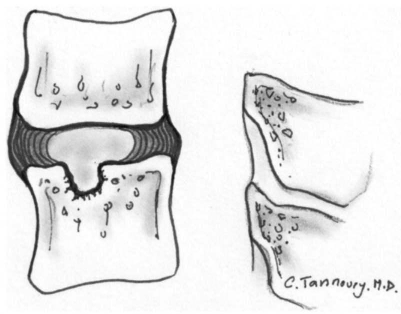

Figure 7. Intravertebral herniation (Schmorl node). Disc material is displaced beyond the disc space through the vertebral endplate into the vertebral body, as shown here in sagittal projection.

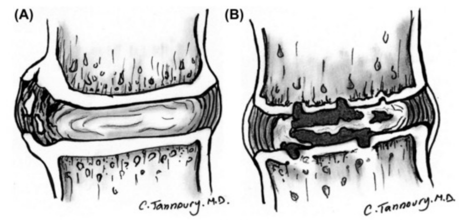

Figure 8. Types of disc degeneration by radiographical criteria. **A**, Spondylosis deformans is manifested by apophyseal osteophytes, with relative preservation of the disc space. **B**, Intervertebral osteochondrosis is typified by disc space narrowing, severe fissuring, and endplate cartilage erosion.

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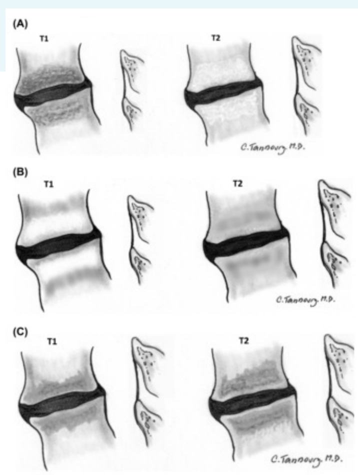

Figure 10. Reactive vertebral body marrow changes. These bone marrow signal changes adjacent to a degenerated disc on magnetic resonance imaging. T1- and T2-weighted sequences are frequently classified as Modic I (**A**), Modic II (**B**), or Modic III (**C**).

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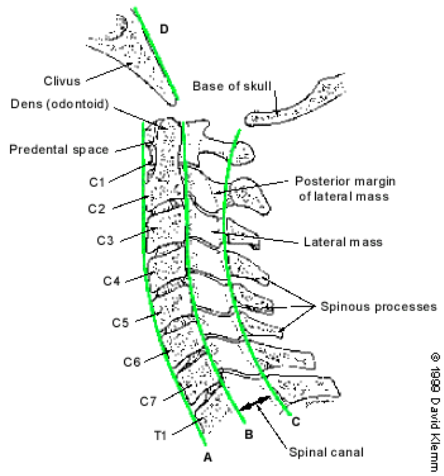
"MRI Vision"



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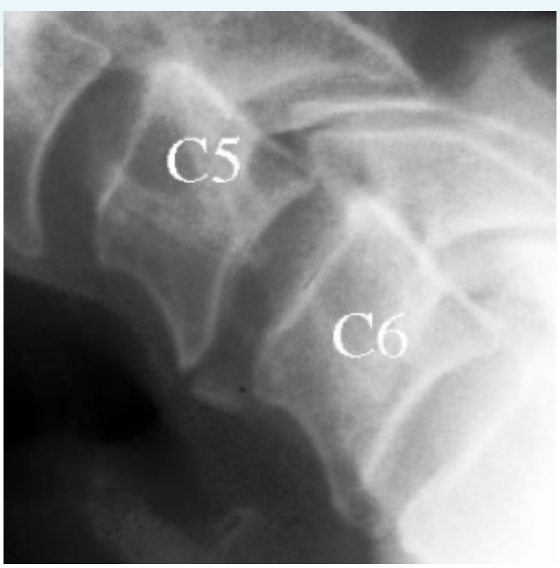

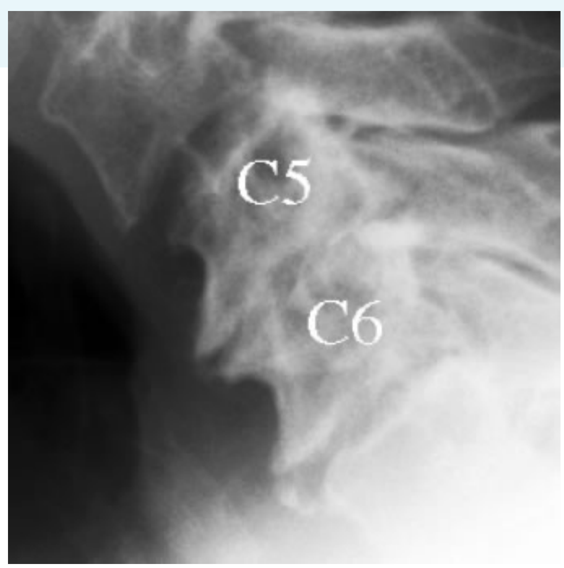

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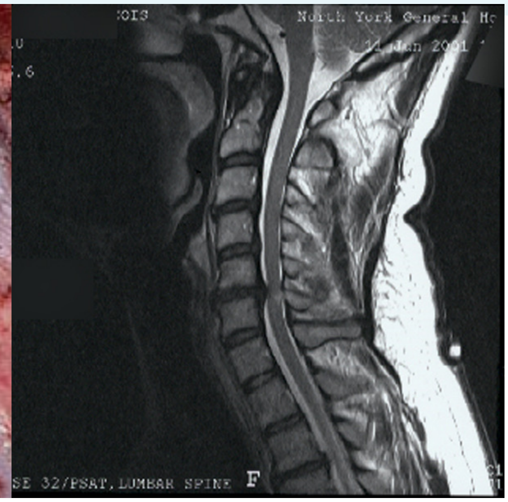

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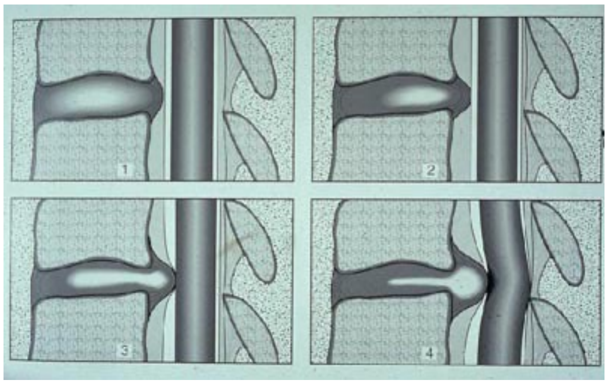

Rauschning Grading System for disc protrusions is based on the assessment of the normal specimens and actual disc herniations:

Grade 0: straight contour of the posterior annulus fibrosus.
Grade 1: small annulus fibrosus protrusion.
Grade 2: medium–size annulus protrusion obliterating 2/3 of the anterior epidural and subarachnoid spaces.
Grade 3: large disc protrusion dislocating the spinal cord posteriorly.
Grade 4: large disc protrusions compressing the spinal cord.

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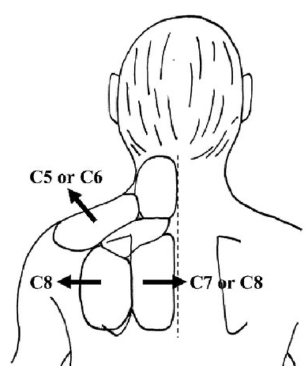
Cervical Roots as Origin of Pain in the Neck or Scapular Regions
Tanaka et al. *Spine*. Volume 31(17), 1 August 2006, pp E568-E573

- A prospective study was conducted to determine whether the pain in the neck or scapular regions in patients with cervical radiculopathy originates from the compressed root and whether the site of the pain is useful for diagnosing the level.
- It was confirmed through this study that scapular region pain is generally the initial symptom in radiculopathy and can persist alone before the arm or finger symptoms develop.
- Pain in the scapular region can originate directly in the compressed root, and the site of the pain is valuable for determining the localization of the involved root.



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Dynamic Stenosis

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Morphologic Changes in the Cervical Neural Foramen due to Flexion and Extension: In Vivo Imaging Study.

Kitagawa et.al. Spine. 29(24):2821-2825, December 15, 2004.

Conclusions. The present results are consistent with those of previous in vitro studies and may explain the clinical observation that cervical extension aggravates symptoms in patients with cervical radiculopathy and that flexion often relieves them.

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Upright MRI

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Upright MRI

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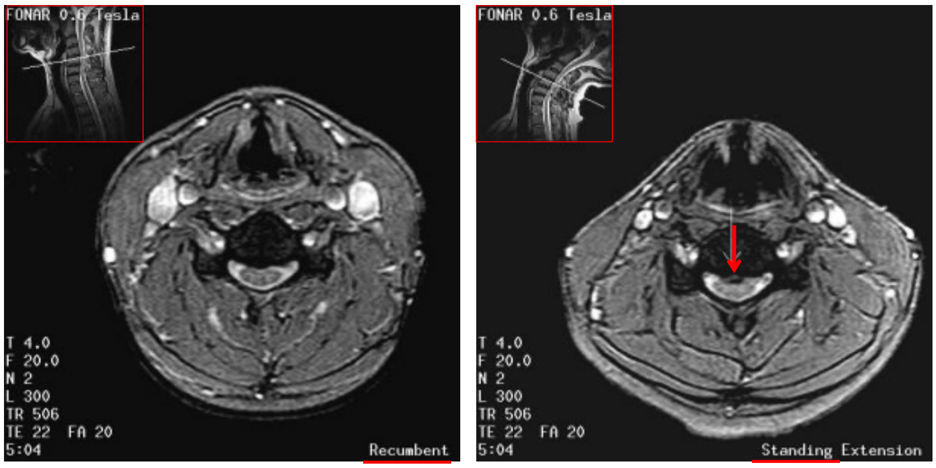
Upright MRI



Clinical Radiology (2008) 63, 1035–1048

PICTORIAL REVIEW

Upright positional MRI of the lumbar spine

F. Alyas[a,b], D. Connell[a,b], A. Saifuddin[a,b,*]

[a]London Upright MRI Centre, London, UK, and [b]Department of Radiology, The Royal National Orthopaedic Hospital NHS Trust, Stanmore, Middlesex, UK

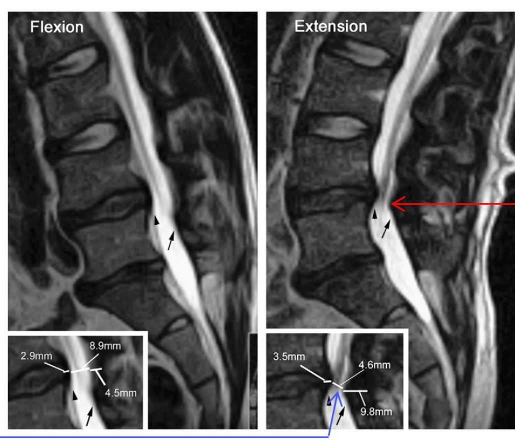


Figure 1 A 30-year-old man with non-specific LBP demonstrating increased posterior disc bulge on extension. Sagittal T2W images in seated flexion and extension demonstrate posterior L4/L5 disc bulge that increases on extension (arrowheads). There is also inward bulging of the ligamentum flavum on extension (arrows), contributing to narrowing of the central canal. Insets demonstrate the changes in the disc herniation and ligamentum flavum, which have resulted in a reduction in anteroposterior canal diameter of 48.3%.

Cervical Degenerative Myelopathy

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Cervical Spondylotic Myelopathy

History: This 67 yr. old female presented with history of numbness/tingling in left upper extremity, several weeks duration. Recent investigations for this complaint included an EKG and NCV studies. More recent onset of urinary urgency, bilateral aching pain in the lower extremities and "loss of control" of the right leg prompted consultation with another physician who ordered MRI examination, images of which are shown here.

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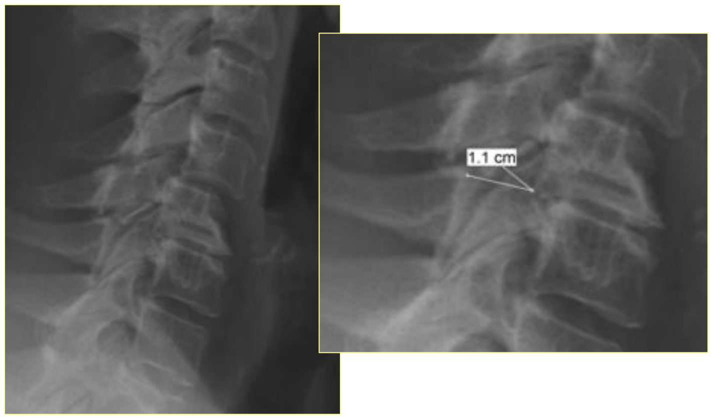
Cervical Spondylotic Myelopathy



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Cervical Spondylotic Myelopathy

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Cervical Spondylotic Myelopathy

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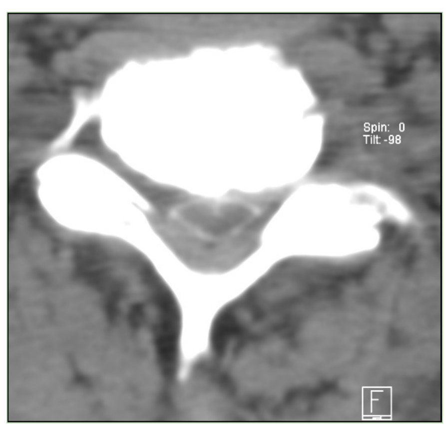
Instructive Case



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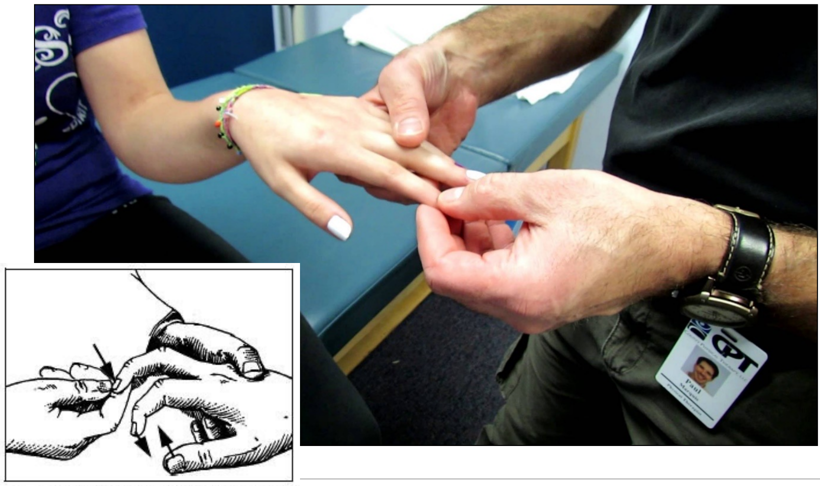
Hoffman's Sign



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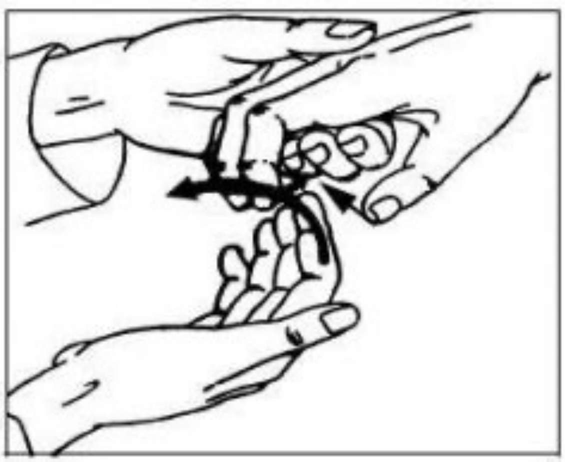
Tromner Sign



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Clin Spine Surg. 2016 Jul 11. [Epub ahead of print]

The Significance of the Trömner Sign in Cervical Spondylotic Myelopathy Patient.

Chaiyamongkol W[1], Laohawiriyakamol T, Tangtrakulwanich B, Tanutit P, Bintachitt P, Siribumrungwong K.

⊕ Author information

Abstract

STUDY DESIGN: This study is a diagnostic analysis.

OBJECTIVE: To investigate the diagnostic accuracy of Trömner sign in cervical spondylotic myelopathy (CSM), and how its presence correlates with the severity of myelopathy.

SUMMARY OF BACKGROUND DATA: A clinical presentation of myelopathy corresponding with image findings is a current standard to diagnose CSM. Trömner sign is an alternative of well-known Hoffmann sign to detect CSM. Little is known about its diagnostic accuracy and how its presence correlates with the severity of CSM.

MATERIALS AND METHODS: Consecutive patients with clinical diagnosis of CSM and other cervical spondylosis-related problems were enrolled in either CSM group, cervical spondylotic radiculopathy group, or axial pain group. Normal volunteers and patients without spine-related issues were used as a control. All participants were examined for the presence of myelopathic signs. Magnetic resonance imaging studies of all participants were reviewed by a radiologist.

RESULTS: There were 85 participants included in the study. Diagnostic sensitivity was 76%, 94%, 76%, and 36% for Hoffmann sign, Trömner sign, inverted radial reflex, and Babinski sign, respectively. Trömner sign had relatively high sensitivity (95%) despite of mild degree of myelopathy. Negative predictive value was 60%, 85%, 59%, and 38% for Hoffmann sign, Trömner sign, inverted radial reflex, and Babinski sign, respectively. There were 63%-71% of patients in either axial pain group or cervical spondylotic radiculopathy group had positive Trömner sign. Most of CSM patients with cord signal changed had positive myelopathic sign. Regarding CSM patient without cord signal change, most of tests were negative except Trömner sign.

CONCLUSIONS: High sensitivity (94%) and relatively high negative predictive value (85%) for Trömner sign indicate the usefulness of Trömner sign in ruling out CSM. High incidence of positive Trömner sign in presymptomatic cervical cord compression patients suggests Trömner sign could have a useful role in early detection of presymptomatic patients.

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Tandem Spinal Stenosis

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REVIEWS

Evaluation and Treatment of Tandem Spinal Stenosis

Baker, Joseph F. MCh, FRCSI

Author Information

Journal of the American Academy of Orthopaedic Surgeons: March 15, 2020 - Volume 28 - Issue 6 - p 229-239

- Tandem spinal stenosis (TSS) is defined as stenosis affecting two or more noncontiguous anatomic regions of the spine.
- Classically, TSS is considered as the one which simultaneously affects the cervical and lumbar region, but the thoracic spine can also be involved, and in rare instances, all three regions of the spine may be affected simultaneously.1-3
- TSS may present with a constellation of symptoms and signs that can confuse and mislead the clinician.
- It may be difficult to persuade a patient presenting with lumbar spine–dominant symptoms that a previously undetected cervical spinal stenosis (CSS) is a greater priority for intervention and vice versa.

Figure 2

Full-spine imaging allows a quick assessment for stenosis that may affect other noncontiguous spinal segments.

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CES

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CLINICAL CASE SERIES

Cauda Equina Syndrome

Poor Recovery Prognosis Despite Early Treatment

Planty-Bonjour, Alexia MD[a,b]; Kerdiles, Gaelle MD[a]; François, Patrick MD, PhD[a]; Destrieux, Christophe MD, PhD[a,b]; Velut, Stephane MD, PhD[a,b]; Zemmoura, Ilyess MD, PhD[a,b]; Cook, Ann-Rose MD[a]; Terrier, Louis-Marie MD[a,b]; Amelot, Aymeric MD, PhD[a,b]

Author Information

SPINE: January 15, 2022 - Volume 47 - Issue 2 - p 105-113

Summary of Background Data.

- CES is a neurologic impairment of variable symptoms associating urinary, bowel, and sexual dysfunctions with or without motor or sensitive deficits caused by nerve root compression of the cauda equina.
- The definition of CES remains debated, as well as the prognosis factors for favorable functional recovery and the benefit of early surgery.

CLINICAL CASE SERIES

Cauda Equina Syndrome

Poor Recovery Prognosis Despite Early Treatment

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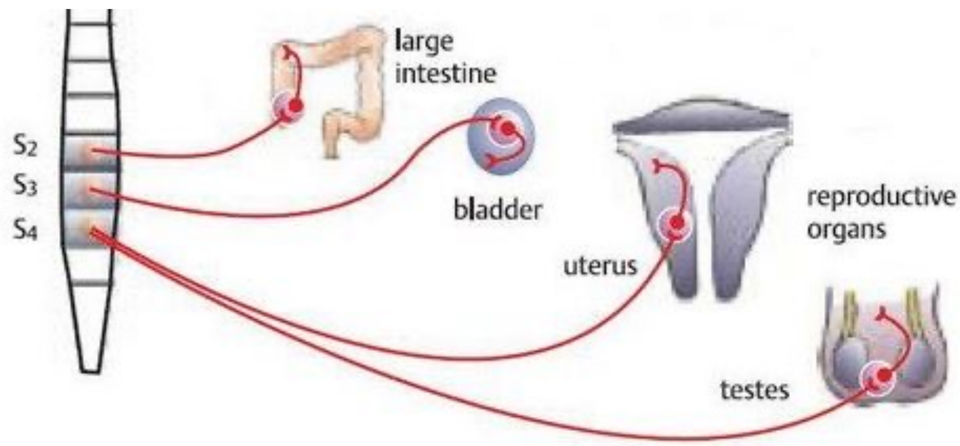
Results

- The patients were young with a median age of 46.8 years (range 18–86 yrs). At presentation:
  - 60% were affected by a motor deficit,
  - 42.8% a sensitive deficit,
  - 70% urinary dysfunctions, and
  - 44% bowel dysfunctions.
- **The mean follow-up was 15.5 months.**
- Time to surgery within an **early timing < 24 or 48 hours or later did not represent a prognosis factor of recovery in CES.**
- Incomplete *versus* complete CES did not show better recovery.



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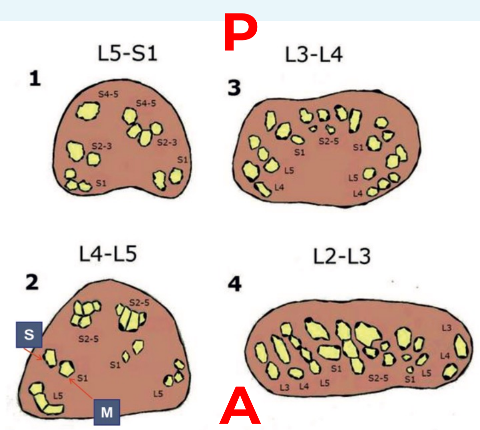

Figure 1. Diagrams of the cauda equina on CT and MRI. (M=motor, S=sensory).

Folia Medica 2017;59(4);377-86.
doi: 10.1515/folmed-2017-0038

- ...the minimal space that is occupied by the dural sac and is necessary for the nerve roots of the cauda equina is about 77±13 mm2 at the level of L3.
- Any reduction of this area causes an increase in the intrathecal pressure of the cerebrospinal fluid between the nerve roots of the cauda equina.
- ...the pressure inside the dural sac of the cauda equina elevates when the cross-sectional area ranges between 60 and 80 mm2.
- As a result, if the cross-sectional area of the dural sac decreases to 63 ± 13 mm2, the pressure is increased to 50 mmHg.
- ...if the cross sectional area of the dural sac is reduced to 57±11 mm2, the pressure increases to 100 mmHg.
- Therefore, a small reduction can cause an abrupt increase in the pressure inside the dural sac.6,7

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Chiropractic Care of IVD HNP, DCM AND CES

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SPINAL NEWS
International
Issue 24 July 2012

Managing cervical spondylotic myelopathy

The management of cervical spondylotic myelopathy remains controversial and the topic is the focus of a session at this year's IMAST. The moderator of the session, K Daniel Riew, Mildred B Simon professor of Orthopedic Surgery, chief of Cervical Spine Surgery, Washington University Orthopedics, St Louis, USA, talked to *Spinal News International* about these controversies and the dangers of bad surgery

Conservative treatment for cervical spondylotic myelopathy is often initiated on the basis of clinician preference. Which conservative treatments do you prefer to use?

I use anti-inflammatories, neck immobilisation with a collar, and observation.

The *BMJ* recently ran a debate on cervical spinal manipulation for mechanical neck pain in which one side[1] argued that the practice should be abandoned

The *BMJ* recently ran a debate on cervical spinal manipulation for mechanical neck pain in which one side[1] argued that the practice should be abandoned because its risks outweighed its benefits. What is your view?

Most patients can receive spinal manipulation. If they have severe spinal cord compression, then I do not recommend it. However, I have seen thousands of patients who have undergone chiropractic spinal manipulation and I can count on one hand the number of patients who have been harmed by it—there are many more patients who have been harmed by bad spinal operations.

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Review > J Manipulative Physiol Ther. Nov-Dec 1996;19(9):597-606.

Magnetic resonance imaging and clinical follow-up: study of 27 patients receiving chiropractic care for cervical and lumbar disc herniations

D J BenEliyahu

Conclusion: This prospective case series suggests that chiropractic care may be a safe and helpful modality for the treatment of cervical and lumbar disc herniations. A random, controlled, clinical trial is called for to further substantiate the role of chiropractic care for the nonoperative clinical management of intervertebral disc herniation.

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Relationship of Modic Changes, Disk Herniation Morphology, and Axial Location to Outcomes in Symptomatic Cervical Disk Herniation Patients Treated With High-Velocity, Low-Amplitude Spinal Manipulation: A Prospective Study

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Michel Kressig, MChiroMed,[a,b] Cynthia K. Peterson, RN, DC, MMedEd,[b] Kyle McChurch, DC,[a] Christof Schmid, DC,[c] Serafin Leemann, DC,[c] Bernard Anklin, DC,[c] and B. Kim Humphreys, DC, PhD[b]

ABSTRACT

Objective: The purpose of this study was to evaluate whether cervical disk herniation (CDH) location, morphology, or Modic changes (MCs) are related to treatment outcomes.

Methods: Magnetic resonance imaging (MRI) and outcome data from 44 patients with CDH treated with spinal manipulative therapy were evaluated. MRI scans were assessed for CDH axial location, morphology, and MCs. Pain (0-10 for neck and arm) and Neck Disability Index (NDI) data were collected at baseline; 2 weeks; 1, 3, and 6 months; and 1 year. The Patient's Global Impression of Change data were collected at all time points and dichotomized into "improved," yes or no. Fischer's exact test compared the proportion improved with MRI abnormalities. Numerical rating scale and NDI scores were compared with MRI abnormalities at baseline and change scores at all time points using the *t* test or Mann-Whitney *U* test.

Results: Patients who were Modic positive had higher baseline NDI scores ($P = .02$); 77.8% of patients who were Modic positive and 53.3% of patients who were Modic negative reported improvement at 2 weeks ($P = .21$). Fifty percent of Modic I and 83.3% of Modic II patients were improved at 2 weeks ($P = .07$). At 3 months and 1 year, all patients with MCs were improved. Patients who were Modic positive had higher NRS and NDI change scores. Patients with central herniations were more likely to improve only at the 2-week time point ($P = .022$).

Conclusions: Although patients who were Modic positive had higher baseline NDI scores, the proportion of these patients improved was higher for all time points up to 6 months. Patients with Modic I changes did worse than patients with Modic II changes at only 2 weeks. (J Manipulative Physiol Ther 2016;39:565-575)

Key Indexing Terms: *Cervical Spine; Disk Herniation; Chiropractic Manipulation; MRI; Outcomes; Modic Changes*

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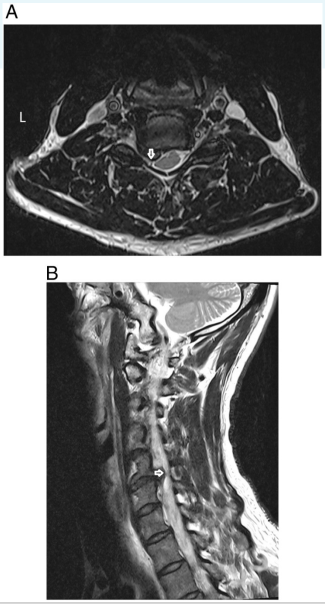

J Manipulative Physiol Ther 2016;39:565-575

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Symptomatic, Magnetic Resonance Imaging–Confirmed Cervical Disk Herniation Patients: A Comparative-Effectiveness Prospective Observational Study of 2 Age- and Sex-Matched Cohorts Treated With Either Imaging-Guided Indirect Cervical Nerve Root Injections or Spinal Manipulative Therapy

CrossMark

Cynthia K. Peterson, RN, DC, MMedEd,[a b] Christian W.A. Pfirrmann, MD, MBA,[c] Jürg Hodler, MD, MBA,[d] Serafin Leemann, DC,[e] Christof Schmid, DC,[e] Bernard Anklin, DC,[e] and B. Kim Humphreys, DC, PhD[f]

J Manipulative Physiol Ther 2016;39:210-217.

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Practical Applications

- A higher proportion of patients who were Modic positive and had CDH reported improvement after cervical manipulation compared with patients who were Modic negative at 2 weeks, 1 month, and 3 months.
- Patients with CDH who were Modic positive had significantly higher baseline disability scores, but at all follow-up time points other than 6 months, there were no differences compared with patients who were Modic negative.
- Patients with central herniations were more likely to improve at the 2-week time point compared with patients with paracentral or foraminal herniations.

J Manipulative Physiol Ther 2016;39:565-575.

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The Facet Syndrome:
Zygapophyseal Joints and Chiropractic Care

James Demetrious, DC, DABCO

Diplomate, American Board of Chiropractic Orthopedists

www.PostGradDC.com

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Purpose…

"To always care for patients in a manner that best serves their health, interests, and well-being. To continue to learn, teach and share our knowledge and ability to help others."

~ James Demetrious, DC, DABCO

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Course Syllabus

- Introduction – How Chiropractic Works
- Anatomy
- Peri-Articular Edema and Synovitis
- Meniscoids, plica and cartilage
- HVLA, LVLA and traction
- Chiropractic AEs

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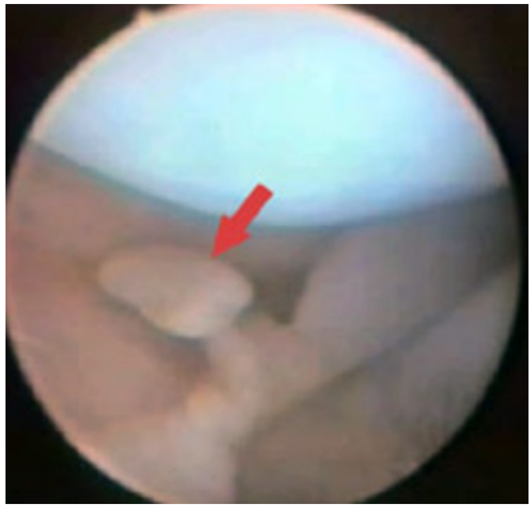
One day, I was playing tennis with a friend…



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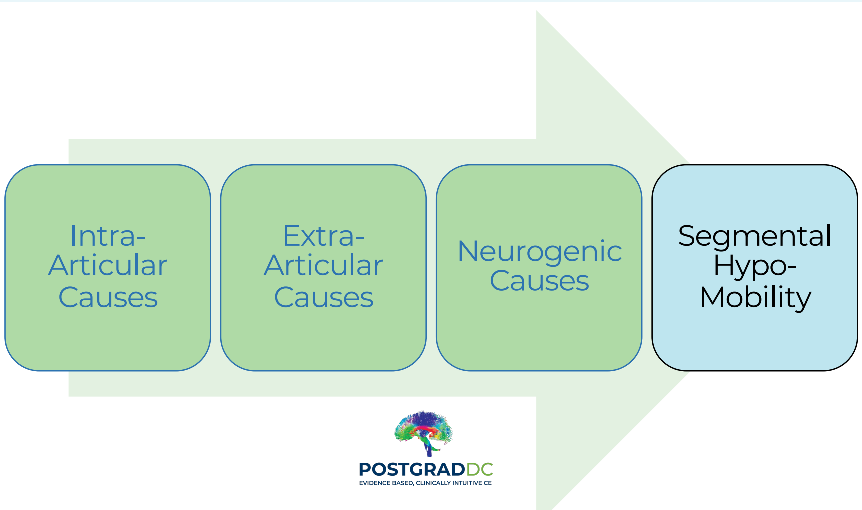
How Chiropractic Works



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Anatomy

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ELSEVIER

European Journal of Radiology 50 (2004) 134–158

EJR
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Acquired degenerative changes of the intervertebral segments at and suprajacent to the lumbosacral junction
A radioanatomic analysis of the nondiscal structures of the spinal column and perispinal soft tissues

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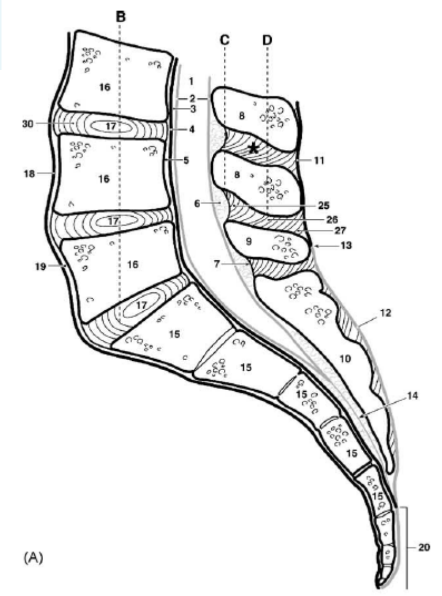

Jinkins. ***European Journal of Radiology;*** 50 (2004) 134-158.

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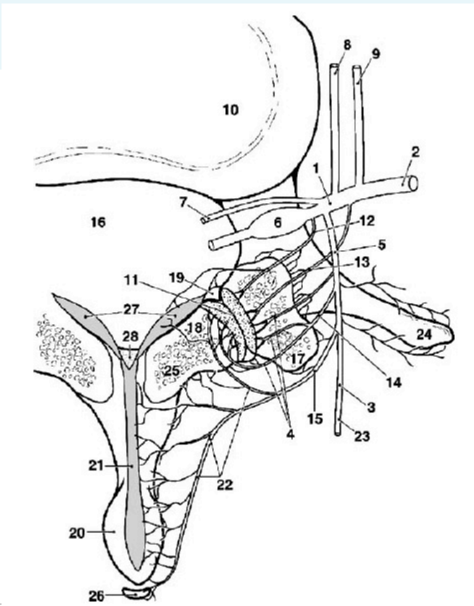

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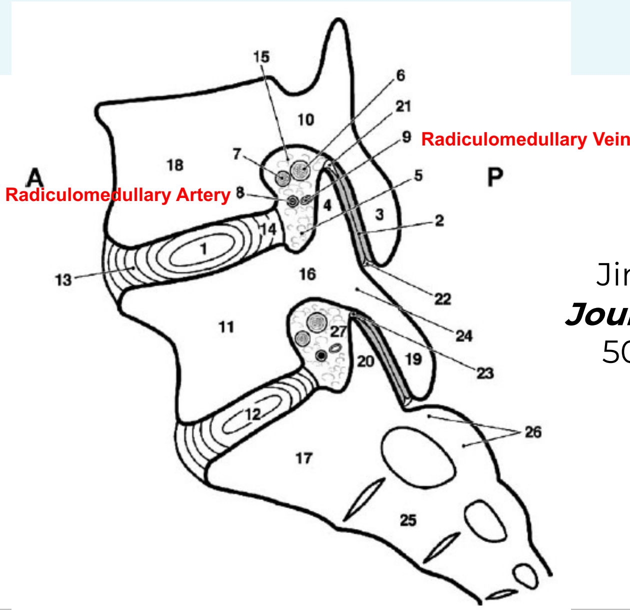

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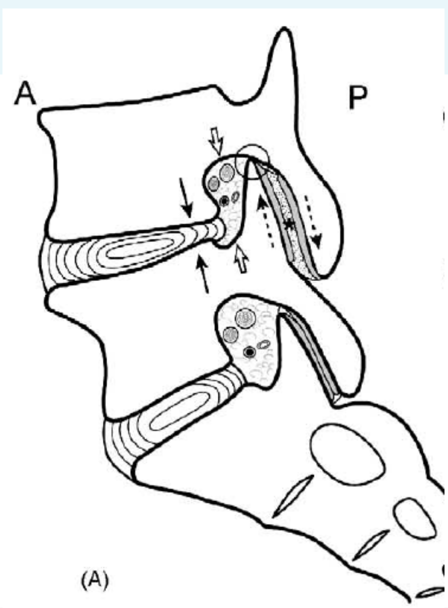

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Interexaminer Reliability of T2-Weighted Magnetic Resonance Imaging for Lumbar Bright Facet Sign

Gary A. Longmuir, MAppSc, DC,[a,b] and Raymond N. Conley, DC[c]

Abstract

Objective: The aims of this study were to characterize the bright facet response within the lumbar spine, to identify a constellation of findings associated with the response, and to quantify the interexaminer agreement on the previous objectives.

Methods: A retrospective study of lumbar magnetic resonance images obtained on 105 (N = 105) adult subjects (62 men and 43 women; age range, 18-84 years; mean age, 46.51 ± 16.01 years) were reviewed by 2 musculoskeletal radiologists for the presence of high signal within the facet articulations (bright facet response) on fast spin echo T2-weighted images.

Results: Of the 630 lumbar facet articulations imaged (L3/L4 through L5/S1), 340 (54%) and 346 (55%) respectively, per examiner, did show a bright facet response. Interexaminer agreement with respect to the level and grading of a bright facet response was almost perfect with κ ranging from 0.85 to 0.91 (SE, 0.06). Prevalence of bright facet responses averaged 40.5% at L5/S1, 56.5% at L3/L4, and 66.5% at the L4/L5 level. There was an association with degenerative facet and disk changes.

Conclusion: The bright facet response was a common phenomenon on T2-weighted magnetic resonance imaging of the lumbar spine in these cases. There was sufficient agreement with respect to the presence and extent of the bright facet response to conclude that the examiners' determinations were not made by random chance. There exist sufficient repeatability and reliability that a single descriptive term can be applied to unify the bright facet response, the bright facet sign. (J Manipulative Physiol Ther 2008;31:593-601)

Key Indexing Terms: *Hydrarthrosis; Radiography; Diagnostic Imaging; Chiropractic*

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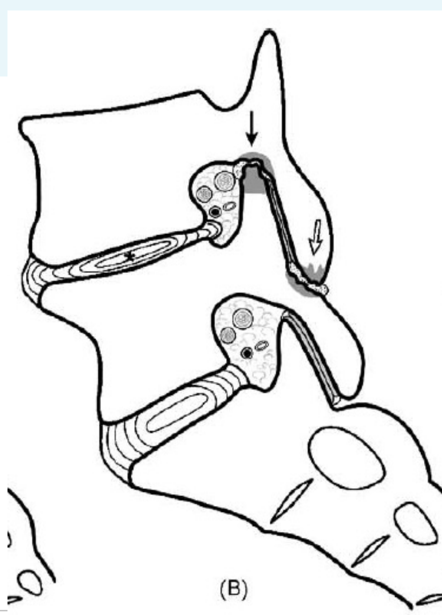

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Degenerative Foraminal Stenosis

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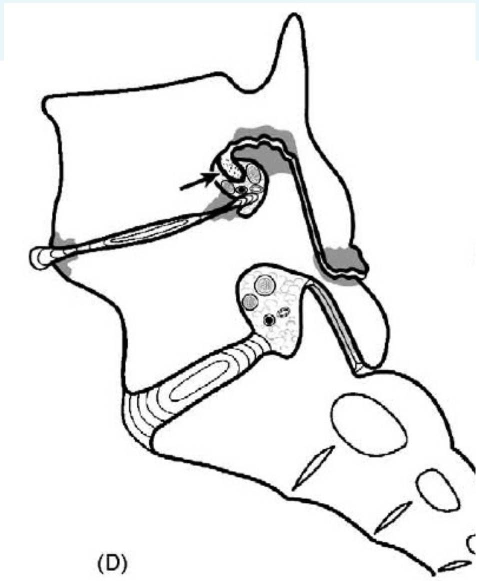

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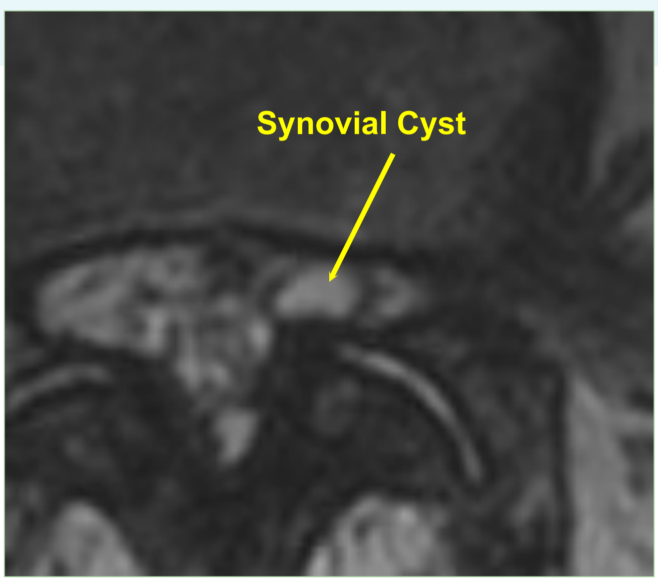

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SPINE Volume 34, Number 23, pp 2518–2524
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The Prevalence and Pathogenesis of Synovial Cysts Within the Ligamentum Flavum in Patients With Lumbar Spinal Stenosis and Radiculopathy

Martin J. Wilby, MA, MB, BChir, PhD, FRCS,* Robert D. Fraser, AM, MD, FRACS,*
Barrie Vernon-Roberts, AO, MD, PhD, FRCPath, FRCPA,*†
and Robert J. Moore, MAppSc, PhD*†

2524 Spine • Volume 34 • Number 23 • 2009

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Figure 1. Macroscopic image of a freshly excised intact synovial cyst forming a dome-shaped swelling, which bulged into the spinal canal. It can be seen that the smooth intraspinal surface of the cyst is continuous with the inner surface of the ligamentum flavum cranial and caudal to the cyst. The cyst contained xanthochromic fluid, which was fluctuant when compressed.

2524 Spine • Volume 34 • Number 23 • 2009

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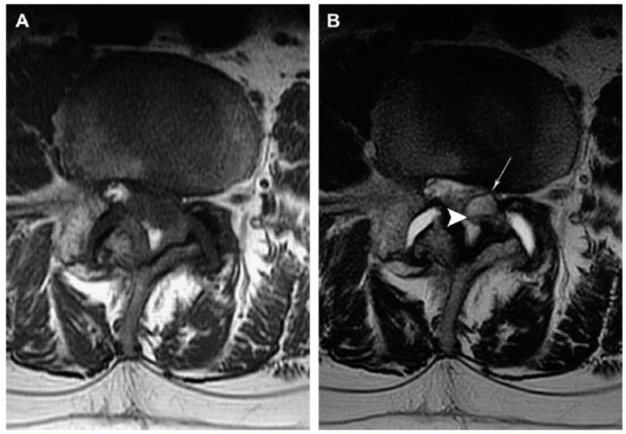

Fig. 10. Hemorrhagic synovial cyst. A 56-year-old man presents with acute left leg and back pain. Axial T1-weighted (*A*) MR image demonstrates bilateral L4-L5 facet osteoarthrosis, but the synovial cyst is difficult to identify because it is isointense to cerebrospinal fluid. Axial T2-weighted MR image (*B*) clearly shows bilateral joint effusions and a well-defined synovial cyst (*white arrow*), with a fluid-blood level (*arrowhead*) arising from the left-sided joint and low-intensity fibrotic rim.

Radiol Clin N Am 50 (2012) 705–730.

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ORIGINAL RESEARCH

The "Thickened" Ligamentum Flavum: Is It Buckling or Enlargement?

F.H. Chokshi
R.M. Quencer
W.R.K. Smoker

BACKGROUND AND PURPOSE: Thickening of the LF is ascribed to buckling due to DSN. Uncertainty exists as to whether this can occur without DSN. Our primary hypothesis was that facet degenerative changes alone, independent of DSN, can thicken the LF. Our secondary hypothesis was that inflammatory changes surrounding degenerative facet joints may incite thickening.

MATERIALS AND METHODS: Fifty-two patients were divided into 1 of 3 groups: group 1 (normal lumbar spine, $n = 21$), group 2 (LF thickening and FH with normal height of the L4–5 disk, $n = 18$), and group 3 (LF thickening and FH with decreased height of the L4–5 disk, $n = 13$). LF thickness measured on axial T1WI at the midpoint of the LF length was compared with that in group 1. Facet joints were evaluated for spurring, joint fluid, and cortical irregularity, indicating facet degeneration. Enhancement of the facet joints and LF thickening were also evaluated ($n = 2$). The Student *t* test was used to compare groups.

RESULTS: Normal LF thickness (group 1) was 3.1 mm, whereas LF thickness averaged 4.9 mm in group 2 and 5.3 mm in group 3 (both $P < .001$). Patients with asymmetric LF thickness showed greater LF thickness on the side with greater FH. There was more LF enhancement on the side with greater facet degenerative disease.

CONCLUSIONS: LF thickening can be secondary to facet degenerative changes, independent of DSN. Inflammatory changes may be an inciting factor for LF thickening.

ABBREVIATIONS: DDD = degenerative disk disease; DSN = disk space narrowing; FH = facet hypertrophy; LF = ligamentum flavum; T1WI = T1-weighted imaging

AJNR Am J Neuroradiol 31:1813–16 | Nov-Dec 2010 | www.ajnr.org

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Conclusions

- Our investigation supports our primary hypothesis that adjacent facet degenerative changes alone, in the absence of disc space narrowing, can cause thickening of the LF.
- Moreover, post-contrast images of LF thickening and FH support our secondary hypothesis that inflammatory changes surrounding the degenerative facet joint may be the inciting etiology of this thickening.

AJNR Am J Neuroradiol 31:1813–16 | Nov-Dec 2010 | www.ajnr.org

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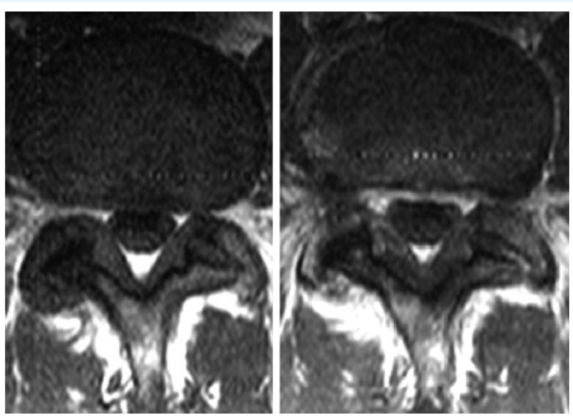

Fig 5. Pre- (left) and postcontrast (right) axial T1WIs at L4–5, show asymmetric thickening of the LF and FH, with subtle enhancement of the LF adjacent to the hypertrophied facet joint. Subtle enhancement of the lateral aspect of the left facet joint is also seen.

AJNR Am J Neuroradiol 31:1813–16 | Nov-Dec 2010 | www.ajnr.org

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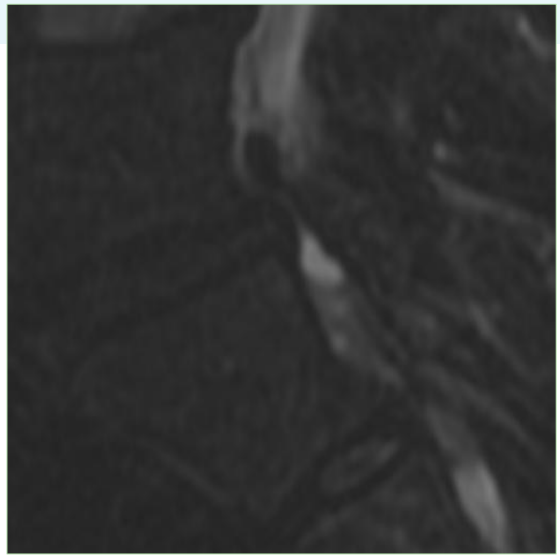

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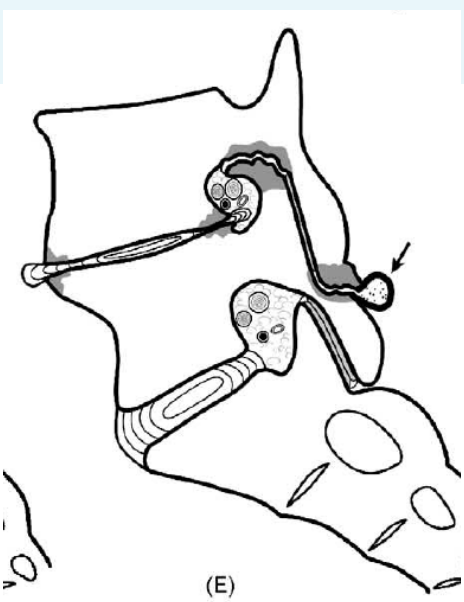

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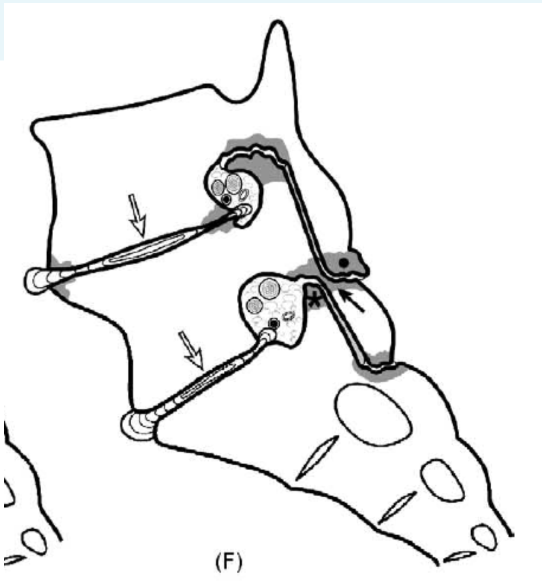

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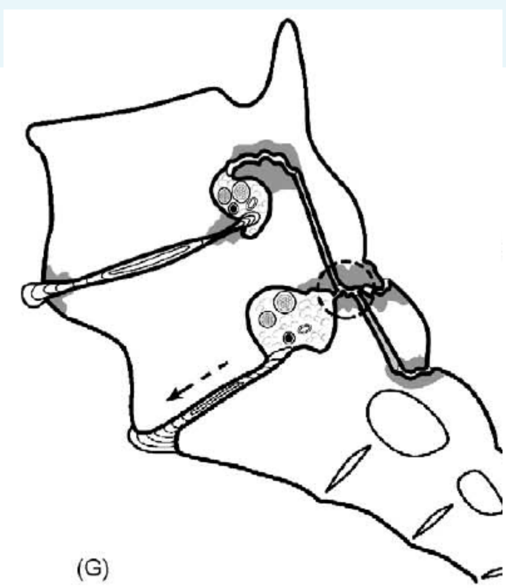

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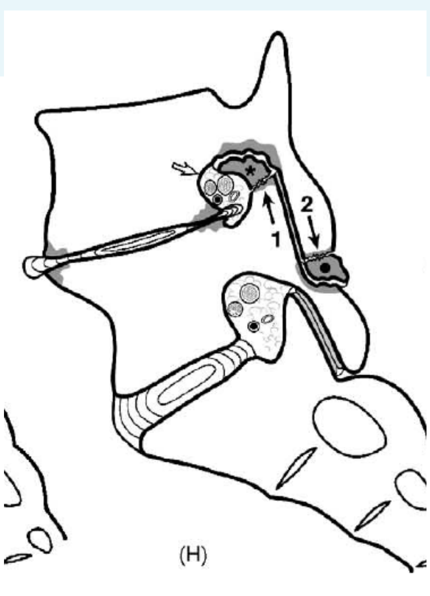

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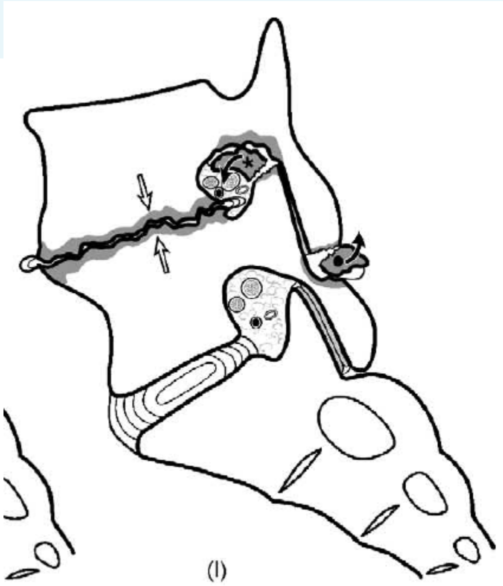

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Journal of Healthcare Engineering
Volume 2022, Article ID 2486745, 7 pages
https://doi.org/10.1155/2022/2486745

Hindawi

Research Article

A Systematic Review and Meta-Analysis of the Facet Joint Orientation and Its Effect on the Lumbar

Zhirui Zheng, Youqiang Wang, Tong Wang, Yue Wu, and Yuhui Li

The Second Affiliated Hospital of Harbin Medical University Orthopedic Surgery Three Ward, Harbin, China

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Received 4 November 2021; Revised 21 December 2021; Accepted 10 January 2022; Published 22 February 2022

- Therefore, it was observed that facet tropism is related to lumbar disc herniation and degenerative lumbar spondylolisthesis.
- Our meta-analysis demonstrated a unique link between the facet tropism and the lumbar disk degeneration along with degenerative lumbar spondylolisthesis.

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Peri-Articular Edema and Synovitis on Imaging

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PAIN MEDICINE
Volume 9 • Number 4 • 2008

SPINE SECTION

Original Research Article

Fat-Saturated MR Imaging in the Detection of Inflammatory Facet Arthropathy (Facet Synovitis) in the Lumbar Spine

Leo F. Czervionke, MD, and Douglas S. Fenton, MD
Mayo Clinic Jacksonville, Department of Radiology, Jacksonville, Florida, USA

Conclusion. Facet synovitis is a common condition and appears to correlate with the patient's pain. Detection of active inflammatory facet osteoarthropathy (facet synovitis) within and surrounding the facet joints is possible with MR imaging using a fat-saturation technique.

PAIN MEDICINE. Volume 9 • Number 4 • 2008

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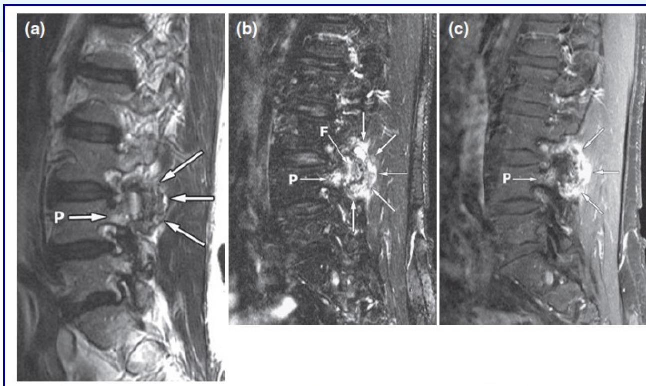

Figure 1 Facet synovitis: the value of sagittal fat-saturated imaging. (a) Right parasagittal T2-weighted spin echo image, obtained without fat saturation, shows enlargement (hypertrophy) of the right L3-4 articular processes and facets (arrows), secondary to osteoarthritis, with thickening of the capsule of the facet joint. Subtle T2 signal hyperintensity is seen in the affected facets as well as in the right L4 pedicle. (b) Right parasagittal T2-weighted fast spin echo image with fat saturation, corresponding to (a). "Hot facet" appearance: intense enhancement in the perifacetal soft tissues (arrows), L3-4 facets (F), and L4 pedicle (P) indicating grade 4 facet synovitis. (c) Right parasagittal contrast-enhanced T1-weighted spin echo image, corresponding to image (a), obtained with fat suppression shows intense enhancement of the right L3-4 perifacetal soft tissues (arrows) adjacent to the enlarged facets and enhancement of the right L4 pedicle (P).

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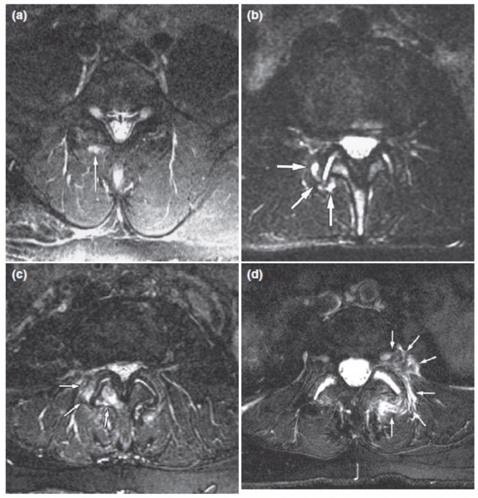

Figure 2 Grading facet synovitis: fat-saturated T2-weighted imaging. (a) Grade 1. Small T2 hyperintensity (arrow) in the posterior-inferior capsule of the right L4-5 facet joint represents earliest sign of facet synovitis. (b) Grade 2. T2 signal hyperintensity (arrows) in posterior portion of right L3-4 facets involves less than 50% of the facet joint perimeter. (c) Grade 3. T2 signal hyperintensity (arrows) involves greater than 50% of facets as well as the right L4 lamina. (d) Grade 4. Extensive abnormal T2 signal (arrows) involves and surrounds the L4-5 facets on the left with abnormal T2 hyperintense tissue within and lateral to the left L5-S1 neural foramen. Note more fluid than normal in both L5-S1 facet joints.

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Table 1 A grading system for facet synovitis as seen by MR fat-suppression techniques

Grade	Criteria
0	No signal abnormality
1	Signal abnormality confined to joint capsule
2	Periarticular signal abnormality involving less than 50% of the perimeter of the joint*
3	Periarticular signal abnormality involving more than 50% of the perimeter of the joint*
4	Grade 3 with extension of signal abnormality into the intervertebral foramen, ligamentum flavum, pedicle, transverse process, or vertebral body

* Signal abnormality may extend into the articular pillar or lamina, but does not contribute to the definition of the grade.
MR = magnetic resonance.

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Imaging of Posterior Element Axial Pain Generators

Facet Joints, Pedicles, Spinous Processes, Sacroiliac Joints, and Transitional Segments

Amy L. Kotsenas, MD

KEYWORDS

• Baastrup disease • Bertolotti syndrome • Facet synovitis • Fat-suppressed MR imaging • ^{18}F-FDG PET/CT • Interspinous bursitis • Posterior elements • SPECT

KEY POINTS

- The role of the posterior elements in generating axial back and neck pain is well established.
- Morphologic imaging findings are nonspecific and are frequently present in asymptomatic patients.
- Edema, inflammation, and hypervascularity are more specific for sites of pain generation.
- Physiologic imaging techniques such as fat-suppressed magnetic resonance imaging, single-photon emission computed tomography (CT), or ^{18}F-fluorodeoxyglucose positron emission tomography combined with CT are more sensitive for edema, inflammation, and hypervascularity than morphologic imaging alone.

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Box 4
Grading facet synovitis

Grade: Signal Abnormality/Enhancement Criteria

- 0: None
- 1: Confined to join capsule
- 2: Periarticular <50% of joint perimeter
- 3: Periarticular >50% of joint perimeter
- 4: Extension to foramen, ligamentum flavum, pedicle, transverse process, or vertebral body

Adapted from Czervionke LE, Fenton DS. Fat-saturated MR imaging in the detection of inflammatory facet arthropathy (facet synovitis) in the lumbar spine. Pain Med 2008;9(4):400–6; with permission.

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Box 1
Posterior element pain generators

- Facet joints
- Ligamentum flavum
- Pedicles and pars interarticularis
- Spinous processes and interspinous ligaments
- Transitional lumbosacral segments and pseudoarticulations
- Sacroiliac joints

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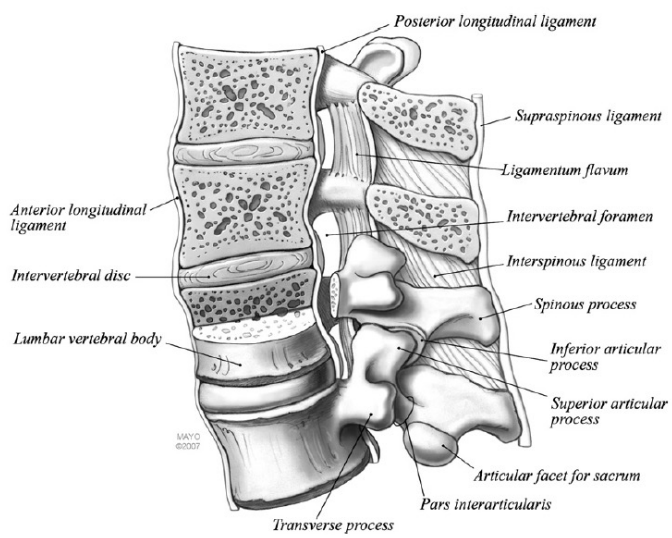

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Box 2
Physiologic imaging techniques

- Fat-suppressed MR imaging techniques
  - Short T1 inversion recovery (STIR)
  - Fat-saturation fast spin-echo (FSE) T2-weighted or contrast-enhanced (CE) T1-weighted
  - Water-excitation FSE T2-weighted or CE T1-weighted
  - 3-point Dixon water-fat separation (IDEAL)
- Nuclear medicine bone scintigraphy
- ^{18}F-fluorodeoxyglucose positron emission tomography combined with CT (FDG-PET/CT)
- Weight-bearing/axial-loading imaging

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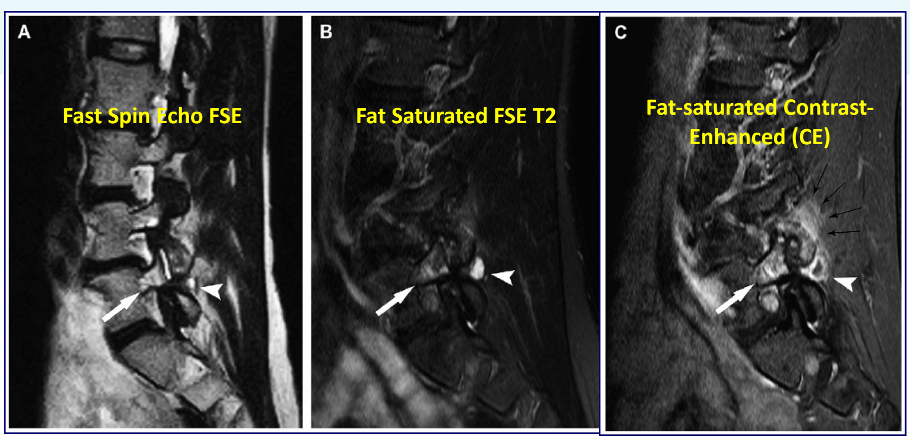

Fat-suppression MR techniques. A 45-year-old woman presents with LBP worse with sitting. L5 pedicle edema (white arrow) and posterior L4-L5 facet synovial cyst (white arrowhead) are poorly visualized on standard fast spin-echo (FSE) T2-weighted sagittal sequence (A), and are much better demonstrated on fat-saturated FSE T2-weighted (B) and fat-saturated contrast-enhanced (CE) T1-weighted sagittal images (C). The fat-saturated CE T1-weighted sagittal sequence (C) best demonstrates facet edema and extensive periarticular soft tissue inflammation (black arrows).

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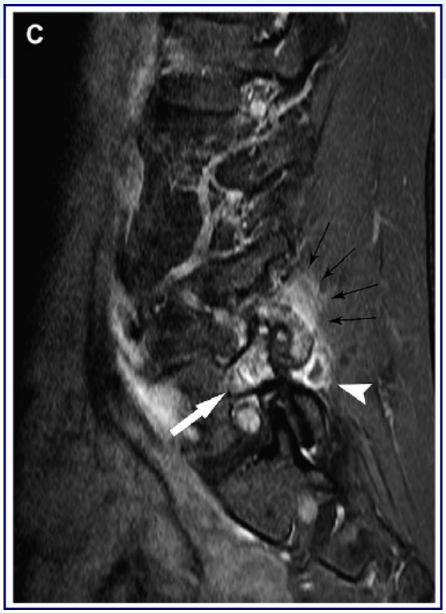

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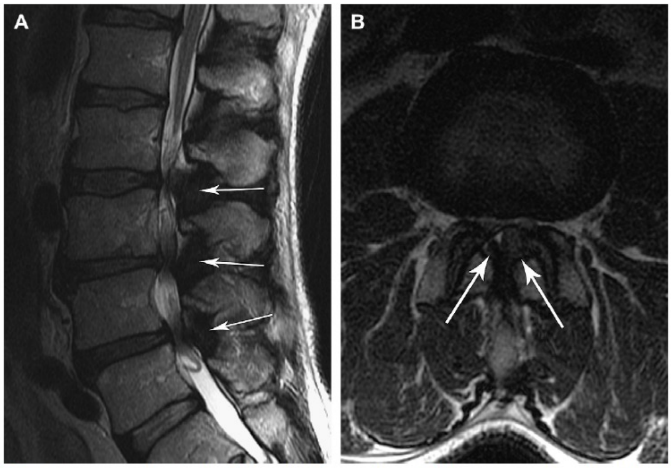

Fig. 7. Facet joint osteoarthrosis and spinal stenosis. A 67-year-old man with low back pain and weakness in both legs exacerbated with walking. Sagittal (*A*) and axial (*B*) FSE T2-weighted MR images demonstrate multilevel loss of disc space height with resultant redundancy of the ligamentum flavum (*arrows*), causing severe spinal stenosis at each level.

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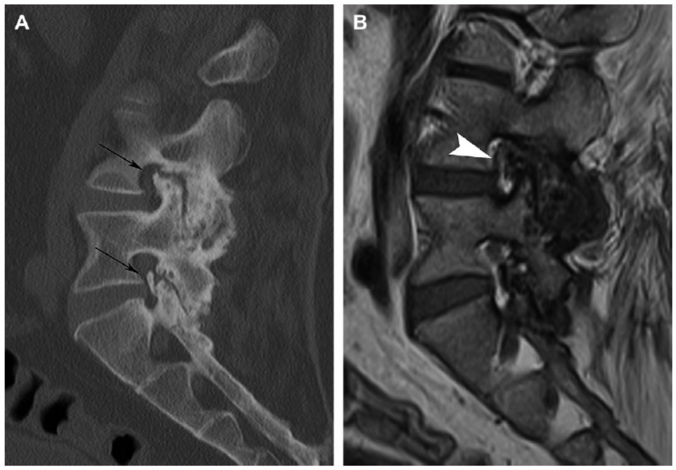

Fig. 8. Superior articular facet osteophytes. A 47-year-old man imaged for right-sided radiculopathy. Sagittal CT (*A*) and sagittal FSE T2-weighted MR (*B*) images demonstrate osteophytes from the right superior articular facets at L5 and S1 (*arrows*) with impingement of the exiting L4 nerve root (*arrowhead*).

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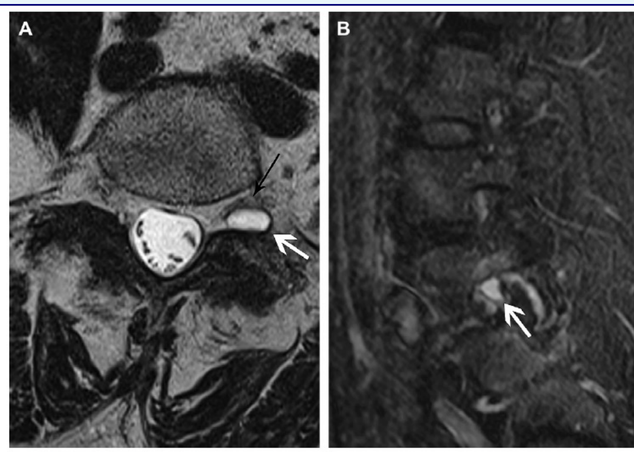

Fig. 9. Synovial cyst in the neural foramen. A 50-year-old woman presents with LBP radiating down the left leg to the foot. Axial FSE T2-weighted sequence (*A*) shows a cystic structure in the left L5 neural foramen (*white arrow*) compressing the exiting nerve root (*black arrow*). Sagittal STIR sequence (*B*) more clearly demonstrates that the cyst (*white arrow*) arises from a degenerated facet joint with associated synovial effusion, pedicle and periarticular soft-tissue edema.

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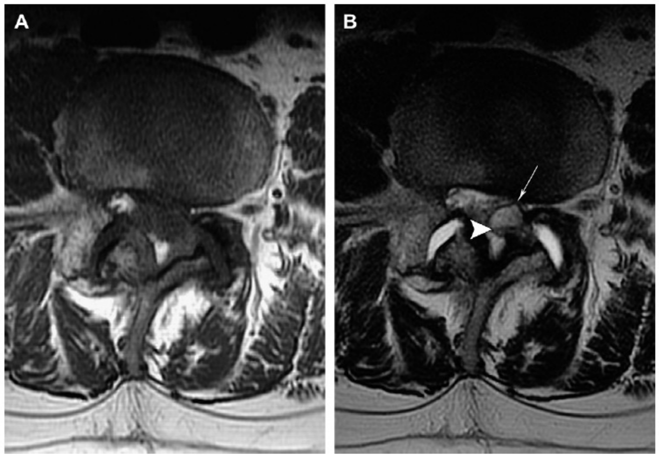

Fig. 10. Hemorrhagic synovial cyst. A 56-year-old man presents with acute left leg and back pain. Axial T1-weighted (*A*) MR image demonstrates bilateral L4-L5 facet osteoarthrosis, but the synovial cyst is difficult to identify because it is isointense to cerebrospinal fluid. Axial T2-weighted MR image (*B*) clearly shows bilateral joint effusions and a well-defined synovial cyst (*white arrow*), with a fluid-blood level (*arrowhead*) arising from the left-sided joint and low-intensity fibrotic rim.

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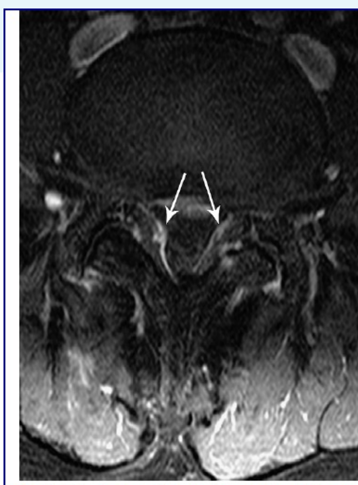

Fig. 11. Ligamentum flavum degenerative inflammation. A 84-year-old man presents with axial LBP. Axial fat-suppressed CE T1-weighted sequence demonstrates enhancement of bilateral ligamentum flavum (*white arrows*). Note bilateral facet osteoarthrosis and grade 2 facet synovitis.

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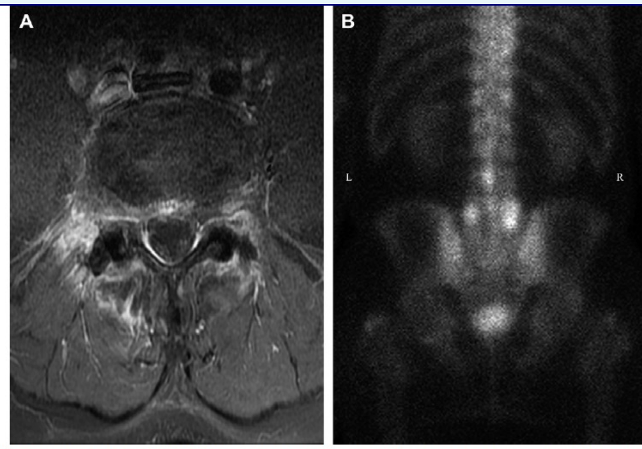

Fig. 13. Facet synovitis, grade 4. A 74-year-old man with a history of prostate carcinoma and right lower lumbar mechanical pain Axial fat-suppressed CE T1-weighted MR image (A) shows bilateral facet osteoarthrosis, and grade 4 synovitis on the right at the L4-L5 level, with extensive periarticular inflammatory enhancement extending into the right neural foramen. Grade 3 synovitis is present on the left. Radionuclide bone scan (B) in the PA projection demonstrates increased radionuclide uptake at the level of the L4-L5 facet joints, greater on the right. (*Courtesy of* Timothy Maus, MD, Mayo Clinic, Rochester, MN; with permission.)

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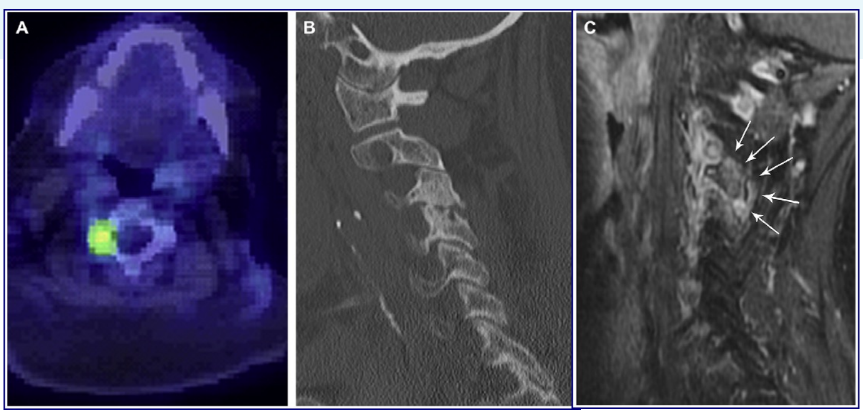

FDG-PET/CT facet synovitis. A 68-year-old man with a history of small cell lung carcinoma presents with right neck pain. Axial FDG-PET/CT image (A) shows increased radiotracer uptake on the right at C4-C5. Sagittal CT (B) demonstrates facet osteoarthrosis with subchondral sclerosis and cysts. Fat-suppressed CE T1-weighted MR image (C) demonstrates facet synovitis with bone marrow edema and periarticular soft-tissue inflammation (white arrows).

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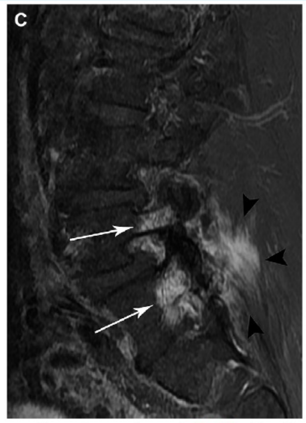

Fig. 15. Pedicle edema. A 74-year-old man (same patient as in Fig. 13) with a history of prostate carcinoma and right lower lumbar mechanical pain. Sagittal FSE T2-weighted image (*A*) demonstrates bone marrow edema in the right L4 and L5 pedicles (*white arrows*) without frank fracture line; facet synovitis is not appreciated. Sagittal fat-suppressed FSE T2-weighted (*B*) and CE T1-weighted (*C*) images also clearly demonstrate pedicle marrow edema (*white arrows*), but also clearly depict facet synovitis and extensive periarticular soft tissue inflammation and enhancement (*black arrowheads*).

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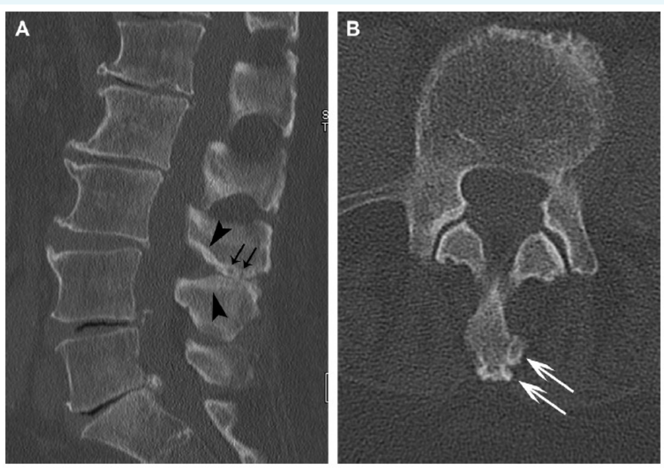

Fig. 16. Baastrup phenomenon. A 85-year-old man presents with chronic LBP and right leg pain. Sagittal (*A*) and axial CT (*B*) images demonstrate contact between the L3 and L4 spinous processes with subchondral sclerosis (*arrowheads*), erosions (*black arrows*), appositional flattening, and marginal osteophytes (*white arrows*).

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Baastrup phenomenon and interspinal bursitis. A 84-year-old man presents with LBP and neurogenic claudication. Sagittal fat-suppressed T1- weighted MR image shows multilevel interspinous (arrowheads) and supraspinous (arrows) ligament degenerative inflammation and enhancement.

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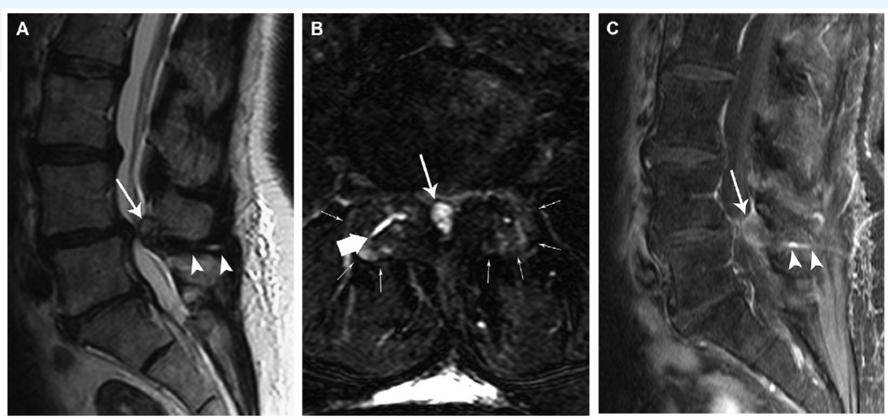

Fig. 18. Interspinal bursitis and midline epidural cyst. A 59-year-old woman with a history of breast cancer presents with back pain radiating to left buttock exacerbated in the upright position. Sagittal FSE T2-weighted image (*A*) shows fluid in the interspinous space (*arrowheads*) tracking to a poorly visualized midline posterior epidural cyst (*white arrows*). Axial fat-suppressed FSE T2-weighted image (*B*) better demonstrates the midline posterior epidural cyst (*arrow*), concurrent bilateral facet synovitis (*thick white arrow*), and right facet joint effusion (*small white arrows*). Enhancement in the interspinal space (*arrowheads*) and at the periphery of the midline epidural cyst (*arrow*) is well seen on the sagittal fat-suppressed CE T1-weighted image (*C*).

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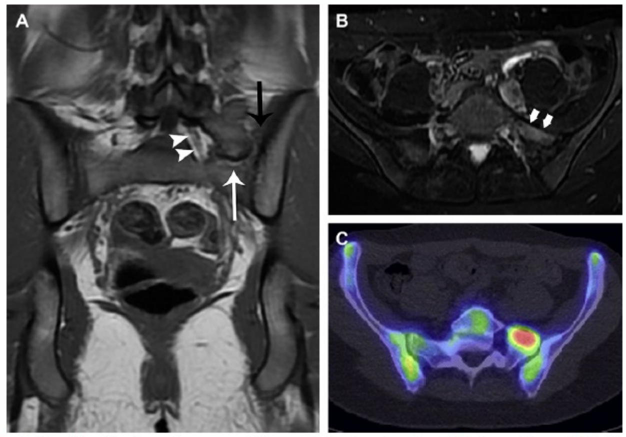

Fig. 19. Transitional lumbosacral segment. A 17-year-old female patient imaged for 1-year history of left-sided LBP. Coronal T1-weighted image (*A*) shows left-sided transitional lumbosacral segment articulating with both the sacrum (*white arrow*) and iliac wing (*black arrow*). The coronal plane clearly depicts the exiting nerve root (*white arrowheads*). Axial fat-suppressed FSE T2-weighted sequence (*B*) demonstrates marrow edema in the enlarged transverse process at the transitional level (*thick white arrows*), and there is increased radiotracer uptake in this region on radionuclide SPECT fused with CT (*C*). (*Courtesy of* Timothy Maus, MD, Mayo Clinic, Rochester, MN; with permission.)

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Box 5
Importance of clinical context

Axial, nonradicular pain → seek out a posterior element cause

Additional suggestive findings:

- Morning back stiffness
- Decreased range of motion
- Mechanical pain with extension, flexion, or rotation maneuvers
- Pain to palpation over facet joints and spinous processes

Patient age

- Young → more likely discogenic
- Older → more likely posterior elements

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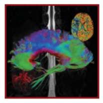

Imaging of Degenerative and Infectious Conditions of the Spine

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Imaging is important in the evaluation of patients with degenerative disease and infectious processes. There are numerous conditions that can manifest as low back pain (LBP) or neck pain in a patient, and in many cases, the cause may be multifactorial. Clinical history and physical examination are key components in the evaluation of such patients; however, physical examination has variable sensitivity and specificity. Although studies have demonstrated that uncomplicated acute LBP and/or radiculopathy are self-limited conditions that do not warrant any imaging, neuroimaging can provide clear anatomic delineation of potential causes of the patient's clinical presentation. Various professional organizations have recommendations for imaging of LBP, which generally agree that an imaging study is not indicated for patients with uncomplicated LBP or radiculopathy without a red flag (eg, neurological deficit such as major weakness or numbness in lower extremities, bowel or bladder dysfunction, saddle anesthesia, fever, history of cancer, intravenous drug use, immunosuppression, trauma, or worsening symptoms). Different imaging modalities have a complementary role in the diagnosis of pathologies affecting the spine. In this review, we discuss the standard nomenclature for lumbar disk pathology and the utility of various clinical imaging techniques in the evaluation of LBP/neck pain for potential neurosurgical management. The imaging appearance of spinal infections and potential mimics also is reviewed. Finally, we discuss advanced neuroradiological techniques that offer greater micro-structural and functional information.

KEY WORDS: CT, Degenerative disease, Infectious disease, MRI, Spinal infection

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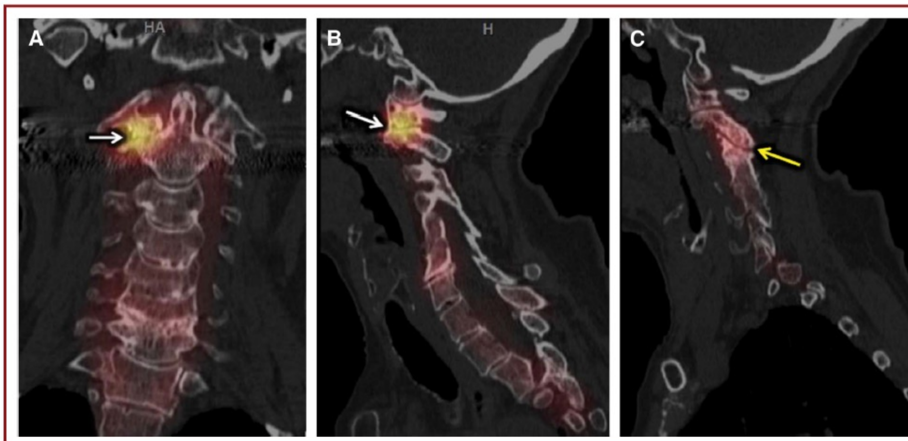

FIGURE 10. *Fused SPECT/CT images in the (A) coronal and parasagittal (B) right and (C) left planes display the significant increased radionuclide uptake in the right C1-C2 facet joint (white arrows) and moderate uptake in the left C2-C3 facet joint (yellow arrow). This modality can help localize pain generators, which is helpful in the setting of severe spondylosis.*

Neurosurgery 79:315–335, 2016

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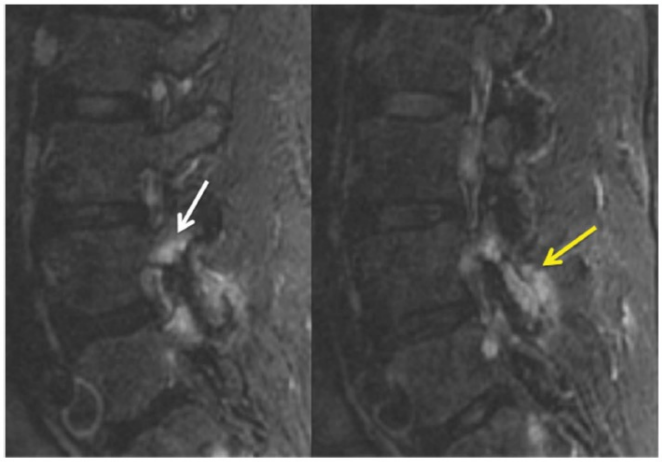

FIGURE 12. Parasagittal STIR images display edema in the L4 and L5 pedicles (left, white arrow) and the L4-L5 facet joint (right, yellow arrow) caused by a stress reaction.

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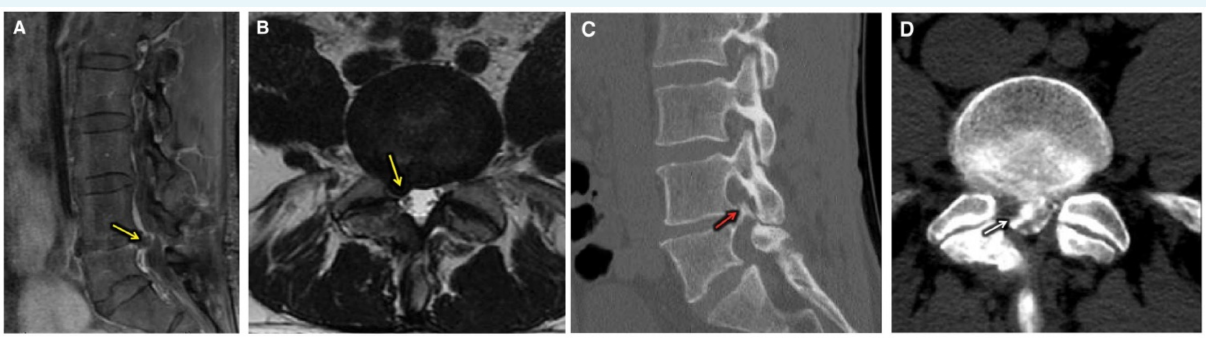

FIGURE 13. *A, sagittal postcontrast T1-weighted, fat-saturated image and (B) axial T2-weighted image show soft tissue protruding from the L4-L5 disk space into the right subarticular zone (yellow arrows). C, CT myelogram sagittal reconstruction better delineates the osteophytic component (red arrow) impinging on the transiting L5 nerve. The edematous right L5 nerve can be precisely followed along its course on the (D) axial CT myelogram (white arrow).*

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How Does Chiropractic Work?

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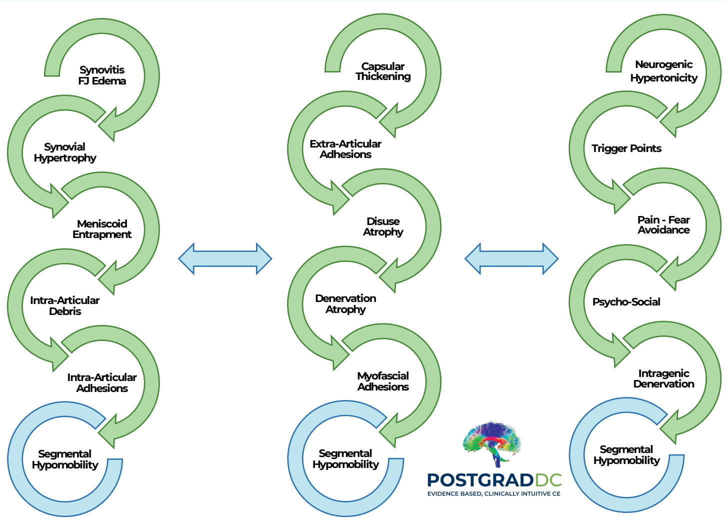
Intra-Articular Segmental Hypomobility | **Extra-Articular** Segmental Hypomobility | **Neurogenic** Segmental Hypomobility



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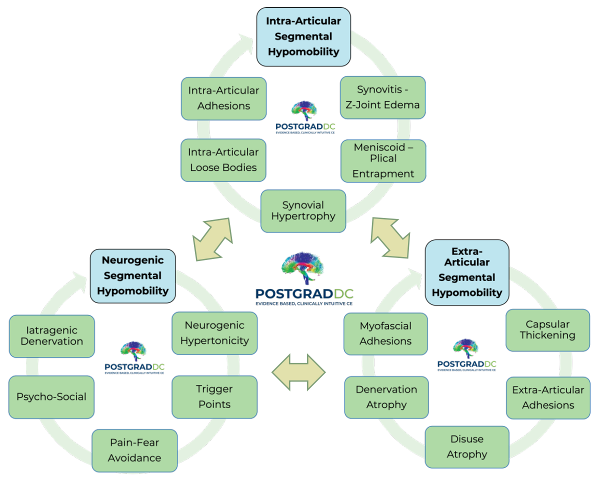
How Chiropractic Works



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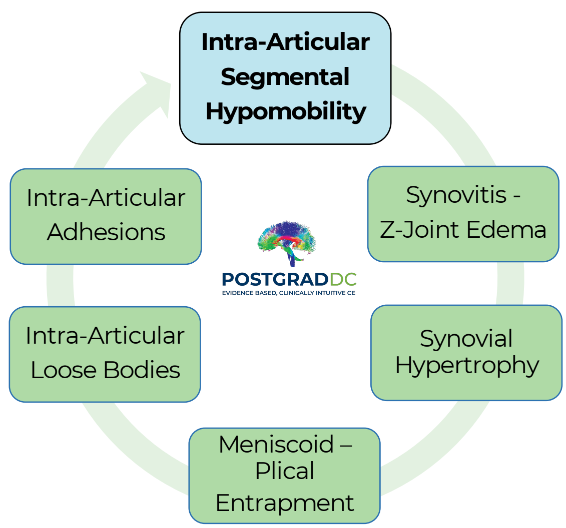
How Chiropractic Works – <u>Intra-Articular</u> Segmental Hypomobility



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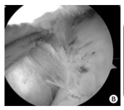
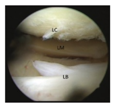
How Chiropractic Works – Intra-Articular Segmental Hypomobility

Segmental Hypomobility



Knee Surg Relat Res 2013;25(4):202-206.

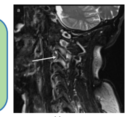
Intra-Articular Adhesions



Gaillard, F. Intra-articular loose bodies. Radiopaedia.org.

Intra-Articular Loose Bodies

Synovitis - Z-Joint Edema



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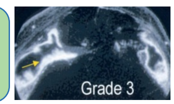
Synovial Hypertrophy



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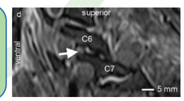

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How Chiropractic Works – Extra-Articular Segmental Hypomobility

Extra-Articular Segmental Hypomobility

Capsular Thickening

Extra-Articular Adhesions

Disuse Atrophy

Denervation Atrophy

Myofascial Adhesions

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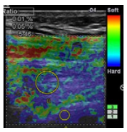
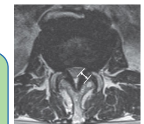
How Chiropractic Works – Extra-Articular Segmental Hypomobility

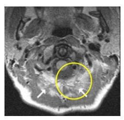
Extra-Articular Segmental Hypomobility


JB & MT (2013) 17,356-364.

Myofascial Adhesions

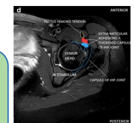
Capsular Thickening


Yoshiiwa et al. (2016) ASJ / *10*, 1132 - 1140.

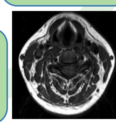

Richard Hallgren, PhD.

Denervation Atrophy

Extra-Articular Adhesions


Skeletal Radiol (2021) 50:2541–2548.

Disuse Atrophy


Elliott: Spine, (2006) 31(22)..E847-E855.

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How Chiropractic Works – Neurogenic Segmental Hypomobility

Neurogenic Segmental Hypomobility

Iatragenic Denervation

Neurogenic Hypertonicity

Psycho-Social

Trigger Points

Pain-Fear Avoidance

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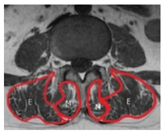
How Chiropractic Works – Neurogenic Segmental Hypomobility

Neurogenic Segmental Hypomobility

Iatrogenic Denervation



Fu et al. 2020. Scientific Reports 10.

Neurogenic Hypertonicity

Causes
Spasticity is generally caused by damage or disruption to the area of the brain and spinal cord that are responsible for controlling muscle and stretch reflexes. These disruptions can be due to an imbalance in the inhibitory and excitatory signals sent to the muscles, causing them to lock in place.

https://www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Spasticity

Psycho-Social

Editorial

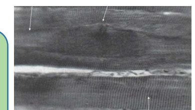
Psychosocial factors in low back pain: letting go of our misconceptions can help management

Mary O'Keeffe [1,2], Steven Z George [3], Peter B O'Sullivan [4,5], Kieran O'Sullivan [6,7]

Correspondence to Dr. Mary O'Keeffe, Faculty of Medicine and Health, School of Public Health, University of Sydney, Sydney, NSW 2050, Australia;

dx.doi.org/10.1136/bjsports-2018-099816

Trigger Points



Travell and Simons' The Trigger Point Manual.. 1999.

Pain-Fear Avoidance

The Journal of Pain, Vol 19, No 11 (November), 2018: pp 1352–1365
Available online at www.jpain.org and www.sciencedirect.com

Brain Mechanisms of Anticipated Painful Movements and Their Modulation by Manual Therapy in Chronic Low Back Pain

Dan-Mikael Ellingsen, Vitaly Napadow, Ekaterina Protsenko, Ishtiaq Mawla, Matthew H. Kowalski, David Swensen, Deanna O'Dwyer-Swensen, Robert R. Edwards, Norman Kettner, and Marco L. Loggia

A. A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, School of Medicine, University of California, San Francisco, California, Neuroscience Graduate Program, University of Michigan Medical School, Ann Arbor Michigan, Osher Integrative Care Center, Brigham and Women's Hospital, Boston, MA, Massachusetts, Melrose Family Chiropractic & Sports Injury Centre, Melrose, Massachusetts, Department of Anesthesiology, Harvard Medical School, Brigham & Women's Hospital, Boston, Massachusetts, Department of Radiology, Logan University, Chesterfield, Missouri

Ellingsen et al. (2018) Journal of Pain.

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Synovitis and Synovial Hypertorphy

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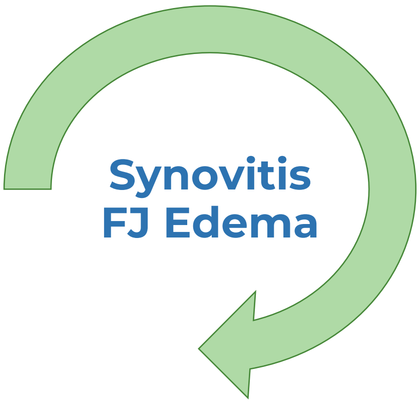
Intra-Articular Segmental Hypomobility



> J Manipulative Physiol Ther. 2008 Oct;31(8):593-601. doi: 10.1016/j.jmpt.2008.09.008.

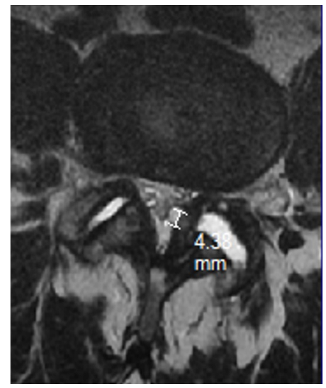
Interexaminer reliability of T2-weighted magnetic resonance imaging for lumbar bright facet sign

Gary A Longmuir [1], Raymond N Conley

Affiliations + expand

PMID: 18984242 DOI: 10.1016/j.jmpt.2008.09.008

https://dx.doi.org/10.1594/ecr2016/C-1225



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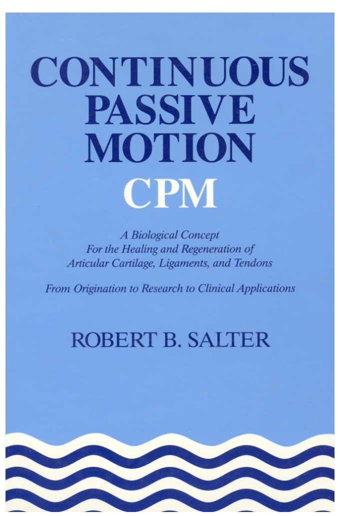
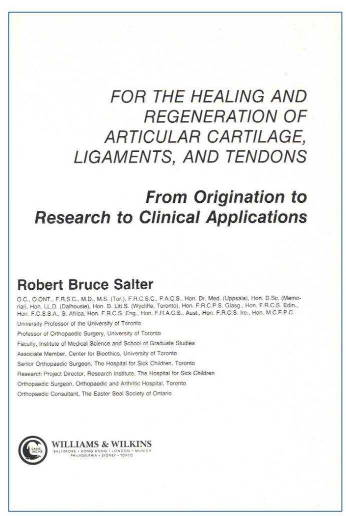
Robert Salter, MD





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Reactions of Synovial Membrane

- The synovial membrane, which secrete synovial fluid for both nutrition and lubrication of the articular cartilage, is capable of reacting to abnormal conditions in one or more of three ways:
  - By producing an excessive amount of fluid (effusion),
  - By becoming thicker (hypertrophy),
  - By forming intra-articular adhesions between itself and the articular cartilage.
- A joint effusion may be serous, inflammatory or hemorrhagic.

Salter: Continuous Passive Motion

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Reactions of Synovial Membrane

- A joint effusion may be serous, inflammatory or hemorrhagic.
- **All but the transient effusions cause a second reaction in the synovial membrane, namely varying degrees of synovial hypertrophy.**
- **Synovial adhesions can also form, especially as the result of a <u>prolonged limitation of joint motion from any cause,</u>** including prolonged immobilization of the abnormal.
- This explains the well-known clinical observation that prolonged immobilization of a diseased or injured joint is more likely to lead to persistent joint stiffness.

Salter: Continuous Passive Motion

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Reaction of the Synovial Membrane

- Small fragments of abraded that cartilage may float in the synovial fluid as loose bodies but tend to become incorporated in the synovial membrane which, in turn, reacts by undergoing hypertrophy and producing a moderate synovial effusion.
- The synovial fluid of such an effusion has an increased mucin content and consequently exhibits increased viscosity.
- The fibrous capsule becomes greatly thickened and fibrotic thereby limiting joint motion even further.

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Intra-Articular Segmental Hypomobility

Synovial Hypertrophy

MRI

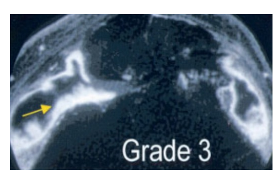
Suggested MR imaging for assessment of synovial disease include T1 weighted images before and after intravenous contrast as well as T2 weighted fat saturated or STIR images in at least two different planes.

In the setting of synovial hyperplasia, the synovium will be thickened and show avid enhancement after contrast administration [1]. For the matter, the inflammatory activity is best reflected by early enhancement.

A correlation between the synovial volume and joint swelling and tenderness or synovial inflammatory activity has been shown [1,8,9].

Signal characteristics

- **T1:** hypointense
- **T2:** hyperintense
- **T2FS/PDFS:** hyperintense
- **T1 C+ (Gd):** enhancement



Feger, J. Synovial hyperplasia. Reference article, Radiopaedia.org. (accessed on 13 Jun 2022) https://doi.org/10.53347/rID-81410

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Meniscoids, Plica and Cartilage

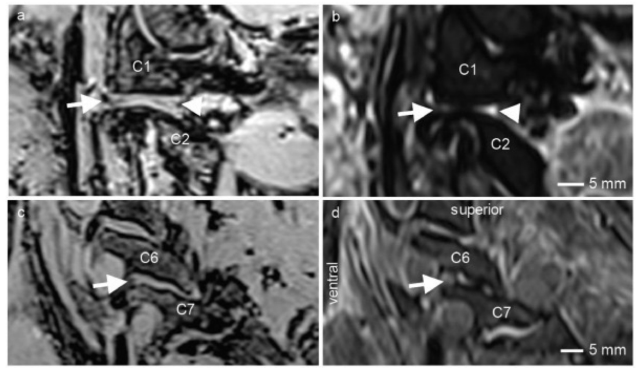
Peripheral Proliferation

- The peripheral rim of articular cartilage of a synovial joint, is covered by a type of perichondrium which is continuous with the synovial membrane.
- In the presence of cartilage degeneration, the peripheral perichondrium proliferates and gradually produces an almost complete peripheral rim (which in any single radiographic projection resembles a lip or a spur).
- Subsequently, it's deeper part undergoes endochondral ossification (osteophyte formation).
- This explains why osteophytes associated with degenerative joint disease are always covered with cartilage.

Salter: Continuous Passive Motion

Intra-Articular Segmental Hypomobility

Meniscoid - Plical Entrapment



Farrell et al. JMPT, 43, 6, 2020: 579-587.

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Hayashi *et al. BMC Musculoskeletal Disorders* 2013, **14**:292
http://www.biomedcentral.com/1471-2474/14/292

BMC Musculoskeletal Disorders

RESEARCH ARTICLE **Open Access**

Prevalence of MRI-detected mediopatellar plica in subjects with knee pain and the association with MRI-detected patellofemoral cartilage damage and bone marrow lesions: data from the Joints On Glucosamine study

Daichi Hayashi[1,2*], Li Xu[1,3], Ali Guermazi[1], C Kent Kwoh[4,5], Michael J Hannon[4], Mohamed Jarraya[1], Stephanie M Green[4], John M Jakicic[6], Carolyn E Moore[7] and Frank W Roemer[1,8]

* Correspondence: dhayashi@bu.edu
[1]Quantitative Imaging Center, Department of Radiology, Boston University School of Medicine, FGH Building 3rd Floor, 820 Harrison Avenue, Boston, MA 02118, USA
[2]Department of Radiology, Bridgeport Hospital, Yale University School of Medicine, Bridgeport, CT 06610, USA
Full list of author information is available at the end of the article

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- The mediopatellar plica is a synovial fold representing in embryonic remnant from the developmental process of the synovial cavity formation in the knee.
- It can be directly visualized by arthroscopy, but can also be evaluated noninvasively using conventional MRI.
- Asymptomatic synovial plicae may be found within structurally normal knee joints.
- However, direct trauma, repetitive sports activities, or other pathologic knee conditions may provoke secondary inflammation in the synovial tissues around the plica, and may result in increasing fibrotic changes, loss of elasticity, and varying degrees of synovitis.

Hayashi et al. BMC Musculoskeletal Disorders 2013, 14:292

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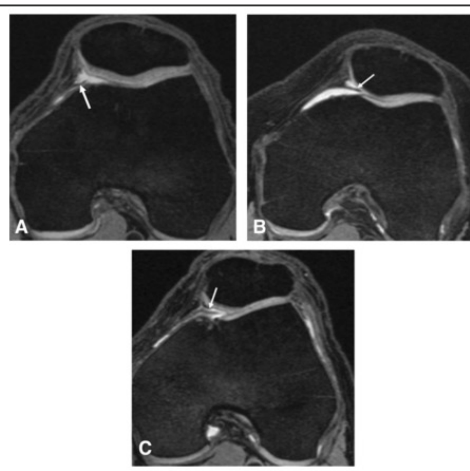

Figure 1 MRI classification scheme of mediopatellar plicae modified from the Sakakibara arthroscopic classification. (A) Type A lesion in the left knee consisting of a cord-like elevation in the synovial wall; **(B)** Type B lesion in the left knee, which has a shelf-like appearance but does not cover the anterior surface of the medial trochlea; **(C)** Type C lesion in the left knee, which has a large shelf-like appearance and covers the anterior surface of the medial trochlea.

Hayashi et al. BMC Musculoskeletal Disorders 2013, 14:292

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Please say that again

Review

Synovial plicae of the knee joint: the role of advanced MRI

Katerina Vassiou,[1] Marianna Vlychou,[2] Aristidis Zibis,[1] Athina Nikolopoulou,[1] Ioannis Fezoulidis,[2] Dimitrios Arvanitis[1]

Vassiou K, et al. Postgrad Med J 2015;91:35–40.

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- Synovial plicae are normal anatomic structures of the knee that may become symptomatic.
- The MRI is an established technique for evaluating the anatomy of the knee, and it is a valuable tool for detecting plicae because of its high resolution resulting in increased tissue characterization.
- At MRI, knee plicae appear as low intensity structures of variable size and thickness and they are better visualized at fluid sensitive sequences with or without fat suppression.
- The combined use of clinical examination and MRI may also facilitate the diagnosis of fibrotic or inflamed plicae that may be symptomatic.

Vassiou K, et al. Postgrad Med J 2015;91:35–40.

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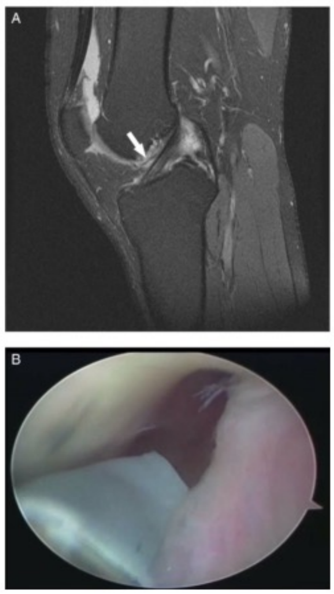

Figure 2 (A) Sagittal MR image with fat suppression shows a linear low-signal-intensity structure anterior and parallel to the anterior cruciate ligament, which represents an infrapatellar plica (arrow). (B) Arthroscopic image of an infrapatellar plica just in front of the anterior cruciate ligament which is not visible.

Vassiou K, et al. Postgrad Med J 2015;91:35–40.

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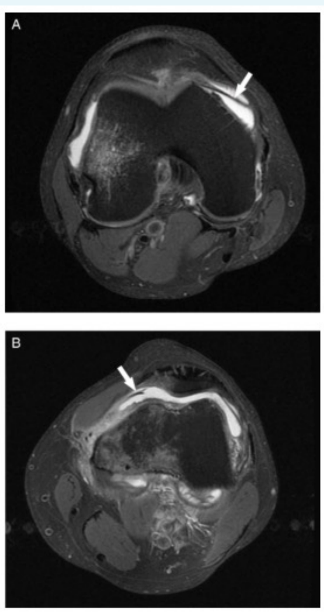

Figure 3 (A) Axial intermediate-weighted MR image with fat suppression reveals a well-demarcated medial plica (arrow) extending toward the midline of the trochlear groove and classified as Sakakibara B. (B) Axial intermediate-weighted MR image with fat suppression indicates a linear structure at the lateral aspect of the suprapatellar pouch that corresponds to a lateral plica (arrow). A medial plica coexists.

Vassiou K, et al. Postgrad Med J 2015;91:35–40.

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- Symptomatic plicae are thickened structures secondary to knee trauma, or other pathologic conditions of the knee.
- The most commonly symptomatic plica is the medial.
- Arthroscopy is considered to be the gold standard for identification of knee plicae.
- The presence of symptomatic plica has been correlated with knee impingement syndromes and early osteoarthritis.

Vassiou K, et al. Postgrad Med J 2015;91:35–40.

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OPEN ACCESS Freely available online PLOS | ONE

Matrix Metalloproteases and Tissue Inhibitors of Metalloproteinases in Medial Plica and Pannus-like Tissue Contribute to Knee Osteoarthritis Progression

Chih-Chang Yang[1], Cheng-Yu Lin[1], Hwai-Shi Wang[1*], Shaw-Ruey Lyu[2,3]

1 Department of Anatomy, National Yang-Ming University, Taipei, Taiwan, R.O.C., 2 Joint Center, Tzu-Chi Dalin General Hospital, Chiayi, Taiwan, R.O.C., 3 Tzu-Chi University, Hualien, Taiwan, R.O.C.

Abstract

Osteoarthritis (OA) is characterized by degradation of the cartilage matrix, leading to pathologic changes in the joints. However, the pathogenic effects of synovial tissue inflammation on OA knees are not clear. To investigate whether the inflammation caused by the medial plica is involved in the pathogenesis of osteoarthritis, we examined the expression of matrix metalloproteinases (MMPs), tissue inhibitors of metalloproteinases (TIMPs), interleukin (IL)-1β, and tumor necrosis factor (TNF)-α in the medial plica and pannus-like tissue in the knees of patients with medial compartment OA who underwent either arthroscopic medial release (stage II; 15 knee joints from 15 patients) or total knee replacement (stage IV; 18 knee joints from 18 patients). MMP-2, MMP-3, MMP-9, IL-1β, and TNF-α mRNA and protein levels measured, respectively, by quantitative real-time PCR and Quantibody human MMP arrays, were highly expressed in extracts of medial plica and pannus-like tissue from stage IV knee joints. Immunohistochemical staining also demonstrated high expression of MMP-2, MMP-3, and MMP-9 in plica and pannus-like tissue of stage IV OA knees and not in normal cartilage. Some TIMP/MMP ratios decreased significantly in both medial plica and pannus-like tissue as disease progressed from stage II to stage IV. Furthermore, the migration of cells from the pannus-like tissue was enhanced by IL-1β, while plica cell migration was enhanced by TNF-α. The results suggest that medial plica and pannus-like tissue may be involved in the process of cartilage degradation in medial compartment OA of the knee.

- Osteoarthritis is characterized by degradation of the cartilage matrix and gradually progresses without any repair of the damaged tissue, leading to pathologic changes in the joints.
- Previous studies on patients with OA of the knee have focused on degradation of the cartilage extracellular matrix.
- More recently, synovial tissue inflammation was also found to be a pathogenetic factor in the OA knee.
- There is evidence for the role of pathologic medial plica in the pathogenesis of medial compartment OA of the knee joint.
- Pannus-like tissue shows dense vascularity and contains aggressive macrophage-like cells and invasive fibroblast like cells.
- These cells, which may originate from the bone marrow or synovial membrane might contribute to cartilage erosion.
- It was recently demonstrated that matrix metalloproteinase (MMP)-3 mRNA and protein are highly expressed in the medial plica and pannus like tissue of the knees of patients with early-stage medial compartment OA.

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Outerbridge Classification

A grading system for joint cartilage breakdown:

Grade 0 - normal

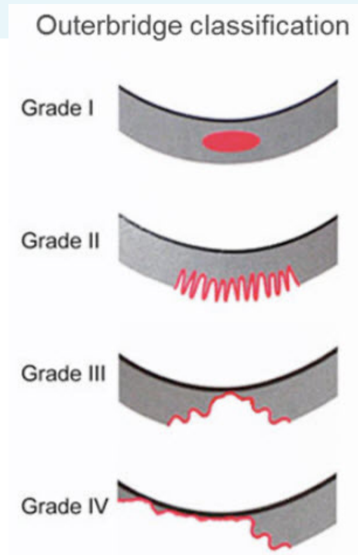
Grade I - cartilage with softening and swelling

Grade II - a partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter

Grade III - fissuring to the level of subchondral bone in an area with a diameter more than 1.5 cm

Grade IV - exposed subchondral bone

Subchondral bone is the bone underneath the white joint cartilage.



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TISSUE ENGINEERING: Part B
Volume 20, Number 6, 2014
© Mary Ann Liebert, Inc.
DOI: 10.1089/ten.teb.2014.0014

Anti-Inflammatory Strategies in Cartilage Repair

Ying Zhang, MS,[1,2] Tyler Pizzute, BS,[1,3] and Ming Pei, MD, PhD[1–3]

[1]Stem Cell and Tissue Engineering Laboratory, Department of Orthopaedics, West Virginia University, Morgantown, West Virginia.
[2]Mechanical and Aerospace Engineering and [3]Exercise Physiology, West Virginia University, Morgantown, West Virginia.

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Intra-Articular Adhesions

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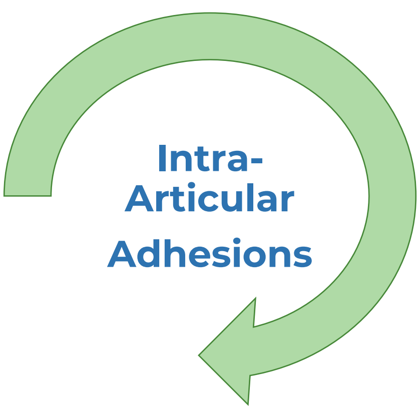
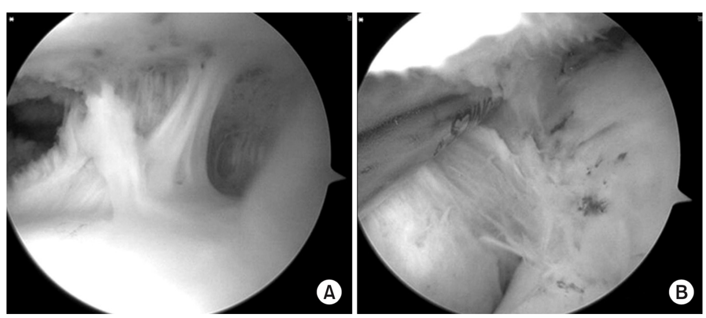
Intra-Articular Segmental Hypomobility





Knee Surg Relat Res 2013;25(4):202-206.

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Intra-Articular Segmental Hypomobility

Intra-Articular Adhesions

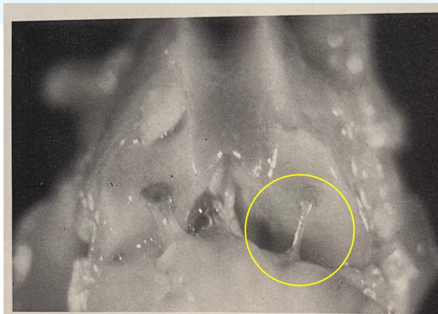

Figure 8.5. Filmy intra-articular adhesions extending from the synovial membrane to full-thickness defects in the medial femoral condyle **(right)** and the lateral femoral condyle **(left)** of an adolescent rabbit's right knee after 3 weeks of immobilization.

Continuous Passive Motion – Robert B. Salter, MD

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Intra-Articular Segmental Hypomobility

Intra-Articular Debris

Intra-articular loose bodies

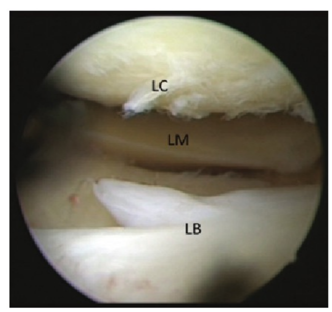
Last revised by Dr Daniel J Bell on 15 Dec 2021

Clinical presentation

Patients may be entirely asymptomatic or complain of pain, clicking and locking, depending on the location and mobility of the fragment as well as any associated secondary degenerative disease, and symptoms from the underlying cause.

Pathology

Intra-articular bodies are composed of cartilage or cartilage and bone and result from any process that leads to disruption of the articular surface. They derive nutrition from synovial fluid and contain any of the cells of bone or cartilage. The surface cells form more cartilaginous layers, so enlarging the body over time. Deeper cells receive less nutrition resulting in cell death and calcification [2].



Gaillard, F., Bell, D. Intra-articular loose bodies. Reference article, Radiopaedia.org. (accessed on 14 Jun 2022) https://doi.org/10.53347/rID-1516

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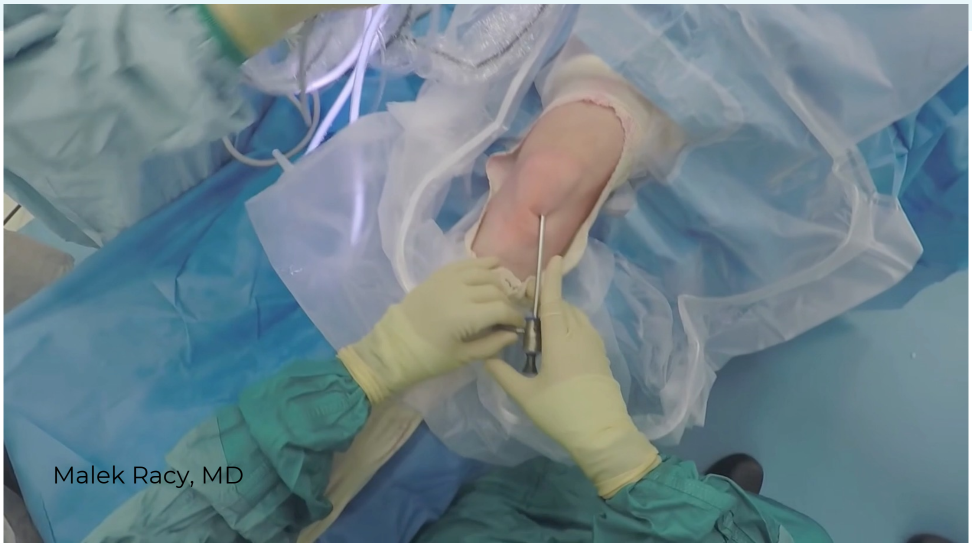

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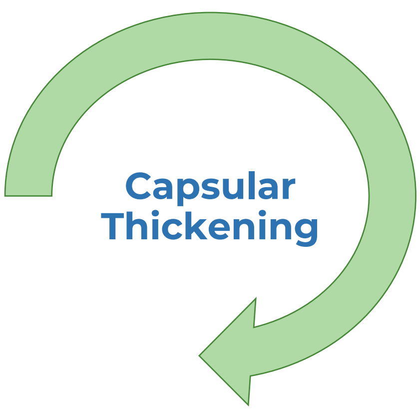
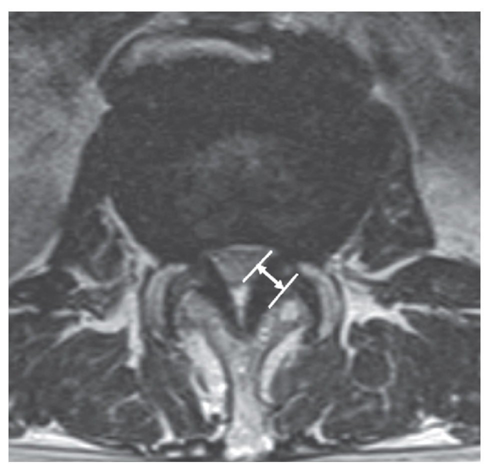
Extra-Articular Segmental Hypomobility





Yoshiiwa et al. (2016). *Asian Spine Journal, 10*, 1132 - 1140.

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Extra-Articular Adhesions

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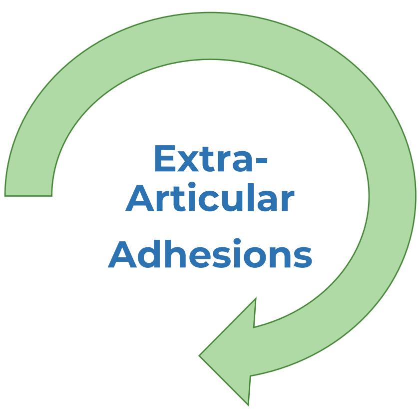
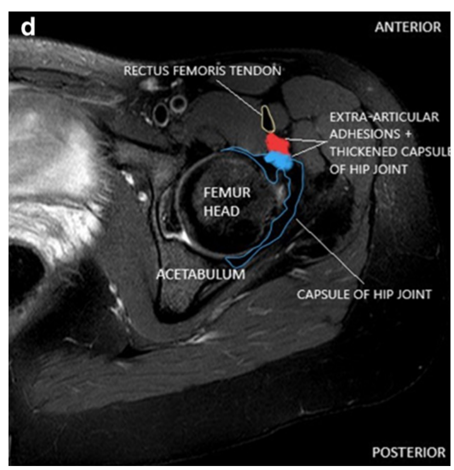
Extra-Articular Segmental Hypomobility





Skeletal Radiol (2021) 50:2541–2548.

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Reactions of Joint Capsular Ligaments

- The fibers capsule and ligaments allow the design range of joint motion that provide stability of the joint by preventing undesired motion.
- These structures react to abnormal conditions either by becoming stretched and elongated (joint laxity), thereby causing instability of the joint, or becoming tight and shortened (joint contracture), thereby restricting the range of joint motion.

Salter: Continuous Passive Motion

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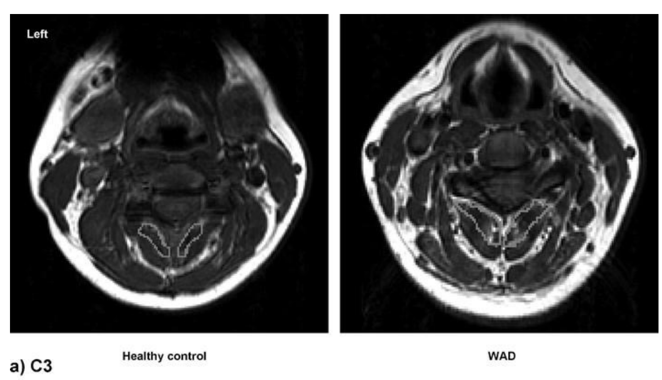
Extra-Articular Segmental Hypomobility



Elliott: Spine, Volume 31(22).October 15, 2006.E847-E855.

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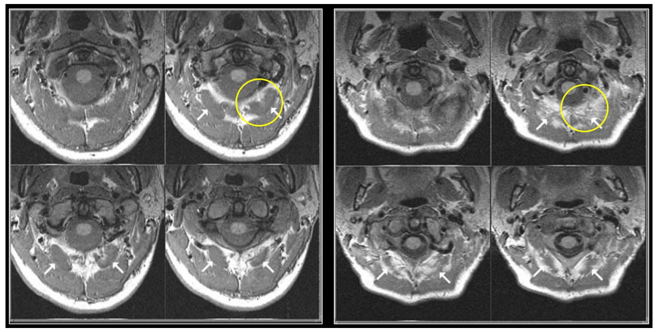
Extra-Articular Segmental Hypomobility

Denervation Atrophy



Richard Hallgren, PhD.

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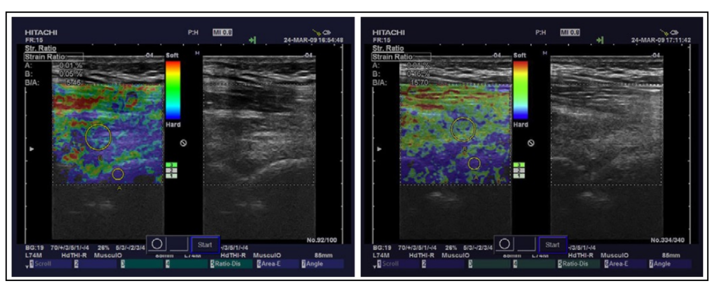
Extra-Articular Segmental Hypomobility

Myofascial Adhesions



Journal of Bodywork & Movement Therapies (2013) 17,356-364.

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Neurogenic Segmental Hypomobility

Neurogenic Hyper-Tonicity

Spasticity
Spasticity is a condition in which muscles stiffen or tighten, preventing normal fluid movement. The muscles remain contracted and resist being stretched, thus affecting movement, speech and gait.

Causes
Spasticity is generally caused by damage or disruption to the area of the brain and spinal cord that are responsible for controlling muscle and stretch reflexes. These disruptions can be due to an imbalance in the inhibitory and excitatory signals sent to the muscles, causing them to lock in place.

https://www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Spasticity

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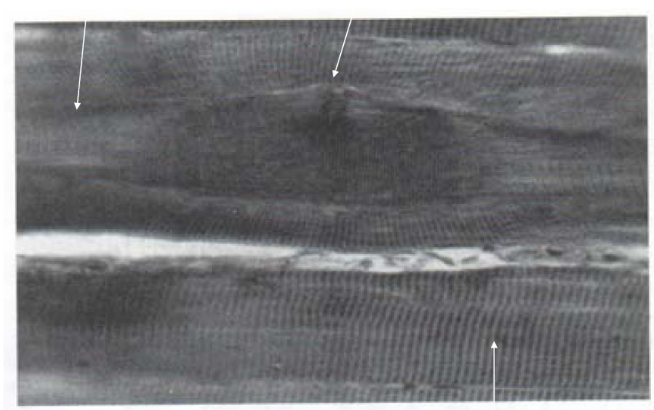
Neurogenic Segmental Hypomobility

Trigger Points



Simons DG, Travell JG, Simons LS. Travell and Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual. Vol. 1. 2nd ed. Baltimore, MD: Williams & Wilkins, 1999.

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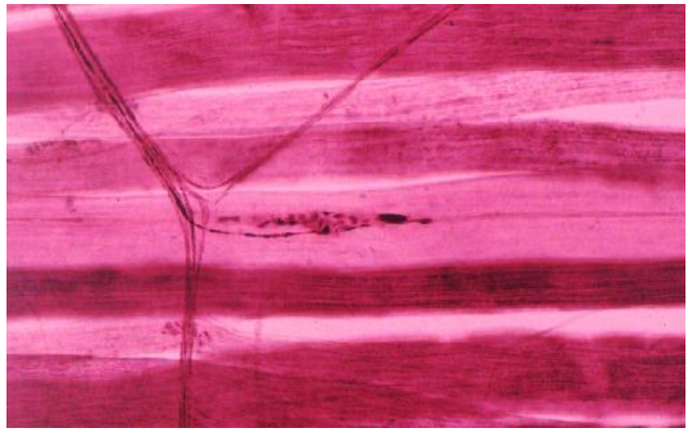
Muscle Spindles

Muscle spindles are elongated receptors which monitor the state of muscle length, supplying afferent signals to the central nervous system (CNS), thereby conferring proprioceptive control.



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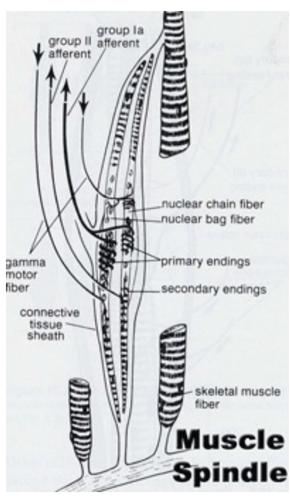
Muscle Spindles



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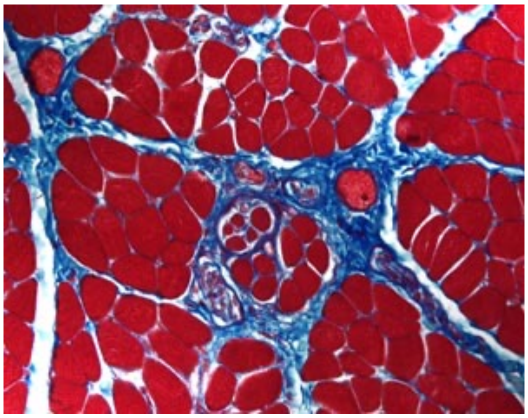
Muscle Spindles



Light microscopic image of multifidus muscle taken in transverse section. Using this histological stain, muscle fibers stain red and connective tissue blue. This image illustrates the appearance of a muscle spindle, seen encapsulated at its center.

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Trigger Points

- Trigger points are sympathetically hyperstimulated muscle spindles.
- The spindle becomes injured with sudden or repeated over-stretch of the involved muscle. This injury would normally heal over a few days, but is unable to do so if there is also tension in the spindles.
- Spindle tension is caused by adrenalin, the same hormone that can increase the heart rate, change blood flow and regulate many other internal body functions.

Open access Original research

BMJ Open **Association between chiropractic spinal manipulative therapy and benzodiazepine prescription in patients with radicular low back pain: a retrospective cohort study using real-world data from the USA**

Robert James Trager,[1] Zachary A Cupler,[2,3] Kayla J DeLano,[4] Jaime A Perez,[4] Jeffery A Dusek[1,5]

Trager RJ, et al. BMJ Open 2022;12:e058769. doi:10.1136/bmjopen-2021-058769.

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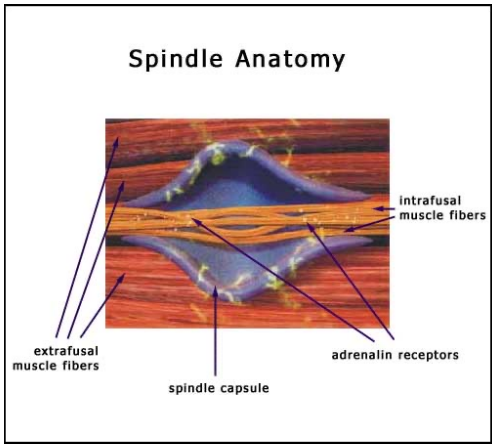
Trigger Points



The spindle capsule is shown in blue. The capsule is filled with hyaluronic acid and is a pressure and pain-sensitive structure, like any viscus. Inside the capsule are the intrafusal muscle fibers. The spindle is approximately the size of a swollen grain of rice and has been called the "eye" of the muscle, providing information on the degree of stretch, tension, and pressure within the muscle.

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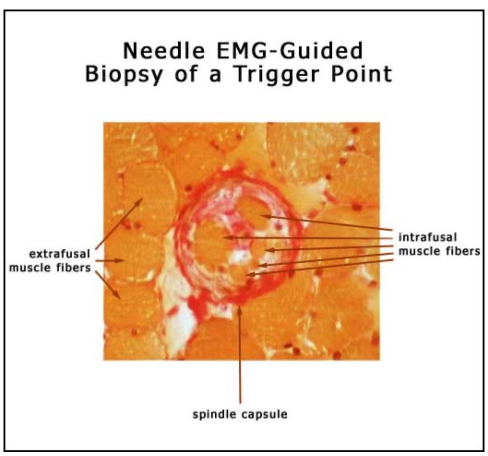
Trigger Points



A biopsy of the trigger point, obtained by needle-EMG-guidied injection of methylene blue showed a muscle spindle. In the cross-sectional biopsy one can seen the spindle capsule containing two bag and four chain intrafusal muscle fibers, and surrounded by extrafusal muscle fibers.

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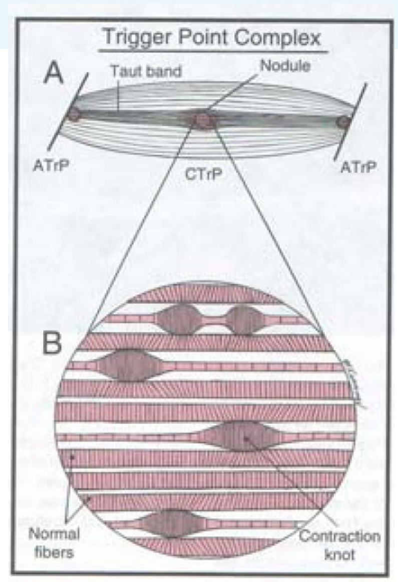
Trigger Points

- Myofascial trigger points are local thickenings of individual muscle fibers that are caused by contractions of a small group of sarcomeres (Siegfried Mense, 2008).

Journal of Bodywork & Movement Therapies (2013) 17, 356–364



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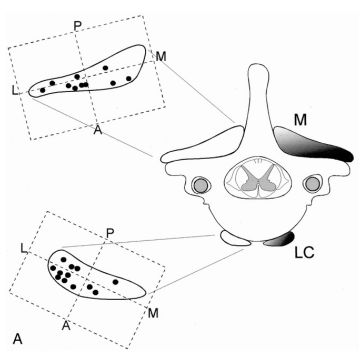
Trigger Points



	Quadrant	LC (16)	Mean age ± sem	M (16)	Mean age ± sem
■	A-L	6	44.0 ± 4.0	10	43.8 ± 6.8
■	P-L	5	48.2 ± 12.1	3	43.7 ± 3.9
■	A-M	4	35.8 ± 12.6	2	21.5 ± 17.5
□	P-M	1	24.0	1	60.0

B

The current study examined spindle characteristics for an intrinsic neck muscle pair (multifidus and longus colli) whose coactivation contributes to segmental stability of the cervical spine.

Boyd Clark: Spine, Volume 27(7).April 1, 2002.694-701

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ORIGINAL ARTICLE

Myofascial pain in patients waitlisted for total knee arthroplasty

Richard Henry MD[1], Catherine M Cahill PhD[1,2,3], Gavin Wood MD[4], Jennifer Hroch[1], Rosemary Wilson RN(EC) PhD[1,5], Tracy Cupido DO[1], Elizabeth VanDenKerkhof RN DrPH[1,5]

R Henry, CM Cahill, G Wood, et al. Myofascial pain in patients waitlisted for total knee arthroplasty. Pain Res Manage 2012;17(5):321-327.

La douleur myoaponévrotique chez les patients en attente d'une arthroplastie totale du genou

CONCLUSION: All patients had trigger points in the vastus and gastrocnemius muscles, and 92% of patients experienced significant pain relief with trigger point injections at the first visit, indicating that a significant proportion of the OA knee pain was myofascial in origin. Further investigation is warranted to determine the prevalence of myofascial pain and whether treatment delays or prevents TKA.

Pain Res Manage Vol 17 No 5 September/October 2012

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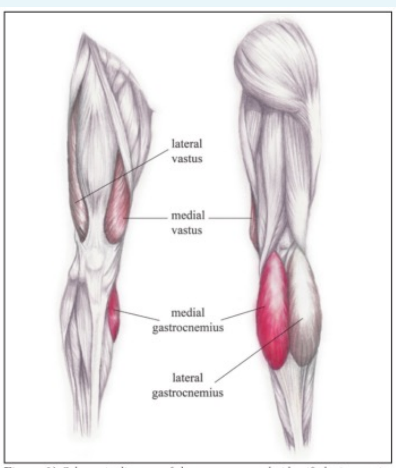

Figure 2) *Schematic diagram of the most commonly identified trigger point locations in the present study. Muscles coloured in red presented with the most common active trigger points that accounted for knee pain. The intensity of the colour shading indicates the most common muscle affected, with the deep red colour indicating the muscle with the most prominent active trigger points*

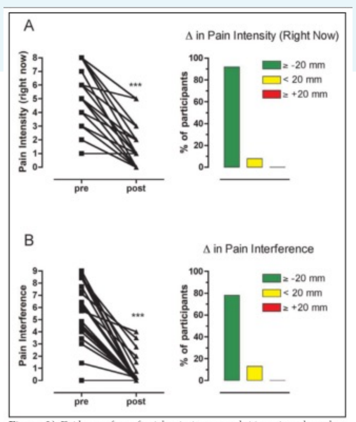

Figure 3) *Evidence of myofascial pain in osteoarthritis patients by reductions in pain scores before (pre) and following (post) intervention at the first interview (week 0) as measured by the brief pain inventory questionnaire.* **A** *Pain intensity right now was significantly attenuated, with 92% of participants reporting a reduction of more than 20 mm on a 100 mm scale (right column).* **B** *Pain interference was significantly attenuated, with 78% of participants reporting a reduction of more than 20 mm on a 100 mm scale. Statistical analysis were performed with a Wilcoxon signed-rank test comparing pre- and post-trigger point injection values. ***P<0.001*

Pain Res Manage Vol 17 No 5 September/October 2012

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Neurogenic Segmental Hypomobility

Pain-Fear Avoidance

American Pain Society

RESEARCH
EDUCATION
TREATMENT
ADVOCACY

PUBLISHED BY ELSEVIER

The Journal of Pain, Vol 19, No 11 (November), 2018: pp 1352–1365
Available online at www.jpain.org and www.sciencedirect.com

Brain Mechanisms of Anticipated Painful Movements and Their Modulation by Manual Therapy in Chronic Low Back Pain

Dan-Mikael Ellingsen,[*] Vitaly Napadow,[*] Ekaterina Protsenko,[*,†] Ishtiaq Mawla,[*,‡] Matthew H. Kowalski,[§] David Swensen,[¶] Deanna O'Dwyer-Swensen,[¶] Robert R. Edwards,[||] Norman Kettner,[**] and Marco L. Loggia[*]

[*]A. A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, [†]School of Medicine, University of California, San Francisco, California, [‡]Neuroscience Graduate Program, University of Michigan Medical School, Ann Arbor Michigan, [§]Osher Integrative Care Center, Brigham and Women's Hospital, Boston, MA, Massachusetts, [¶]Melrose Family Chiropractic & Sports Injury Centre, Melrose, Massachusetts, [||]Department of Anesthesiology, Harvard Medical School, Brigham & Women's Hospital, Boston, Massachusetts, [**]Department of Radiology, Logan University, Chesterfield, Missouri

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Neurogenic Segmental Hypomobility

Psycho-Social

Editorial

PDF

Psychosocial factors in low back pain: letting go of our misconceptions can help management

Mary O'Keeffe[1, 2], Steven Z George[3], Peter B O'Sullivan[4, 5], Kieran O'Sullivan[6, 7]

Correspondence to Dr. Mary O'Keeffe, Faculty of Medicine and Health, School of Public Health, University of Sydney, Sydney, NSW 2050, Australia; mary.okeeffe@sydney.edu.au

http://dx.doi.org/10.1136/bjsports-2018-099816

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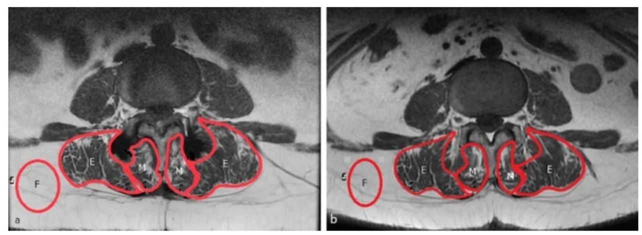
Neurogenic Segmental Hypomobility

Article | Open Access | Published: 03 September 2020

Comparison of paraspinal muscle degeneration and decompression effect between conventional open and minimal invasive approaches for posterior lumbar spine surgery

Chen-Ju Fu, Wen-Chien Chen, Meng-Ling Lu, Chih-Hsiu Cheng & Chi-Chien Niu

Scientific Reports **10**, Article number: 14635 (2020) | Cite this article



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HVLA–SM and LVLA-SM

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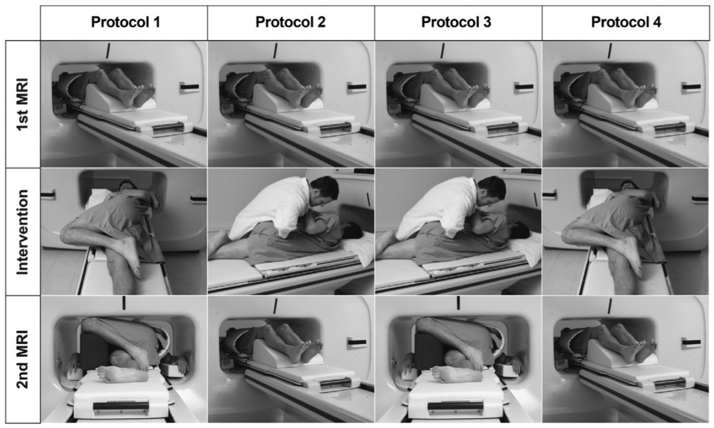
HVLA–SM

208 Cramer et al
MRI Z Joint Changes

Journal of Manipulative and Physiological Therapeutics
May 2013



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HVLA–SM

Cramer et al
Gapping and Cavitation During Manipulation

Journal of Manipulative and Physiological Therapeutics
Month 2012

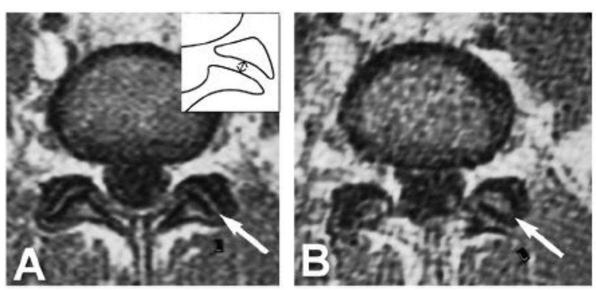

Fig 2. *Pre– (A) and post–spinal manipulation (SMT) (B) horizontal plane (axial) MRI scans of a side-posture SMT participant (group 1) demonstrating gapping of the left L5/S1 Z joint (left side = upside during SMT). Notice that the central width (thickness) of the left post-SMT Z joint space (lateral edge of joint is indicated by arrow in B) is wider than the left pre-SMT Z joint space (arrow in A). The central anterior to posterior distance between the superior and inferior articular processes of the Z joints was measured (A, inset) for the left and right L3/L4, L4/L5, and L5/S1 Z joints from each participant's first and second MRI scans. Figure (B) has been rotated counterclockwise 20° for orientation similar to (A).*

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The Spine Journal 18 (2018) 2333−2342

THE SPINE JOURNAL

Basic Science

Intervertebral kinematics of the cervical spine before, during, and after high-velocity low-amplitude manipulation

William J. Anderst, PhD[a,*], Tom Gale, MS[a], Clarissa LeVasseur, MS[a], Sandesh Raj, BS[a], Kris Gongaware, DC[b], Michael Schneider, DC, DPT[b]

[a] Department of Orthopedic Surgery, University of Pittsburgh, 3820 South Water St, Pittsburgh, PA 15203, USA
[b] Department of Physical Therapy, University of Pittsburgh, 3820 South Water St, Pittsburgh, PA 15203, USA
Received 29 May 2018; revised 30 July 2018; accepted 31 July 2018

CONCLUSIONS: This study is the first to measure facet gapping during cervical manipulation on live humans. The results demonstrate that target and adjacent motion segments undergo facet joint gapping during manipulation and that intervertebral ROM is increased in all three planes of motion after manipulation. The results suggest that clinical and functional improvement after manipulation may occur as a result of small increases in intervertebral ROM across multiple motion segments. This study demonstrates the feasibility of characterizing in real time the manual inputs and biological responses that comprise cervical manipulation, including clinician-applied force, facet gapping, and increased intervertebral ROM. This provides a basis for future clinical trials to identify the mechanisms behind manipulation and to optimize the mechanical factors that reliably and sufficiently impact the key mechanisms behind manipulation.

HVLA–SM

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The Spine Journal 18 (2018) 2333−2342

THE SPINE JOURNAL

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William J. Anderst, PhD[a,*], Tom Gale, MS[a], Clarissa LeVasseur, MS[a], Sandesh Raj, BS[a], Kris Gongaware, DC[b], Michael Schneider, DC, DPT[b]

[a] Department of Orthopedic Surgery, University of Pittsburgh, 3820 South Water St, Pittsburgh, PA 15203, USA
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Received 29 May 2018; revised 30 July 2018; accepted 31 July 2018

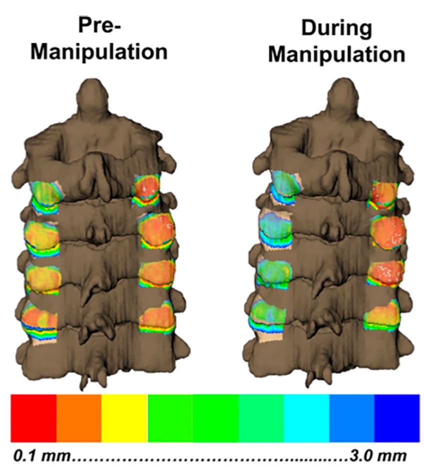
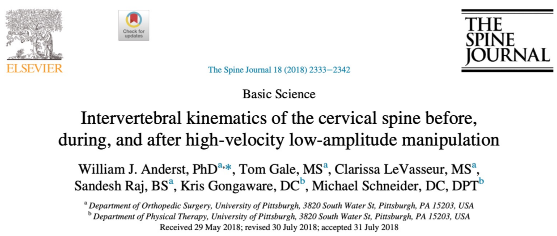


Fig. 3. A posterior view of the cervical spine premanipulation (left) and during manipulation (right). Gapping of the left facet joints is demonstrated by the color-coded facet joint surfaces.

HVLA–SM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The Spine Journal 18 (2018) 2333–2342
THE SPINE JOURNAL

Basic Science

Intervertebral kinematics of the cervical spine before, during, and after high-velocity low-amplitude manipulation

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Received 29 May 2018; revised 30 July 2018; accepted 31 July 2018

2338 *W.J. Anderst et al. / The Spine*

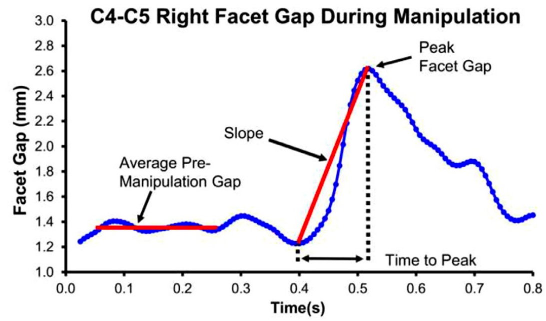

Fig. 4. Facet gapping during manipulation and measured outcome parameters for one representative subject. Each blue dot represents one frame of tracked motion during the manipulation.

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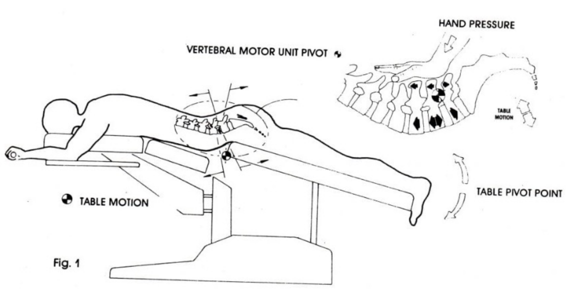
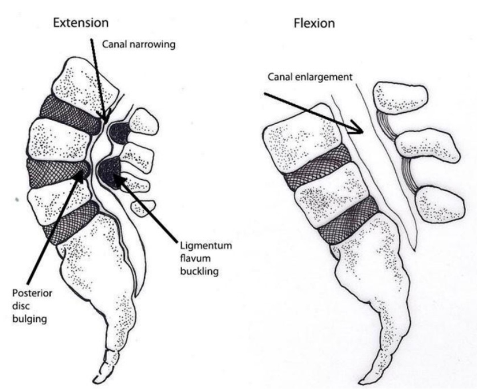
LVLA–SM – Cox Flexion-Distraction





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Instructive Cases

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- Although studies have demonstrated that uncomplicated acute LBP and radiculopathy are self limited conditions that do not warrant any imaging, most professional organizations have recommendations for imaging of LBP in patients with LBP of 6 weeks' duration or with red flags such as:
  - severe or progressive neurological deficit (eg, bowel or bladder function, saddle parasthesia),
  - fever,
  - trauma,
  - sudden back pain with spinal tenderness (especially with history of osteoporosis, cancer, or steroid use),
  - or history of serious medical condition (eg, cancer).

Neurosurgery 79:315–335, 2016

342

Instructive Case…

- 13-year-old male-baseball player
- Severe (7/10) lower back-L5/S1- with S1 paresthesias and radiculitis
- Negative bladder, bowel, weakness
- Onset-4 weeks-negative injuries, trauma or illnesses.
- Afebrile.

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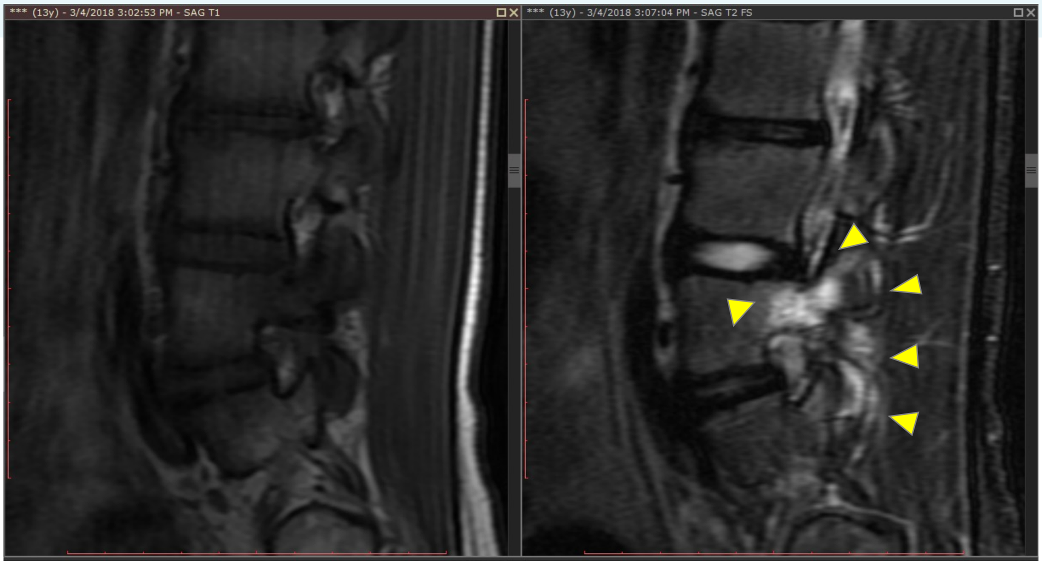
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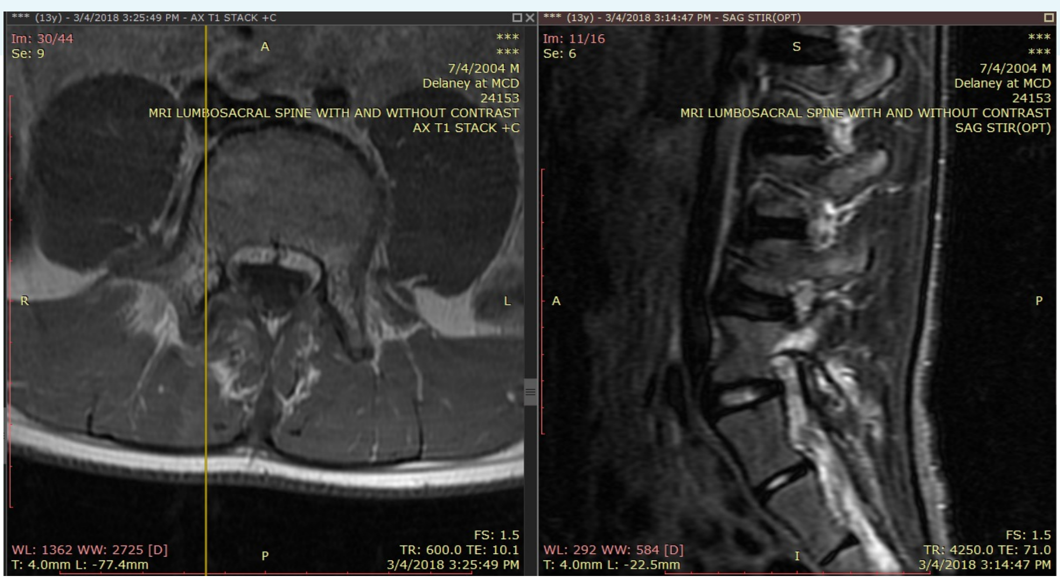
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Im: 30/44
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7/4/2004 M
Delaney at MCD
24153
MRI LUMBOSACRAL SPINE WITH AND WITHOUT CONTRAST
AX T1 STACK +C
R
L
WL: 1362 WW: 2725 [D]
T: 4.0mm L: -77.4mm
P
FS: 1.5
TR: 600.0 TE: 10.1
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Im: 11/16
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S
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7/4/2004 M
Delaney at MCD
24153
MRI LUMBOSACRAL SPINE WITH AND WITHOUT CONTRAST
SAG STIR(OPT)
A
P
WL: 292 WW: 584 [D]
T: 4.0mm L: -22.5mm
I
FS: 1.5
TR: 4250.0 TE: 71.0
3/4/2018 3:14:47 PM

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APPROPRIATE USE CRITERIA

ACR Appropriateness Criteria® Back Pain—Child

Expert Panel on Pediatric Imaging: Timothy N. Booth, MD[a], Ramesh S. Iyer, MD[b], Richard A. Falcone Jr, MD, MPH[c], Laura L. Hayes, MD[d], Jeremy Y. Jones, MD[e], Nadja Kadom, MD[f], Abhaya V. Kulkarni, MD[g], John S. Myseros, MD[h], Sonia Partap, MD[i], Charles Reitman, MD[j], Richard L. Robertson, MD[k], Maura E. Ryan, MD[l], Gaurav Saigal, MD[m], Bruno P. Soares, MD[n], Aylin Tekes, MD[o], Andrew T. Trout, MD[p], Nicholas A. Zumberge, MD[q], Brian D. Coley, MD[r], Susan Palasis, MD[r]

Variant 3. Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Negative radiographs.

Radiologic Procedure	Rating	Comments	RRL
MRI complete spine without IV contrast	8	See references [4,19,20].	○
MRI complete spine without and with IV contrast	6	This procedure is useful if there is concern for inflammation, infection, or neoplasm. See variant 6. See references [8,15,28,33].	○
CT spine area of interest without IV contrast	5	This procedure is useful to evaluate bony lesion. See references [8,15,28,33].	Varies
Tc-99m bone scan whole body with SPECT complete spine	5	This procedure is useful for detection and characterization of pars injury. See references [8,15,28,33].	☢☢☢☢
CT spine area of interest with IV contrast	2		Varies
MRI complete spine with IV contrast	1		○
CT spine area of interest without and with IV contrast	1		Varies
X-ray myelography and post myelography CT complete spine	1		☢☢☢☢

Note: Rating scale: 1, 2, 3 = usually not appropriate; 4, 5, 6 = may be appropriate; 7, 8, 9 = usually appropriate; IV = intravenous; RRL = relative radiation level; SPECT = single-photon emission computed tomography.

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Instructive Case…

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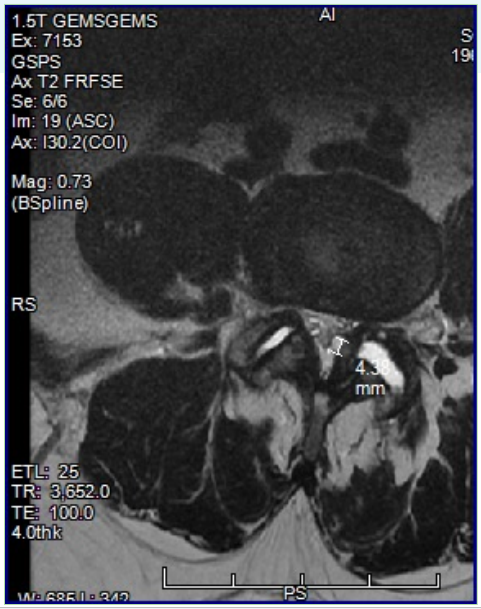

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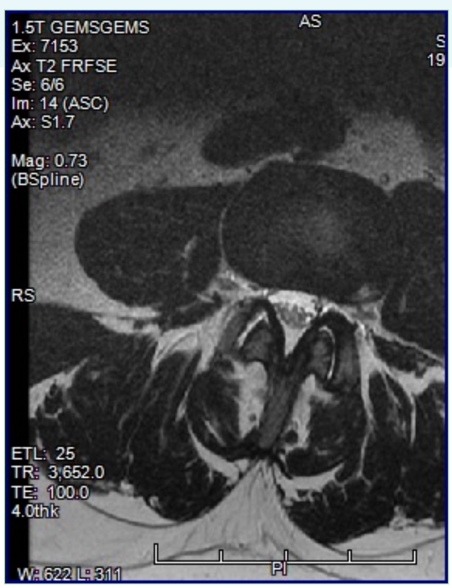

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The Thoracic Spine
Differential Assessment

James Demetrious, DC, DABCO
Diplomate, American Board of Chiropractic Orthopedists

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The Thoracic Spine

- Anatomy
- The Thorax
- Thoracic Disc Herniation
- DDX
- Osteoporosis

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Purpose…

"With sound heart and mind, the chiropractor improves lives through their intellect, heart and hands. In this regard, chiropractic is truly special."

~ James Demetrious, DC, DABCO

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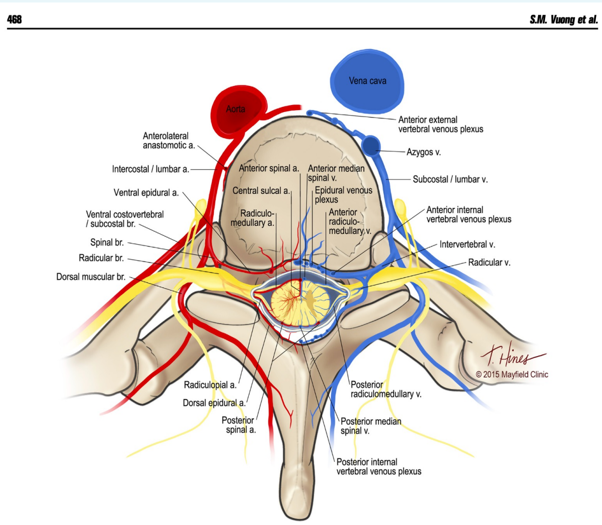
MRI Anatomy



Semin Ultrasound CT MRI 37:466-481 2016

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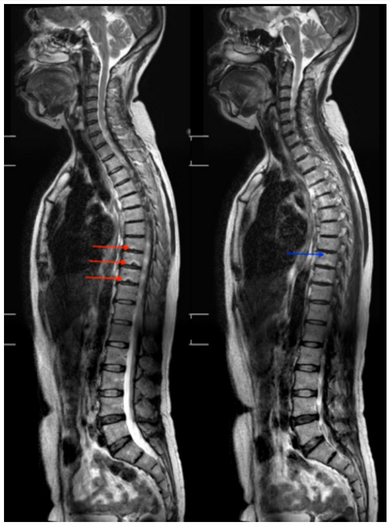
MRI Anatomy



Spine 48(12):p E177-E187, June 15, 2023.

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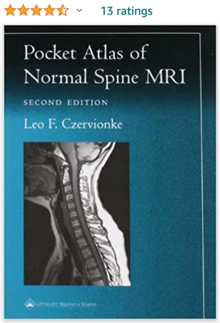
Recommended Text – MRI Anatomy

Pocket Atlas of Spinal MRI (Radiology Pocket Atlas Series) Second Edition
by Leo F. Czervionke (Author)
13 ratings



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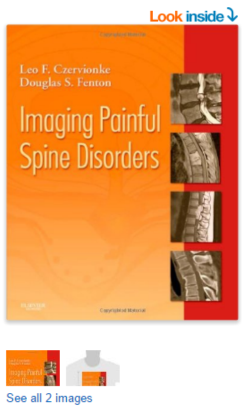
Recommended Text



Imaging Painful Spine Disorders, 1e Hardcover – June 2, 2011
by Leo F. Czervionke MD (Author), Douglas S. Fenton MD (Author)
1 customer review

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Leo F. Czervionke, MD and Douglas S. Fenton, MD present Imaging Painful Spine Disorders, the diagnostic companion to Image-Guided Spine Intervention, with 1,400 high-quality radiographic images to help you diagnose common and rare spine pain conditions. The full-color, easy-to-navigate format takes you from Spinal Anatomy, which includes normal CT and MR images of the cervical, thoracic, and lumbar spine, to Clinical Disorders, where each chapter is introduced by an actual patient case. No other reference features as many case studies illustrating the imaging presentation of back pain, provides a detailed differential diagnosis, and points out clinical pitfalls and common diagnosis errors quite like this one. Access the full text and complete image bank at www.expertconsult.com.

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Czervionke LF, Fenton DS. Imaging Painful Spine Disorders.

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The Thorax

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Costochondritis

Case Reports > J Manipulative Physiol Ther. 2007 May;30(4):321-5.
doi: 10.1016/j.jmpt.2007.03.003.

Conservative treatment of a female collegiate volleyball player with costochondritis

Donald Aspegren [1], Tom Hyde, Matt Miller

Affiliations + expand
PMID: 17509441 DOI: 10.1016/j.jmpt.2007.03.003

0008-3194/2008/224–228/$2.00/©JCCA 2008

Low-tech rehabilitation and management of a 64 year old male patient with acute idiopathic onset of costochondritis

Karen Hudes, BSc, BS, DC*

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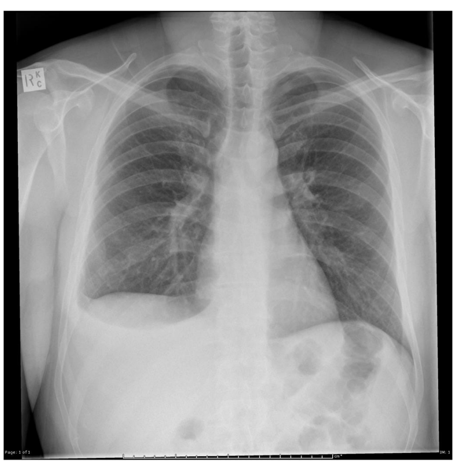
Instructive Case



Jones, J., Lustosa, L. Pleural effusion. Reference article, Radiopaedia.org. (accessed on 20 Oct 2022) https://doi.org/10.53347/rID-6159.

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Pleural Effusion

Plain Radiograph

- Chest radiographs are the most commonly used examination to assess for the presence of pleural effusion; however, it should be noted that on a routine erect chest x-ray as much as 250-600 mL of fluid is required before it becomes evident 6.
- A lateral decubitus projection is most sensitive, able to identify even a small amount of fluid. At the other extreme, supine projections can mask large quantities of fluid.

Jones, J., Lustosa, L. Pleural effusion. Reference article, Radiopaedia.org. (accessed on 20 Oct 2022) https://doi.org/10.53347/rID-6159.

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Pleural Effusion

Differential Diagnosis

- Imaging differential considerations include:
  - raised hemidiaphragm, e.g. hepatomegaly, phrenic nerve palsy
  - collapse or consolidation
- pleural thickening, e.g. old tuberculosis or empyema
- inferior pulmonary ligament
- poor radiographic technique

Jones, J., Lustosa, L. Pleural effusion. Reference article, Radiopaedia.org. (accessed on 20 Oct 2022) https://doi.org/10.53347/rID-6159.

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Pericardial Effusion

Clinical Presentation

- Clinical presentation of pericardial effusions does not relate so much to the size of the effusion but rather the speed at which the fluid has accumulated, as slow gradual accumulation allows the pericardium to stretch and accommodate much larger volumes of fluid 4.
- Regardless of volume, symptoms relate to impaired cardiac function due to intrapericardial pressure approximating intracardiac pressure leading to an impaired filling of low-pressure chambers, particularly the right atrium.
- Dyspnea and reduced exercise tolerance will be early signs, progressing to severe impaired cardiac output and death in severe cases (e.g. cardiac tamponade).

Gaillard, F., Hacking, C. Pericardial effusion. Reference article, Radiopaedia.org. (accessed on 20 Oct 2022) https://doi.org/10.53347/rID-7729

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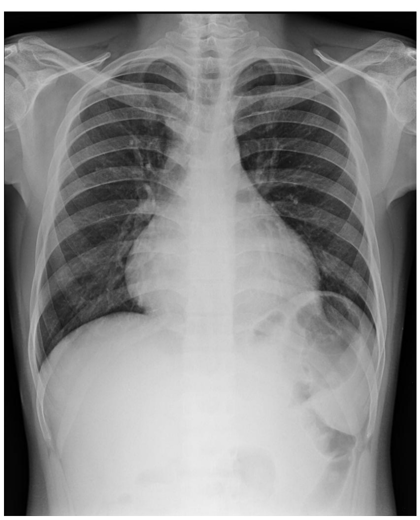
Pericardial Effusion



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Pericardial Effusion

Plain Radiograph

- Small pericardial effusions are often occult on plain film. Greater than 200 mL of pericardial fluid is usually required to become radiographically visible. Radiographic signs include:
- there can be globular enlargement of the cardiac shadow giving a water bottle configuration
- lateral CXR may show a vertical opaque line (pericardial fluid) separating a vertical lucent line directly behind the sternum (pericardial fat) anteriorly from a similar lucent vertical lucent line (epicardial fat) posteriorly; this is known as the Oreo cookie sign [5]
- widening of the subcarinal angle without other evidence of left atrial enlargement may be an indirect clue [2]
- a differential density sign at cardiac borders has been suggested [9], but its specificity is limited
- serially enlarging cardiothoracic ratio
- hemodynamic compromise may manifest with signs of cardiogenic pulmonary edema

Gaillard, F., Hacking, C. Pericardial effusion. Reference article, Radiopaedia.org. (accessed on 20 Oct 2022) https://doi.org/10.53347/rID-7729

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RadioGraphics

686 May-June 2020 radiographics.rsna.org

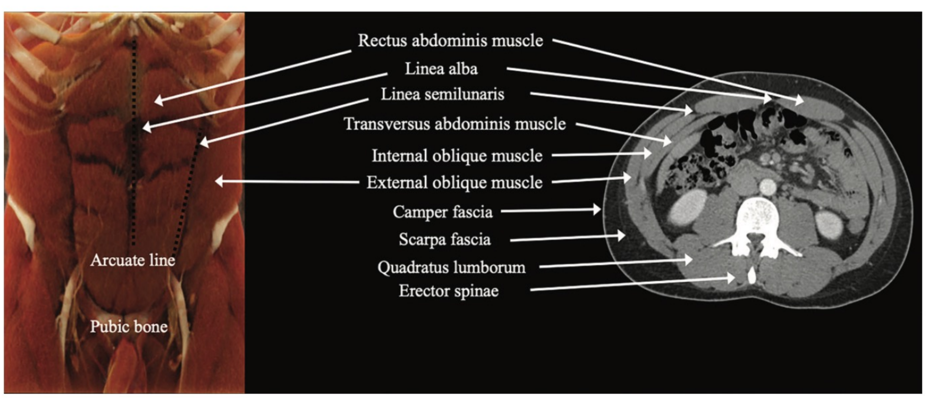

Figure 1. Anatomy of the abdominal wall shown on an axial CT image (right) and a virtual cinematic rendering (left) in a 35-year-old man with abdominal pain and a normal CT examination.

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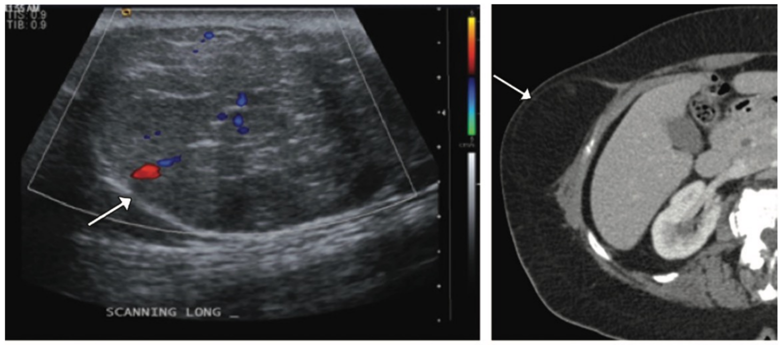

a. b.

Figure 6. Lipoma in a 29-year-old woman with a palpable right upper quadrant abdominal wall mass. **(a)** Color Doppler US image shows a hypovascular hypoechoic mass mirroring the subcutaneous fat with a thin hyperechoic capsule (arrow), which is consistent with a lipoma. **(b)** Axial CT image for evaluation of abdominal pain shows a fat-attenuation encapsulated mass (arrow), which is consistent with a body wall lipoma. Note how poorly discernible the capsule is at its lateral aspect.

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Instructive Case

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ASTR
Annals of Surgical Treatment and Research
http://thesurgery.or.kr
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Ann Surg Treat Res. 2015 Feb; 88(2): 111–113.
Published online 2015 Jan 27. doi: 10.4174/astr.2015.88.2.111
PMCID: PMC4325649
PMID: 25692123

A rare nonincisional lateral abdominal wall hernia

Dong-Ju Kim and Jin-Woo Park

▸ Author information ▸ Article notes ▸ Copyright and License information Disclaimer

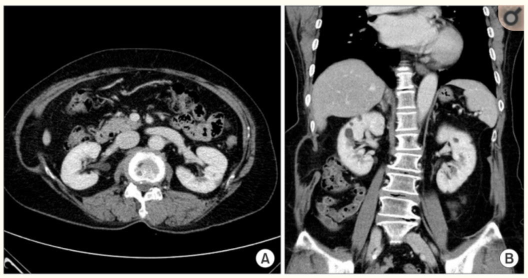

Fig. 1

Radiologic findings of lateral abdominal wall defect. Abdominopelvic CT scan showed omental fat herniation through lateral abdominal wall defect of transversus abdominis muscle and internal oblique muscle (A) at right flank just below costal margin (B).

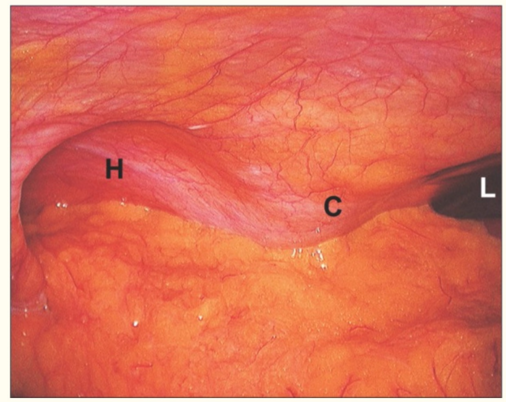

Fig. 2

Laparoscopic view of lateral abdominal wall defect. Laparoscopic exploration of abdomen revealed omental herniation through lateral abdominal wall defect measuring 6.5 cm × 6 cm. Peritoneal lining of hernia sac was smooth and there was no evidence of inflammation or adhesion. L, liver; C, costal margin; H, hernia sac.

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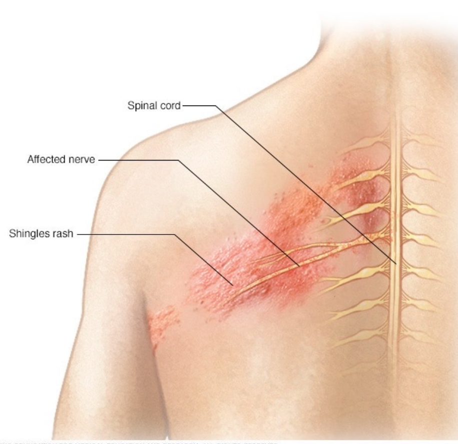
Shingles



- A person with shingles can pass the varicella-zoster virus to anyone who isn't immune to chickenpox.
- This usually occurs through direct contact with the open sores of the shingles rash.
- Once infected, though, the person will develop chickenpox rather than shingles.

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Notalgia Paresthetica

International Journal of Dermatology

Review

Notalgia paresthetica: a review for dermatologists

Matthew Howard MBBS (Hons), BPharm (Hons), Lukas Sahhar MBBS (Hons), BMedSci (Hons), MPH, Frank Andrews B App Sci (Physio), M Musc Physio, Ralph Bergman B App Sci (Physio) ... See all authors

First published: 15 December 2017 | https://doi.org/10.1111/ijd.13853 | Citations: 18

- Notalgia paresthetica (NP) is an underdiagnosed condition that presents with unilateral pruritus medial to the scapula on the midback with or without an associated hyperpigmented or hypopigmented macule.
- Current theories propose the condition is likely multifactorial, including spinal entrapment and muscular compressive neuropathy.

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Notalgia Paresthetica

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2020/139–143/$2.00/©JCCA 2020

Presumptive spondylogenic pruritus: a case study

Leonard J. Faye, DC[1]
Brian S. Budgell, DC, PhD[2]

- Summary: In this case, a severe and chronic complaint of pruritus which was refractory to other forms of care resolved quickly after the institution of chiropractic care. It is therefore hypothesized that the patient's pruritus was etiologically linked to biomechanical problems of the spine.

J Can Chiropr Assoc 2020; 64(2)

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Rib Fracture

JACR Journal of the American College of Radiology — ACR Login

APPROPRIATE USE CRITERIA | VOLUME 16, ISSUE 5, SUPPLEMENT, S227-S234, MAY 01, 2019

ACR Appropriateness Criteria® Rib Fractures

Expert Panel on Thoracic Imaging: • Travis S. Henry, MD • Edwin F. Donnelly, MD, PhD • ... Arlene Sirajuddin, MD • Carol C. Wu, MD • Jeffrey P. Kanne, MD • Show all authors

DOI: https://doi.org/10.1016/j.jacr.2019.02.019 • Check for updates

- Rib fractures are the most common thoracic injury after minor blunt trauma.
- Isolated rib fractures have a relatively low morbidity and mortality and treatment is generally conservative.
- In patients with suspected pathologic fractures, chest CT or Tc-99m bone scans are usually appropriate and complementary modalities to chest radiography based on the clinical scenario.

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Rib Fracture

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DOI: https://doi.org/10.1016/j.jacr.2019.02.019 • Check for updates

ACR Appropriateness Criteria® Rib Fractures. Variants 1 to 3 and Tables 1 and 2.

Variant 1. Suspected rib fractures from minor blunt trauma (injury confined to ribs). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
Radiography rib views	May Be Appropriate	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
Tc-99m bone scan whole body	Usually Not Appropriate	☢☢☢
CT chest with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
US chest	Usually Not Appropriate	O

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DOI: https://doi.org/10.1016/j.jacr.2019.02.019 • Check for updates

Variant 2. Suspected rib fractures after cardiopulmonary resuscitation (CPR). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
Radiography rib views	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	Usually Not Appropriate	☢☢☢
Tc-99m bone scan whole body	Usually Not Appropriate	☢☢☢
US chest	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢

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DOI: https://doi.org/10.1016/j.jacr.2019.02.019 • Check for updates

Variant 3. Suspected pathologic rib fracture. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
CT chest without IV contrast	Usually Appropriate	☢☢☢
Tc-99m bone scan whole body	Usually Appropriate	☢☢☢
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
Radiography rib views	May Be Appropriate	☢☢☢
CT chest with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
US chest	Usually Not Appropriate	O

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Rib Fracture

> J Can Chiropr Assoc. 2020 Apr;64(1):7-15.

Lessons learned from cases of rib fractures after manual therapy: a case series to increase patient safety

Daphne To [1], Anthony Tibbles [1], Martha Funabashi [1]

Affiliations + expand
PMID: 32476664 PMCID: PMC7250508

Table 2.
Incident characteristics. SMT (spinal manipulative therapy); N/A (not applicable, due to unavailable data)

	SMT			Symptom onset	Fracture location	Complications	Time to symptom resolution
	Type	Side	Level				
Case 1	Supine; posterior contact	Bilateral	T3-T6	Immediate	Ribs 5 and 6; left side, axillary region	None	7 weeks
Case 2	Prone; hypothenar transverse contact	Left	C7-T1	Immediate	Ribs 4 and 5; left side, anterolateral region	None	12 weeks
Case 3	Side posture; lumbar roll	Left	L3-L5	Immediate	Rib 9; left side, anterior region	None	N/A

10 J Can Chiropr Assoc 2020; 64(1)

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Rib Fracture

> J Can Chiropr Assoc. 2020 Apr;64(1):7-15.

Lessons learned from cases of rib fractures after manual therapy: a case series to increase patient safety

Daphne To [1], Anthony Tibbles [1], Martha Funabashi [1]

Affiliations + expand
PMID: 32476664 PMCID: PMC7250508

- The chiropractors in this study stressed the importance of verifying and updating potential contributing factors that may be associated with rib fractures over the course of treatments, as well as open and honest communication with the patient as suggested prevention and mitigation strategies.

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DJD

> Spine (Phila Pa 1976). 2023 Jun 15;48(12):E177-E187. doi: 10.1097/BRS.0000000000004632. Epub 2023 Mar 22.

Why Are Some Intervertebral Discs More Prone to Degeneration?: Insights Into Isolated Thoracic "Dysgeneration"

Samuel Tin Yan Cheung [1], Prudence Wing Hang Cheung, Jason Pui Yin Cheung

Affiliations – collapse

Affiliation

1 Department of Orthopedics and Traumatology, The University of Hong Kong, Hong Kong SAR, China.

PMID: 37262423 PMCID: PMC10212581 DOI: 10.1097/BRS.0000000000004632

- Thoracic disc degeneration (DD) manifesting with pain is uncommon due to the stiff ribcage and coronal orientation of the facet joint.
- The prevalence of thoracic disc herniation was found to be only 6.5%, however, when present, it may lead to spinal cord compromise.
- Thoracic DD may result from a number of factors.
- Previous studies found that T6/7 at the apex of spinal curvature was associated with decreases in magnetic resonance imaging (MRI) signal intensity, suggesting a role of compressive stress at the mid-thoracic region.

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1 Department of Orthopedics and Traumatology, The University of Hong Kong, Hong Kong SAR, China.

PMID: 37262423 PMCID: PMC10212581 DOI: 10.1097/BRS.0000000000004632

Conclusion:

- Isolated thoracic degeneration demonstrated an earlier age of onset, mostly involving the mid-thoracic region (T5/6-T8/9), and in association with findings such as SN.
- Subjects with tandem thoracolumbar degeneration had less severe lumbar DD and low back pain as compared with those with isolated lumbar degeneration.

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Thoracic Disc Herniation

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The Royal College of Surgeons of England
doi 10.1308/147870809X401038

On-line Case Report

Thoracic disc prolapse presenting with abdominal pain: case report and review of the literature

NIKOLAOS PAPADAKOS[1], HUSAM GEORGES[1], NAOMI SIBTAIN[2], CHRISTOS M TOLIAS[1]

Departments of [1]Neurosurgery and [2]Neuroradiology, King's College Hospital, London, UK

Ann R Coll Surg Engl 2009; 91

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- Symptomatic thoracic disc prolapse is a rare pathology, reported to occur in 1 per million per year,2,3 accounting for 0.15–4% of all symptomatic disc prolapses.1,2
- Wood *et al.4 reported* 37% of the subjects in their study to have asymptomatic thoracic disc prolapse evident on MRI.
- Up to 75% of thoracic disc prolapses occur below T8, with T11/12 being the commonest level.1–3
- Disc calcification is common and is reported to occur in up to 65% of case.2

Ann R Coll Surg Engl 2009; 91

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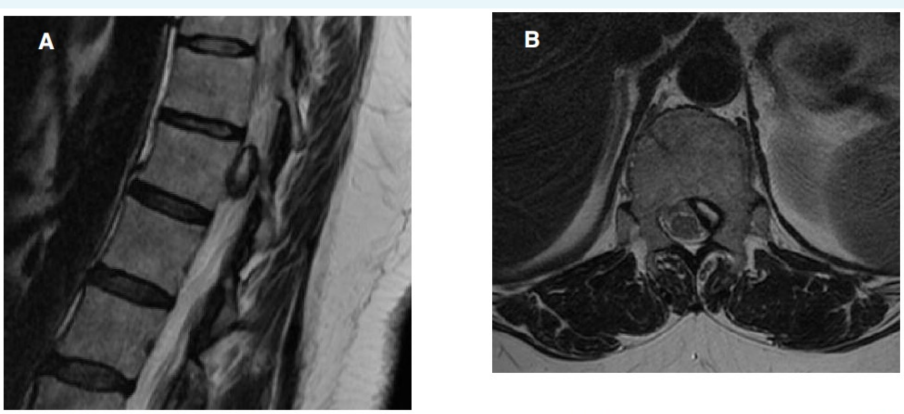

Figure 1 (A) Sagittal and (B) axial T2 images show an intraspinal lesion lying in an epidural left paracentral location at the upper T12 level. It consists of T2 high signal with a thick rim of T2 low signal. It causes distortion of the theca and potential impingement of the left T12 nerve root. The T11/12 disc is noted to be slightly reduced in height.

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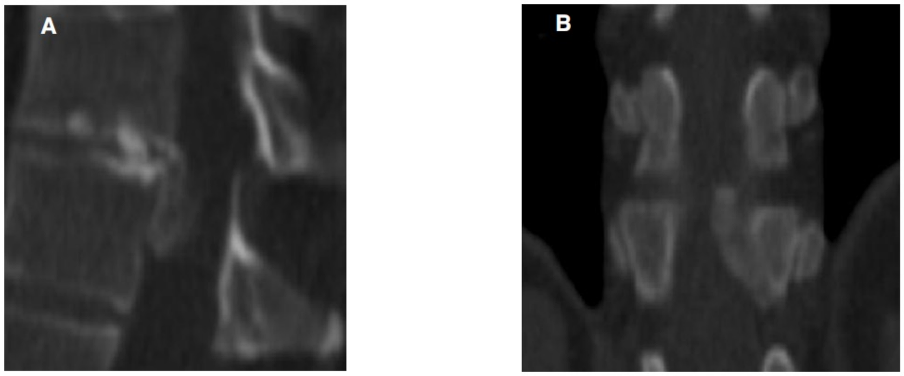

Figure 2 (A) Sagittal and (B) coronal CT reformats show that the abnormality is contiguous with the T11/12 disc and is consistent with a extruded disc, emanating from the T11/12 level. It shows heavy calcification of its periphery (corresponding to the T2 low signal shown on MRI).

Ann R Coll Surg Engl 2009; 91

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- Pain is the commonest symptom associated with thoracic disc prolapse.1,2
- Typical thoracic spinal pain can be unilateral, bilateral or radicular.1,2
- Its nature can be variable – sharp, cutting, shooting, constant or intermittent.1,2
- Pain can also present as non-spinal pain including abdominal pain, testicular or groin pain, upper limb and cardiac pain.1,5–9

Ann R Coll Surg Engl 2009; 91

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- Abnormal neurological symptoms are the second most common presentation.1–3
- These include, sensory (paraesthesia, dysaesthesia and numbness), motor and bladder or bowel disturbance.1–3

Ann R Coll Surg Engl 2009; 91

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Disc Herniation DDX

Cureus
Publishing Beyond Open Access

Cureus. 2022 Jun; 14(6): e25719. Published online 2022 Jun 7.
doi: 10.7759/cureus.25719
PMCID: PMC9261972 | PMID: 35812628

A Dorsal Epidural Herniated Disc Fragment Initially Presenting as Guillain-Barré Syndrome

Monitoring Editor: Alexander Muacevic and John R Adler

Parth N Patel,[1] Michael G Schloss,[1] Kaveri Sharma,[1] and Poonam Dulai[2]

- Guillain-Barré syndrome (GBS) is a rare autoimmune disorder that presents with neurological symptoms that can mimic other conditions.
- This mimicry can hide other important neurological diagnoses.
- Here, we present a rare case of thoracic myelopathy secondary to a sequestered dorsal epidural herniated disc fragment that initially presented with the classic findings of GBS.

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Disc Herniation DDX

Cureus
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Monitoring Editor: Alexander Muacevic and John R Adler

Parth N Patel,[1] Michael G Schloss,[1] Kaveri Sharma,[1] and Poonam Dulai[2]

Hx:

- A 58-year-old female presented with progressing bilateral lower extremity weakness, paresthesias, and absent bilateral lower extremity deep tendon reflexes.
- Lumbar magnetic resonance imaging (MRI) findings were disproportionate to presentation, and lumbar puncture fluid analysis revealed clear, colorless fluid with albuminocytological dissociation.
- The patient was diagnosed with GBS and treated with a short course of intravenous steroids followed by intravenous immunoglobulin.

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Disc Herniation DDX

Cureus
Publishing Beyond Open Access

Cureus. 2022 Jun; 14(6): e25719. Published online 2022 Jun 7.
doi: 10.7759/cureus.25719
PMCID: PMC9261972 | PMID: 35812628

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Hx:

- The patient later developed new-onset ulnar distribution paresthesias, lower extremity spasticity, constipation, and urinary retention that caused a decline in functional progress.
- Further investigation prompted evaluation with cervical and thoracic MRIs, which revealed a left dorsal epidural lesion at the T9-T10 level causing severe cord compression.
- The patient was definitively treated with a T9-T10 laminectomy and excision of the offending lesion.
- Pathology revealed collagenous tissue with fibroblastic proliferation, consistent with a sequestered fragment of the herniated intervertebral disc.

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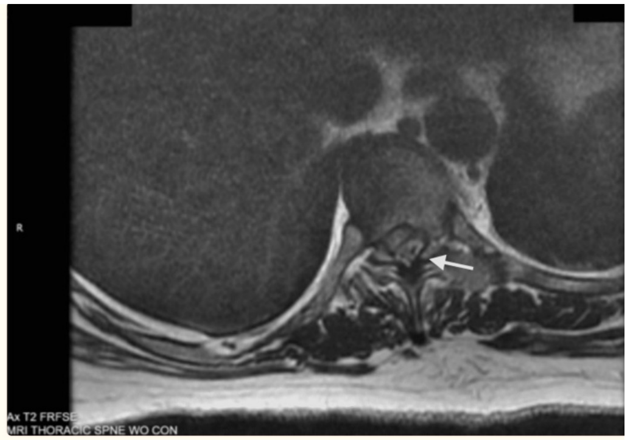
Disc Herniation DDX

Sagittal view depicting dorsal epidural disc fragment centered at the T9-T10 level.



Axial view depicting dorsal epidural disc fragment centered at the T9-T10 level.

Cureus. 2022 Jun; 14(6): e25719.

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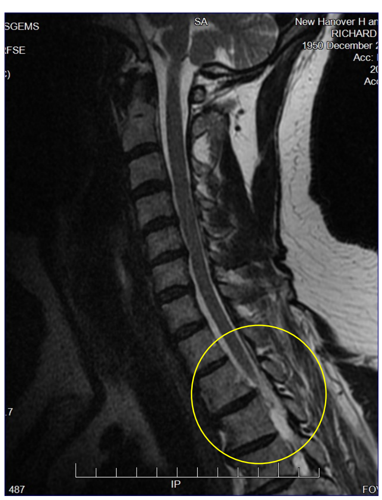
Instructive Case



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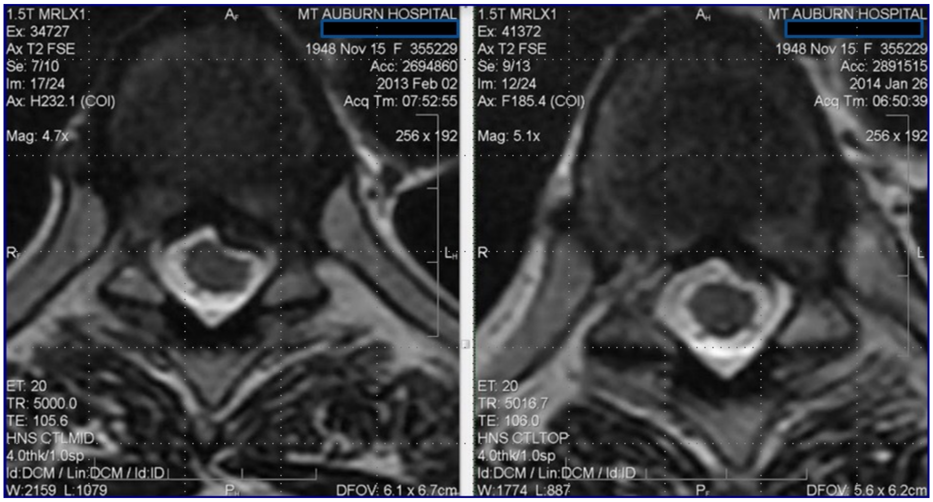

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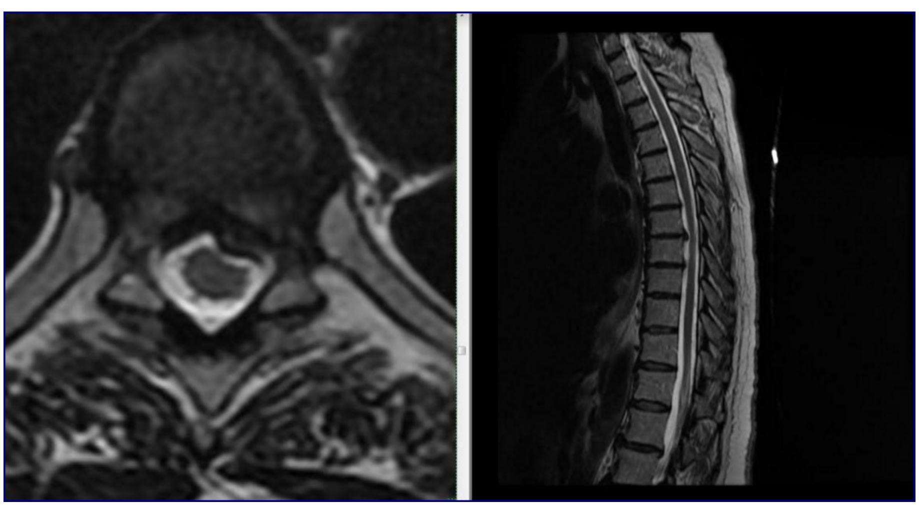

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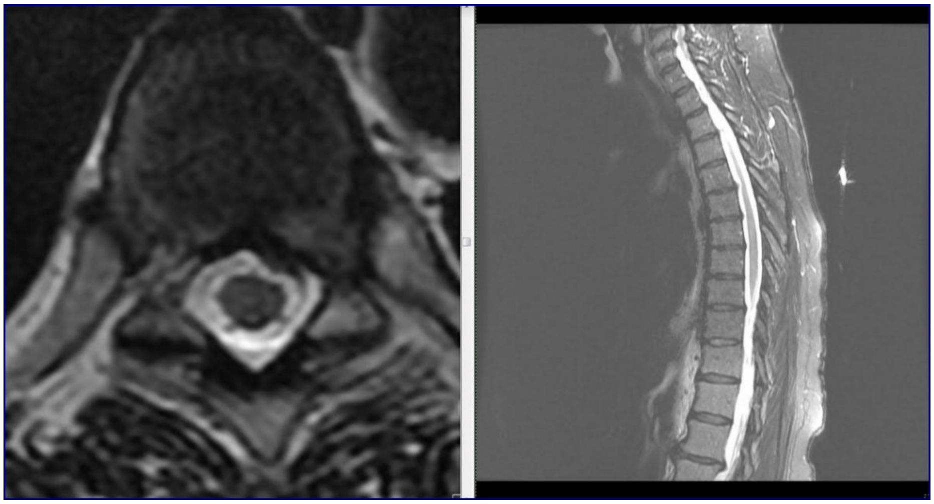

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Instructive Case

- 40-year-old female-Triathlete
- Thoracic/lumbar pain-with radiation to anterior lower ribs
- Onset-13 years previously related to training. Negative trauma or illnesses.
- Symptoms wax and wane depending upon activity.
- Negative relief elsewhere. Sought medical, PT, acupuncture, chiropractic care locally with the consultations at Duke University, and Mayo Clinic without relief. Diagnoses provided thus far:
  - Ankylosing spondylitis
  - Inflammatory bowel disease related spondyloarthropathy
  - Parasitic infection
  - Chiropractic subluxation

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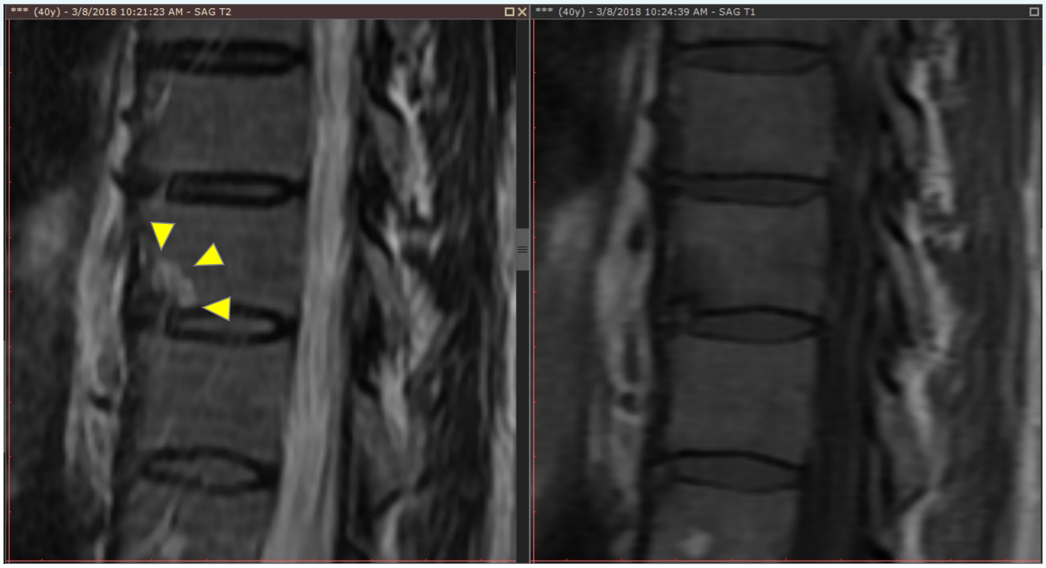

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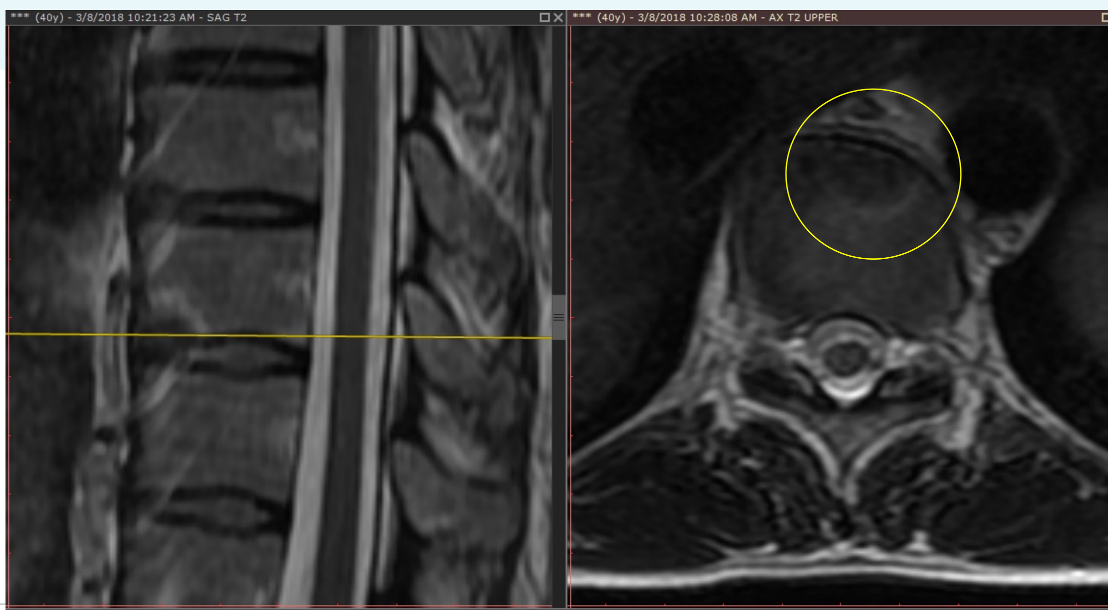

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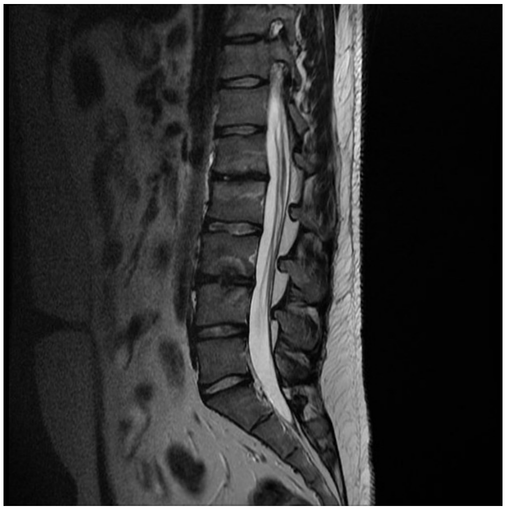

Andersson lesions refer to an inflammatory involvement of the intervertebral discs by spondyloarthritis.

Case courtesy of Dr Renan Ibrahem Adam, Radiopaedia.org, rID: 39462

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Instructive Case

International Journal of Spine Surgery, Vol. 14, No. 3, 2020, pp. 441–446
https://doi.org/10.14444/7058

Schmorl Node—A Cause of Acute Thoracic Pain: A Case Report and Pathophysiological Mechanism

ODED HERSHKOVICH, MD, MHA, JONATHAN E. J. KOCH, MD, MICHAEL P. GREVITT, FRCS (ORTH)
Centre for Spinal Studies and Surgery, Queen's Medical Centre, Nottingham, United Kingdom

Figure 1. Magnetic resonance imaging (MRI) sagittal T2 STIR—First MRI scan demonstrated high signal intensity on T2 (bone marrow edema) surrounding a large Schmorl node (SN) in T7 vertebral body. A radio-opaque marker on the skin marks the site of the maximum pain. Other smaller SNs are seen in the thoracic spine (left). MRI sagittal T2—First MRI showing the large SN in T7 (right).

- Symptomatic SN should be part of the differential diagnosis of thoracolumbar unexplained pain, and the modality of choice for diagnosis would be MRI.
- Once an inflammatory SN is diagnosed, several treatment options are available.
- However, the most likely outcome is spontaneous resolution of symptoms and bone healing within a few months.
- As demonstrated in this case, the conservative approach is recommended when the symptoms can be medically well controlled.

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Schmorl Node

Differential Diagnosis:

- Acute compression fracture,
- degenerative endplate change,
- discitis,
- limbus vertebra,
- bone island,
- focal fatty marrow,
- focal metastasis

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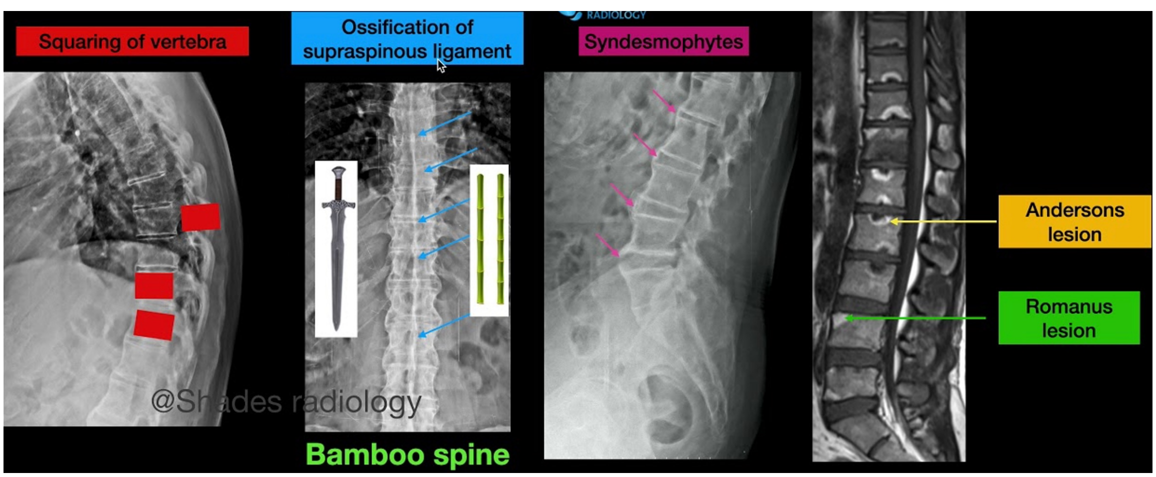
Ankylosing Spondylitis



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Ankylosing Spondylitis

FIGURE 22. Left, sagittal STIR and (right) postcontrast T1-weighted, fat-saturated images demonstrate vertebral osteitis with high STIR signal intensity with contrast enhancement at the anterosuperior and anteroinferior vertebral body corners. These are examples of Romanus lesions in a patient with ankylosing spondylitis.

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Arterial Venous Malformation

Cureus
Publishing Beyond Open Access

Cureus. 2020 Nov; 12(11): e11614. Published online 2020 Nov 21.
doi: 10.7759/cureus.11614

PMCID: PMC7752798 | PMID: 33364131

Spinal Arteriovenous Malformation: Case Report and Review of the Literature

Monitoring Editor: Alexander Muacevic and John R Adler

Tye Patchana,[1] Paras Savla,[1] Taha M Taka,[2] Hammad Ghanchi,[1] James Wiginton, IV,[1] Michael Schiraldi,[3,4] and Vladimir Cortez[4]

- Spinal arteriovenous malformations (AVMs) are a rare form of spinal blood vessel defect that results in vessel engorgement leading to clinical signs secondary to mass effect and ischemia.
- Due to the shunting of arteriole blood to the venous system without capillary access and resistance, over 70% of arterial pressure is transmitted to the venous system [3].
- Venous hypertension can precipitate many neurological deficits secondary to mass effect and normal spinal blood flow disruption along with increased risk for hemorrhage.

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Arterial Venous Malformation

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- **Anson and Spetzler AVM Classification:**
  - Type I: Spinal Dural Arteriovenous Fistula
  - Type II: Intramedullary Arteriovenous Malformation
  - Type III: Extradural-Intradural Arteriovenous Malformations
  - Type IV: Intradural Peri-medullary Arteriovenous Fistula

Arterial Venous Malformation

Cureus

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- **Imaging:**
  - MRI is the modality of choice for initial visualization for spinal AVMs.
  - Magnetic resonance angiography (MRA) is often a supplement of MRI that serves to identify the number of possible arterial feeders that supply the malformation.
  - Computed tomographic angiography (CTA) has been proven as a viable option for spinal AVM visualization.

Arterial Venous Malformation

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- **Imaging:**
  - A 22-year-old male presented with a chief complaint of progressive bilateral lower extremity weakness and numbness.
  - The patient stated that he had gone to a different hospital after experiencing lower extremity numbness, where evaluations were performed and he was discharged.
  - However, he was unable to walk home at this time.
  - Due to the persistence of his symptoms, the patient presented to our institution for the reevaluation of his continued bilateral lower extremity plegia.

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Arterial Venous Malformation

Cureus
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Cureus. 2020 Nov; 12(11): e11614. Published online 2020 Nov 21.
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PMCID: PMC7752798 | PMID: 33364131

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- **Examination:**
  - On physical examination, the patient presented with saddle anesthesia. While the patient denied bowel or bladder incontinence, a Foley catheter was inserted upon admission for urinary retention.
  - By American Spinal Cord Injury Association (ASIA) assessment, the patient was ASIA A with a T11 sensory level.
  - A thoracic spine MRI with and without contrast was ordered, which raised suspicion for spinal AVM at T9-T10, as seen on T2 weighted imaging (Figure (Figure1).1)
  - Differential diagnoses included trauma, tumor, and other vascular abnormality.

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ASIA Scale

Clin Orthop Relat Res. 2017 May; 475(5): 1499–1504. Published online 2016 Nov 4.
doi: 10.1007/s11999-016-5133-4

PMCID: PMC5384910 | PMID: 27815685

Classifications In Brief: American Spinal Injury Association (ASIA) Impairment Scale

Timothy T. Roberts, MD,[1] Garrett R. Leonard, MD,[2] and Daniel J. Cepela, MD[2]

Table 3

American Spinal Injury Association Impairment Scale

A	Complete	No motor or sensory function is preserved in the sacral segments S4–S5.
B	Incomplete	Sensory function preserved but not motor function is preserved below the neurological level and includes the sacral segments S4–S5.
C	Incomplete	Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
D	Incomplete	Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
E	Normal	Motor and sensory function are normal.

Arterial Venous Malformation

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- The patient was taken from the angiography suite to the operating room (OR) for surgery.
- Right-sided hemi-laminectomy and durotomy were performed at T8-T10 which revealed a feeding artery piercing through the dura near the inferior border of the right T9 pedicle surrounded by many arterialized veins.
- Multiple straight clips (five in total) were placed until no flow was detected within the vascular malformation on auscultation with micro-doppler.

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DDX – Instructive Cases

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Instructive Case

Journal of Manipulative and Physiological Therapeutics 525
Volume 15 • Number 8 • October, 1992
0161-4754/92/1508-0525 $03.00/0 © 1992 JMPT

Case Reports

Metastatic Testicular Seminoma of the Cervicothoracic Spine

JAMES DEMETRIOUS, D.C.*

ABSTRACT
A case of metastatic testicular seminoma affecting the cervico-thoracic spine is reported along with its clinical and radiographic findings. Case progression is discussed. (J Manipulative Physiol Ther 1992; 15:525–528).

Key Indexing Terms: Metastasis, Seminoma, Cervical Vertebrae, Spine, Chiropractic.

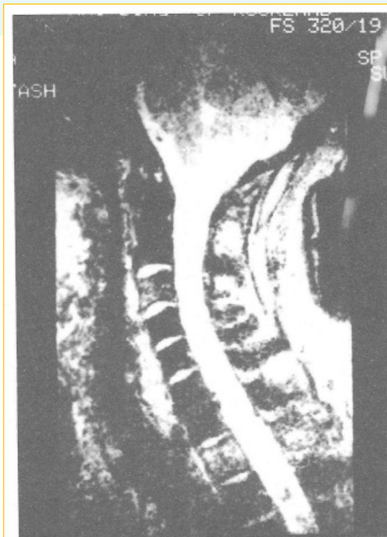

Figure 1. The sagittal image reveals areas of abnormal signal intensity in the C3 and T1 vertebral bodies.

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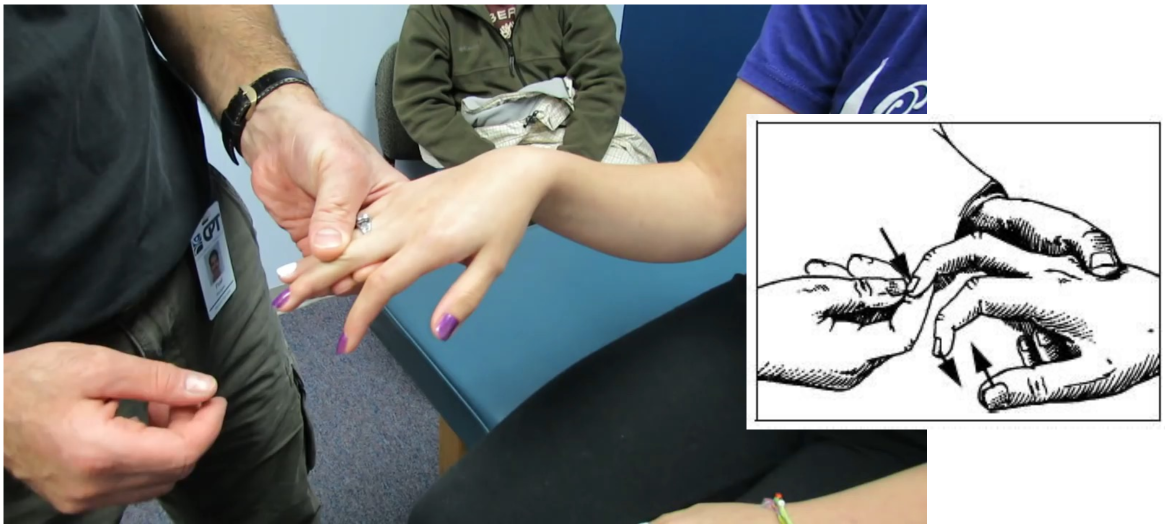
Hoffman's Sign



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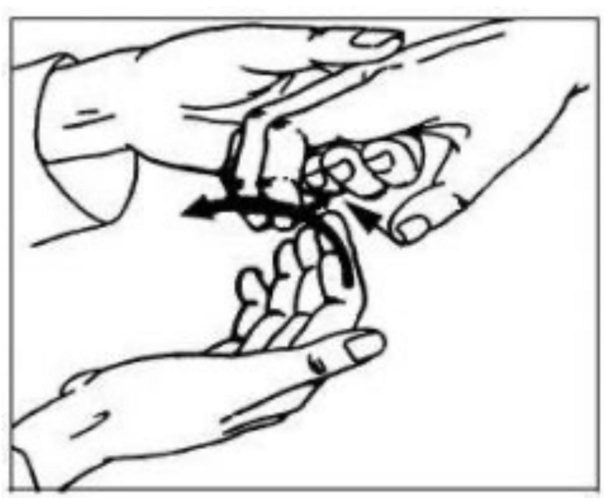
Tromner Sign



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Clin Spine Surg. 2016 Jul 11. [Epub ahead of print]

The Significance of the Trömner Sign in Cervical Spondylotic Myelopathy Patient.

Chaiyamongkol W[1], Laohawiriyakamol T, Tangtrakulwanich B, Tanutit P, Bintachitt P, Siribumrungwong K.

⊕ Author information

Abstract

STUDY DESIGN: This study is a diagnostic analysis.

OBJECTIVE: To investigate the diagnostic accuracy of Trömner sign in cervical spondylotic myelopathy (CSM), and how its presence correlates with the severity of myelopathy.

SUMMARY OF BACKGROUND DATA: A clinical presentation of myelopathy corresponding with image findings is a current standard to diagnose CSM. Trömner sign is an alternative of well-known Hoffmann sign to detect CSM. Little is known about its diagnostic accuracy and how its presence correlates with the severity of CSM.

MATERIALS AND METHODS: Consecutive patients with clinical diagnosis of CSM and other cervical spondylosis-related problems were enrolled in either CSM group, cervical spondylotic radiculopathy group, or axial pain group. Normal volunteers and patients without spine-related issues were used as a control. All participants were examined for the presence of myelopathic signs. Magnetic resonance imaging studies of all participants were reviewed by a radiologist.

RESULTS: There were 85 participants included in the study. Diagnostic sensitivity was 76%, 94%, 76%, and 36% for Hoffmann sign, Trömner sign, inverted radial reflex, and Babinski sign, respectively. Trömner sign had relatively high sensitivity (95%) despite of mild degree of myelopathy. Negative predictive value was 60%, 85%, 59%, and 38% for Hoffmann sign, Trömner sign, inverted radial reflex, and Babinski sign, respectively. There were 63%-71% of patients in either axial pain group or cervical spondylotic radiculopathy group had positive Trömner sign. Most of CSM patients with cord signal changed had positive myelopathic sign. Regarding CSM patient without cord signal change, most of tests were negative except Trömner sign.

CONCLUSIONS: High sensitivity (94%) and relatively high negative predictive value (85%) for Trömner sign indicate the usefulness of Trömner sign in ruling out CSM. High incidence of positive Trömner sign in presymptomatic cervical cord compression patients suggests Trömner sign could have a useful role in early detection of presymptomatic patients.

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Demetrious *Chiropractic & Manual Therapies* 2013, **21**:22
http://www.chiromt.com/content/21/1/22

CHIROPRACTIC & MANUAL THERAPIES

CASE REPORT Open Access

First rib fracture and Horner's syndrome due to a motor vehicle collision: a case report

James Demetrious

Abstract

A case of a first rib fracture and Horner's syndrome due to a motor vehicle collision is reported. Initial evaluation in a hospital emergency department and follow-up by a medical primary care physician failed to provide identification of the Horner's syndrome. Careful assessment and review of the patient's symptoms, signs and images revealed this uncommon and important neurologic case presentation. A brief discussion related to traumatic first rib fracture, Horner's syndrome and arterial dissections of the neck is provided.

Keywords: Horner's syndrome, First rib, Fracture, Collision, Chiropractic, Dissection

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- A 73-year-old man presented to our chiropractic office eight-weeks following a vehicular accident.
- While driving, he suffered a head on collision with an oncoming vehicle.
- He was transported via ambulance to a local hospital where evaluation and extensive imaging was performed.
- The attending emergency medical physician diagnosed rib fractures and the patient was subsequently released from the hospital.
- He sought care with his medical primary care physician (PCP) and received a prescription for pain medication.
- No other recommendations were provided to the patient.

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- The patient's wife reported that while visiting the patient at the hospital immediately following the car accident, she noted asymmetry and partial drooping of his right eyelid.
- The patient and his wife indicated that previous attending physicians neither mentioned nor assessed this condition.
- His past history was negative for contributory medical, neurologic or ophthalmologic disorders.

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- The patient's vital signs were normal. He was alert and oriented. Initial visual inspection revealed miosis and partial ptosis of the right eye.
- His right eye was not responsive to direct or consensual light. Cardinal fields of gaze were normal.
- The patient denied alteration of facial sensation or hemi-facial anhidrosis of the affected side. No other abnormalities were noted on neurologic examination.
- Auscultation of the carotid and subclavian arteries revealed no bruits.

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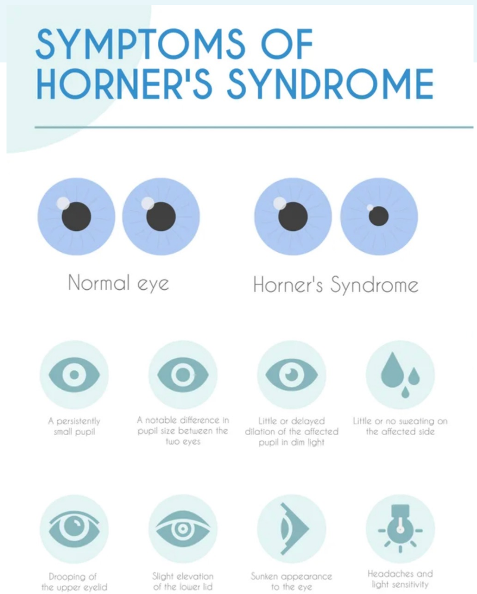

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- The lungs were clear to auscultation.
- Globally decreased cervical range of motion and localized tenderness was noted at C7/T1.
- Palpation revealed tenderness of the first rib at the apex of the right lung.
- The patient reported localized discomfort at C7/T1 upon cervical compression, Spurling’s test and Valsalva maneuver.
- No radiating pain was elicited. No other abnormalities were identified during physical examination.

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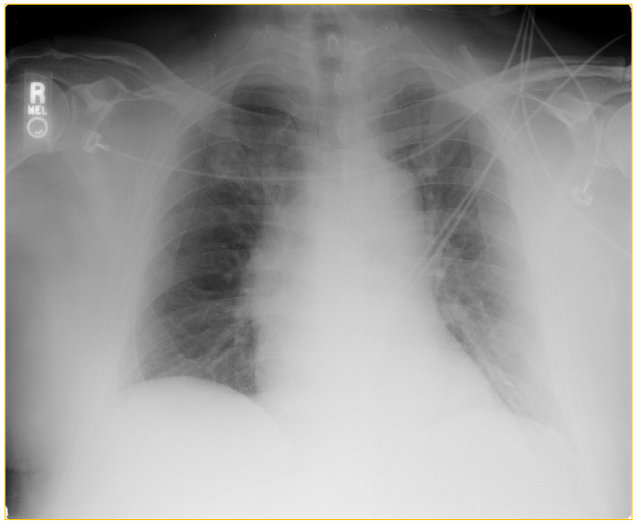

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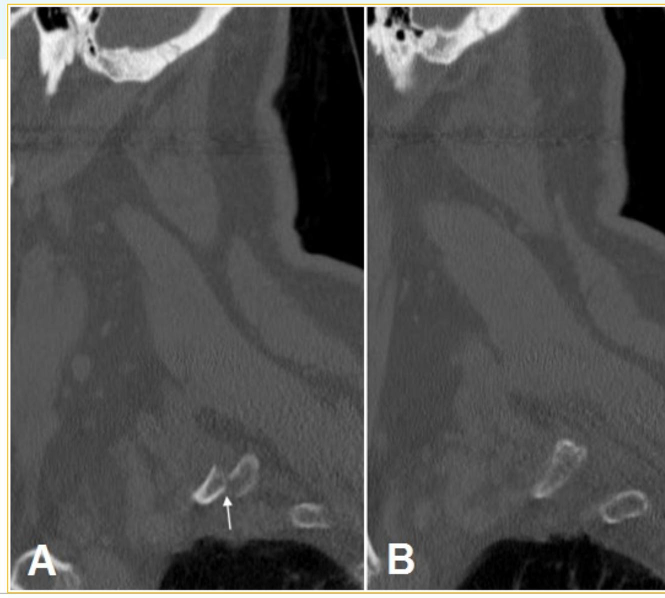

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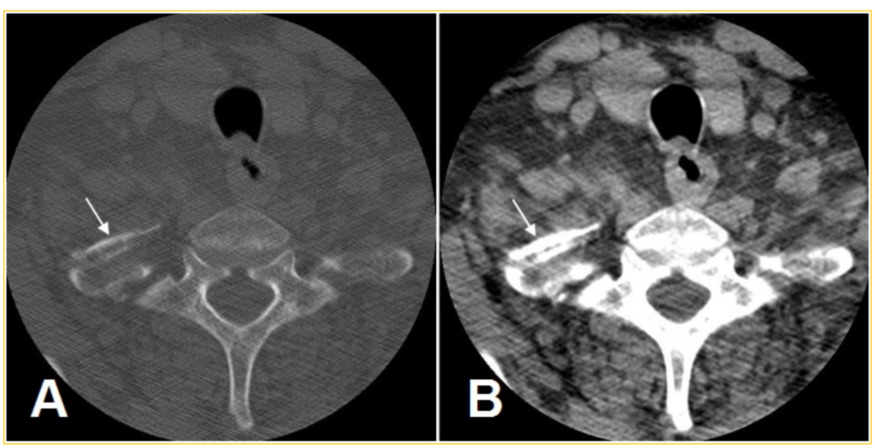

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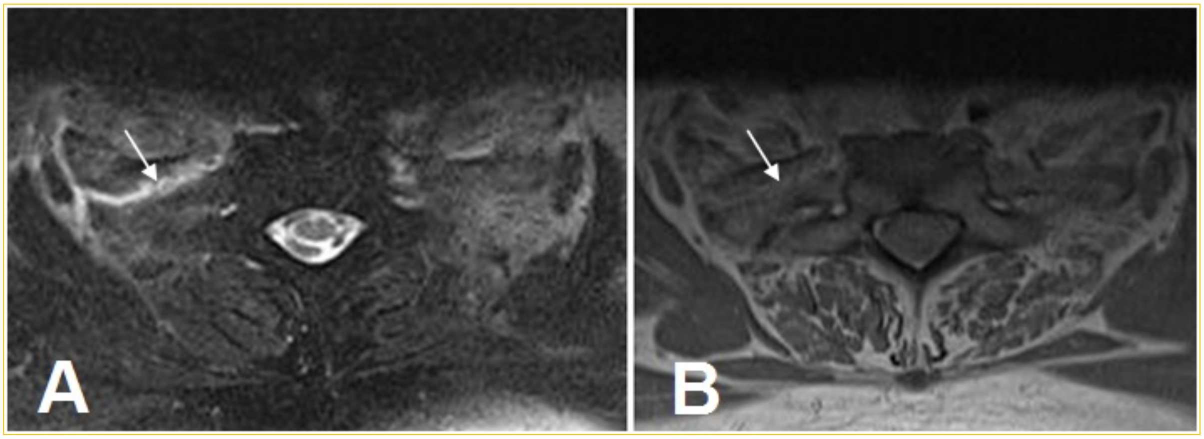

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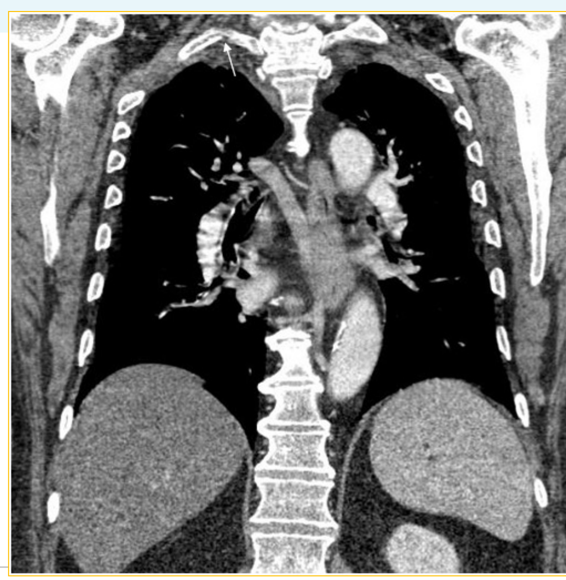

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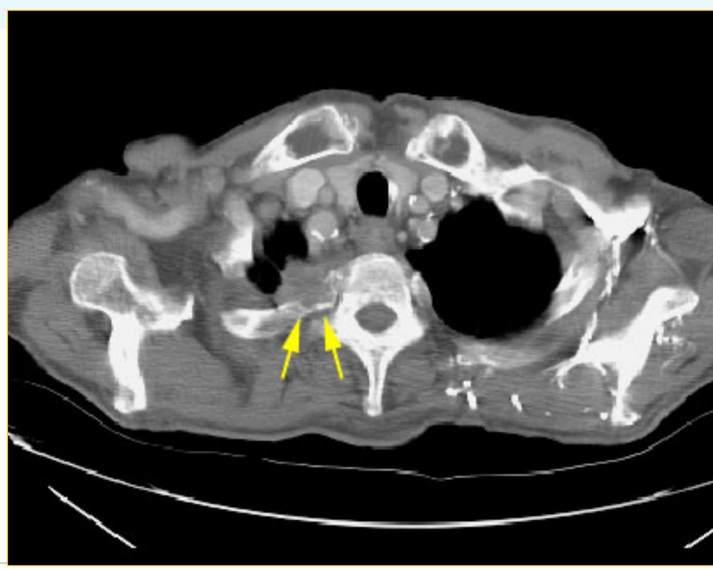

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Revised 2018

American College of Radiology
ACR Appropriateness Criteria®
Suspected Spine Trauma

Variant 2: **Age greater than or equal to 16 years. Suspected acute cervical spine blunt trauma. Imaging indicated by NEXUS or CCR clinical criteria. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT cervical spine without IV contrast	Usually Appropriate	☢☢☢
Radiography cervical spine	May Be Appropriate	☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
CT cervical spine with IV contrast	Usually Not Appropriate	☢☢☢
CT cervical spine without and with IV contrast	Usually Not Appropriate	☢☢☢
CT myelography cervical spine	Usually Not Appropriate	☢☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI cervical spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical spine without IV contrast	Usually Not Appropriate	O

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Revised 2018

American College of Radiology
ACR Appropriateness Criteria®
Suspected Spine Trauma

Table 1. NEXUS Criteria for Cervical Spine Imaging [4]
• Focal neurologic deficit
• Midline spinal tenderness
• Altered level of consciousness
• Intoxication
• Distracting injury

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Revised 2018

American College of Radiology
ACR Appropriateness Criteria®
Suspected Spine Trauma

Table 2. CCR High-Risk Factors for Cervical Spine Injury [5]
• Age >65 years
• Paresthesias in extremities
• Dangerous mechanism
▪ Falls from ≥3 feet/5 stairs
▪ Axial load to head
▪ Motor vehicle crash with high speed, rollover, or ejection
▪ Bicycle collision
▪ Motorized recreational vehicle accident

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Revised 2018

American College of Radiology
ACR Appropriateness Criteria®
Suspected Spine Trauma

Table 3. CCR Low-Risk Factors for Cervical Spine Injury [5]
• Simple rear-end motor vehicle crash
• Patient in sitting position in emergency center
• Patient ambulatory at any time after trauma
• Delayed onset of neck pain
• Absence of midline cervical spine tenderness

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Eye and Brain

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REVIEW

Horner syndrome: clinical perspectives

This article was published in the following Dove Press journal:
Eye and Brain
10 April 2015
Number of times this article has been viewed

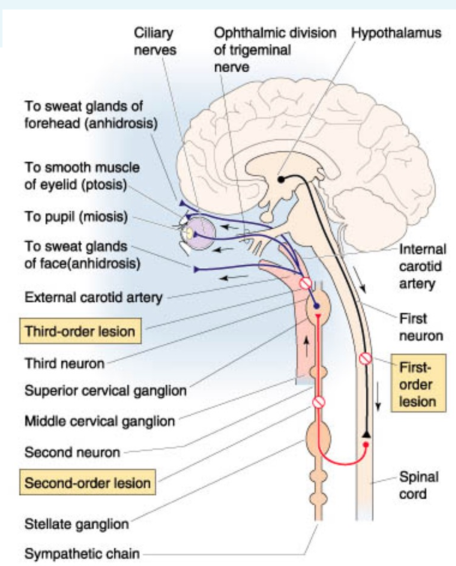
Sivashakthi Kanagalingam[1–3]
Neil R Miller[1–3]

[1]Department of Ophthalmology,
[2]Department of Neurology,
[3]Department of Neurosurgery,
The Johns Hopkins Hospital,
Baltimore, MD, USA

Abstract: Horner syndrome consists of unilateral ptosis, an ipsilateral miotic but normally reactive pupil, and in some cases, ipsilateral facial anhidrosis, all resulting from damage to the ipsilateral oculosympathetic pathway. Herein, we review the clinical signs and symptoms that can aid in the diagnosis and localization of a Horner syndrome as well as the causes of the condition. We emphasize that pharmacologic testing can confirm its presence and direct further testing and management.

Keywords: Horner syndrome, oculosympathoparesis, anisocoria, ptosis, anhidrosis

Horner's Syndrome



Central (First Order)

Hypothalamus
- Stroke
- Tumor

Brainstem
- Stroke (lateral medullary infarction)
- Demyelination
- Tumor

Spinal cord (cervicothoracic)
- Trauma
- Syringomyelia
- Tumor (intramedullary)
- Demyelination
- Myelitis
- Arteriovenous malformation

Preganglionic (Second Order)

Cervical spine disease
Brachial plexus injury

Pulmonary apical lesions
- Apical lung tumor
- Mediastinal tumors
- Cervical rib
- Trauma
- Latrogenic (jugular cannulation, chest tube, thoracic surgery)

Subclavian artery aneurysm

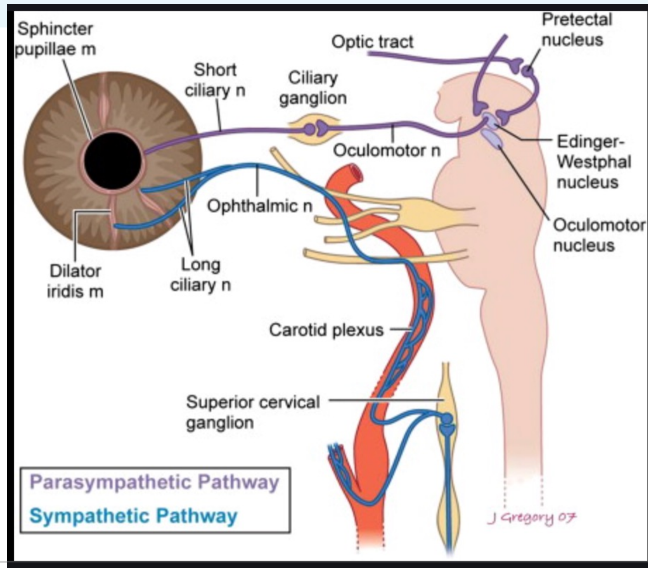
Thyroid tumors

Postganglionic (Third Order)

Superior cervical ganglion
- Trauma
- Jugular venous ectasia
- Latrogenic (surgical neck dissection)

Internal carotid artery
- Dissection
- Aneurysm
- Trauma
- Arteritis
- Tumor

Skull base lesions (nasopharyngeal carcinoma, lymphoma)
Cavernous sinus lesion
- Tumors
- Pituitary tumor
- Inflammation
- Thrombosis
- Carotid aneurysm
- Cluster headache



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Key Points

- Despite the obvious visual cue of a drooping eyelid, the patient's attending medical providers did not properly assess this condition. This is critical as the patient could have suffered a traumatic arterial dissection that may have been undetected and untreated.
- It is important to recognize the fallibility and inherent difficulty of identifying rib fractures.
- Had the patient suffered an undiagnosed post-traumatic arterial dissection, subsequent delivery of chiropractic adjustment, spinal manipulation or manual therapy could have been wrongly implicated as a causative etiology of the dissection and/or Horner's syndrome.

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Instructive Case

Chiropractic & Osteopathy

BioMed Central

Case report

Open Access

Lung cancer metastasis to the scapula and spine: a case report

James Demetrious*[1,2] and Gregory J Demetrious[3]

Address: [1]Private practice, Wilmington, NC, USA, [2]Post-graduate faculty, New York Chiropractic College, Seneca Falls, NY, USA and [3]Private practice, Wilmington, NC, USA

Email: James Demetrious* - jdemetrdc@aol.com; Gregory J Demetrious - gdemetrious@bellsouth.net

* Corresponding author

Published: 12 August 2008

Chiropractic & Osteopathy 2008, **16**:8 doi:10.1186/1746-1340-16-8

This article is available from: http://www.chiroandosteo.com/content/16/1/8

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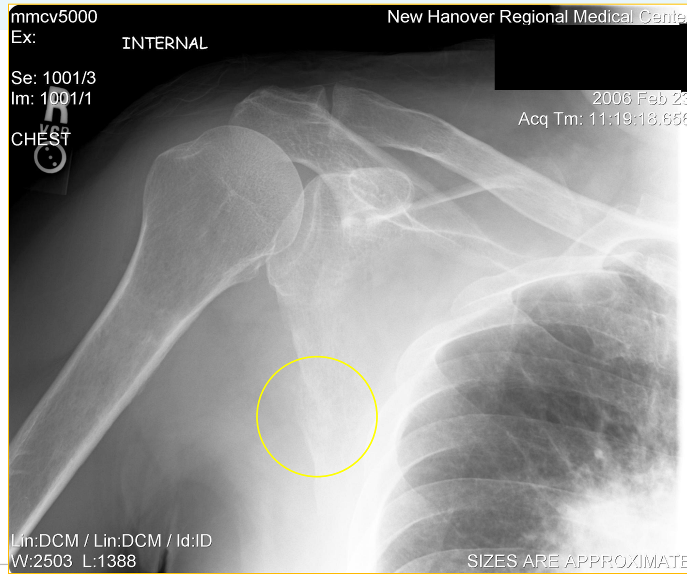

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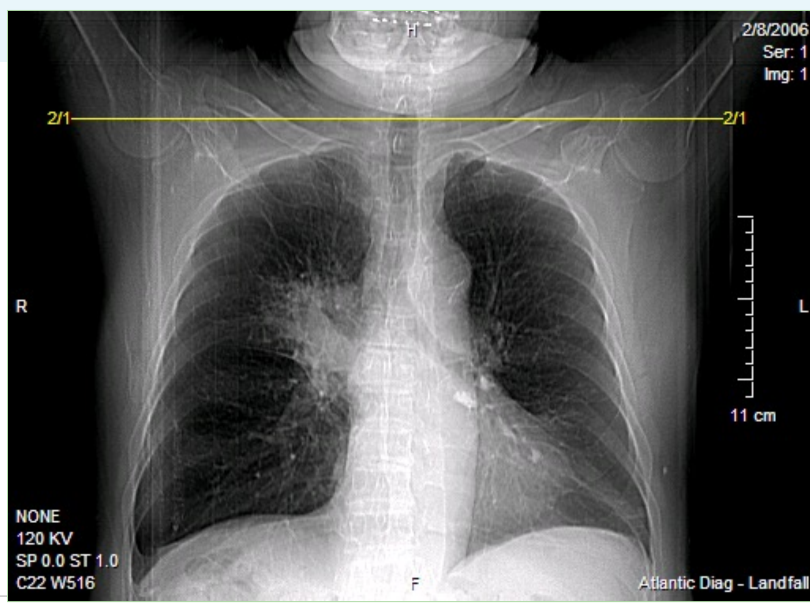

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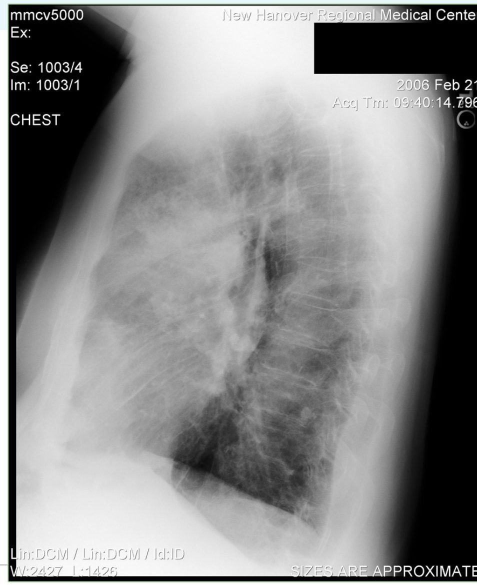

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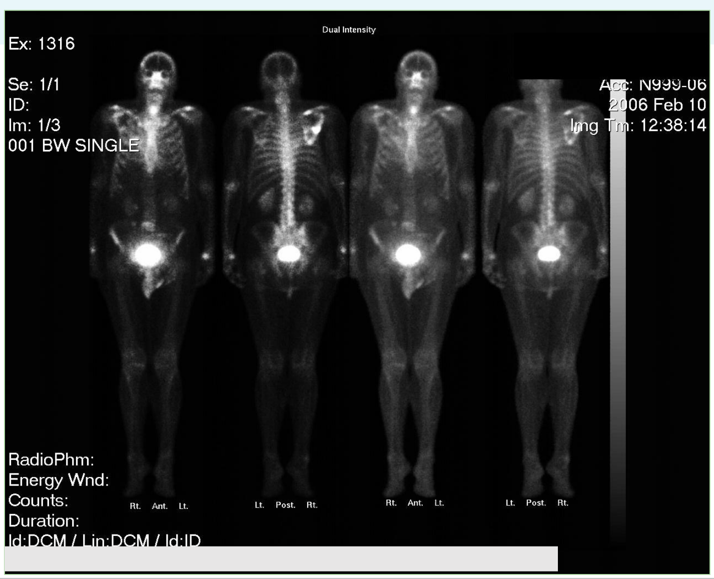

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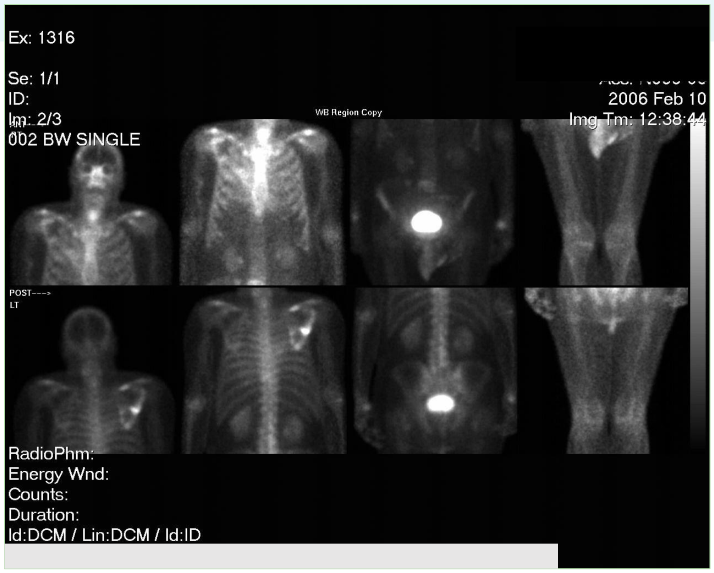

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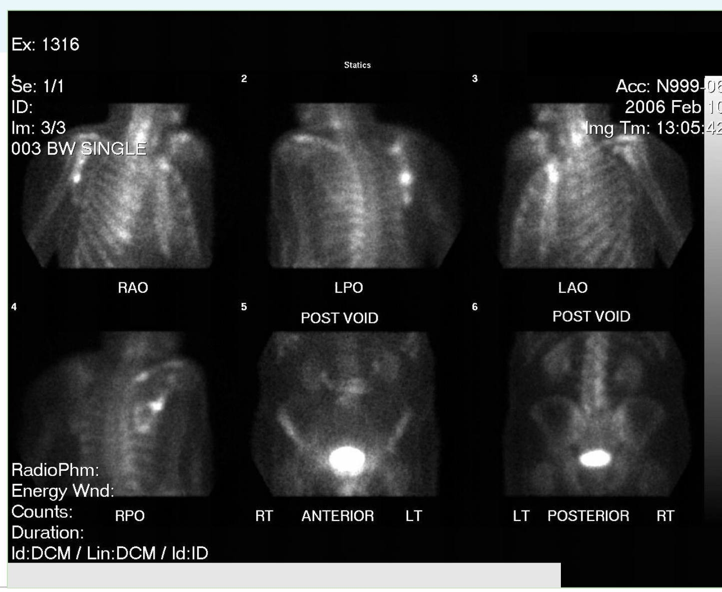

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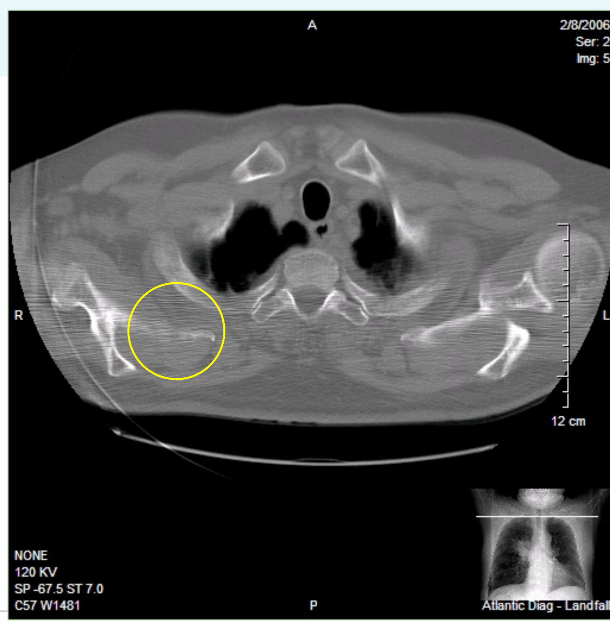
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Atlantic Diag - Landfall

450

Neuro-Oncology Practice
7(S1), i5–i9, 2020 | doi:10.1093/nop/npaa046

Epidemiology of spinal cord and column tumors

Joshua T. Wewel and John E. O'Toole

Atlanta Brain and Spine Care, Piedmont Healthcare, Atlanta, Georgia (J.T.W.); Department of Neurosurgery, University Medical Center, Chicago, Illinois, US (J.E.O)

- The hallmark symptom for spinal metastases is back pain, with 80% to 95% of patients having this symptom.10,14
- Pain can be further characterized as local pain, mechanical pain, or radicular pain.14,15
- When back pain exists in the setting of a known prostate or breast cancer patient, a spinal lesion is present 15% and 20% to 30% of the time, respectively.3,16
- Motor dysfunction is the second most common complaint on presentation, present in 35% to 75% of patients.14
- When there is significant neural compression, sensory disturbances can be present and usually accompany pain and/or motor complaints.14,15

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Neuro-Oncology Practice
7(S1), i5–i9, 2020 | doi:10.1093/nop/npaa046

Epidemiology of spinal cord and column tumors

Joshua T. Wewel and John E. O'Toole

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- A detailed history and neurologic exam is necessary, and the provider is obligated to obtain radiographs.
- In its most severe form, metastatic disease can cause spinal cord compression. Although relatively rare, in 10 per 100 000 patients spinal cord compression necessitates emergent evaluation.10
- The symptoms are often advanced and include weakness (60%-85%), sensory disturbances including saddle anesthesia, and bowel/bladder disturbances.15
- Untreated spinal cord compression can progress to paralysis, sensory loss, and bowel/bladder dysfunction.17

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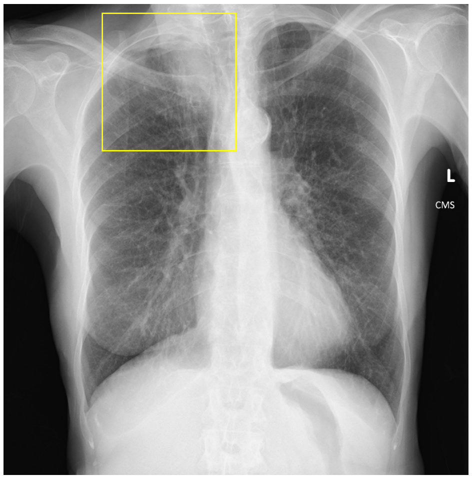
Instructive Case



Bickle, I. Pancoast tumor. Case study, Radiopaedia.org. (accessed on 26 Oct 2021) https://doi.org/10.53347/rID-89868

- 75-year-old patient presents with insidious onset, progressively worsening pain of 3 months duration affecting right posterior rib/scapular area.
- Pain constant and is exacerbated by head and neck movement.
- Orthopedic test revealed positive cervical compression for localized pain. Neurologic assessment was negative.
- X-rays were performed revealing density of the apex of the right lung.
- 5cm apical mass with destruction of the 2nd and 3rd ribs.

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- 5.5 cm soft tissue mass peripherally in the right upper lobe, infiltrating into chest wall with lytic destruction of the posterior ends of right second and third ribs and costovertebral junction.
- Background of emphysema and bronchial wall thickening bilaterally.
- Appearances are of a Pancoast tumor (lung cancer).

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Pancoast Tumor

Pathology

- Apical lung tumors are usually non-small cell lung cancers (NSCLC).

Gaillard, F., Bickle, I. Pancoast tumor. Reference article, Radiopaedia.org. (accessed on 26 Oct 2021) https://doi.org/10.53347/rID-1829

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Pancoast Tumor

Differential Diagnosis

General imaging differential considerations include:

- pulmonary metastases
- mesothelioma
- primary chest wall tumors
    - Ewing sarcoma
    - PNE (primitive neuroectodermal tumor) 7
- chest wall metastases
- apical pleural thickening secondary to e.g. previous pulmonary tuberculosis

- In addition a number of plain film mimics should be considered, including:
    - vascular lesions: e.g. carotid pseudoaneurysm [4]
    - anterosuperior mediastinal masses
    - bronchogenic adenocarcinomas are now more frequently identified [8].

Gaillard, F., Bickle, I. Pancoast tumor. Reference article, Radiopaedia.org. (accessed on 26 Oct 2021) https://doi.org/10.53347/rID-1829

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Pancoast Syndrome

Clinical Presentation

- The syndrome consists of:
  - shoulder pain
  - C8-T2 radicular pain
  - Horner syndrome
- The classical syndrome is uncommon, with Horner syndrome present in only 25%.

Gaillard, F., Bell, D. Pancoast syndrome. Reference article, Radiopaedia.org. (accessed on 26 Oct 2021) https://doi.org/10.53347/rID-1828

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JNMS: Journal of the Neuromusculoskeletal System
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Vol. 3, No. 1, Printed in the U.S.A.
1067-8239/$3.00/95

CASE REPORTS

Metastatic Renal Cell Carcinoma of the Sternum and Spine That Mimicked Costochondritis: A Case Report

James Demetrious, D.C., D.A.B.C.O., Chester, New York

A CASE OF RENAL CELL CARCINOMA with metastasis to the sternum and multiple vertebral levels is presented. Renal cell carcinoma is the most common renal malignancy afflicting adults. Early clinical findings in this case were suggestive of costochondritis and chiropractic vertebral subluxation. However, highly insidious and progressive metastatic disease rapidly overwhelmed the patient. Of interest, the patient reported early relief of painful symptoms through chiropractic and conservative means of care. Chiropractic evaluative procedure mandates that potential pathoclinical contraindications to spinal adjustments be identified as quickly as possible. Palliative relief of early-onset symptoms served to veil the true character of an extremely virulent form of cancer. (JNMS: Journal of the Neuromusculoskeletal System 3:16-19, 1995)

Key words: Chiropractic, Costochondritis, Metastases, Renal cell carcinoma, Spine, Sternum

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Renal Cell Carcinoma

Hindawi
Journal of Oncology
Volume 2021, Article ID 5575295, 17 pages
https://doi.org/10.1155/2021/5575295

Research Article

Bone Metastasis in Renal Cell Carcinoma Patients: Risk and Prognostic Factors and Nomograms

Zhiyi Fan,[1,2] Zhangheng Huang,[2] and Xiaohui Huang[1]

[1]*Hangzhou Medical College, Hangzhou, Zhejiang Province, China*
[2]*Department of Spine Surgery, Affiliated Hospital of Chengde Medical University, Chengde, Hebei Province, China*

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Received 10 February 2021; Revised 7 April 2021; Accepted 27 April 2021; Published 12 May 2021

"Nomogram is a tool that combines multiple biological and clinical variables to predict specific endpoints and has been widely used to predict the prognosis of cancer patients."

- Renal cell carcinoma (RCC) is one of the most common cancers worldwide, with approximately 403,262 new cases and 17,598 deaths in 2018 [1].
- Approximately 15–30% of RCC patients have metastases at the initial diagnosis, and bone is a common site of metastasis [2, 3].
- Bone metastasis (BM) from RCC is predominantly osteolytic and can lead to skeletal-related diseases, which can reduce the quality of life and prognosis of the patients [4, 5].
- The median overall survival (OS) of RCC patients with BM has been reported to be only 12–28 months [6, 7].

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Renal Cell Carcinoma

Cureus
Publishing Beyond Open Access

Cureus. 2021 Aug; 13(8): e17217.
Published online 2021 Aug 16. doi: 10.7759/cureus.17217
PMCID: PMC8442569
PMID: 34540444

Recurrence Risk of Renal Cell Carcinoma Lingers Even Decades After Nephrectomy

Monitoring Editor: Alexander Muacevic and John R Adler

Muhammad Ammar B Hamid,[1] Aasim Sehbai,[1] Shahan Tariq,[1] and Sana Ullah[2]

Author information ▸ Article notes ▸ Copyright and License information Disclaimer

[1] Hematology and Oncology, Alabama Cancer Care (ALCC), Anniston, USA
[2] Oncology, Atomic Energy Cancer Hospital (NORI), Islamabad, PAK

- Renal cell carcinoma (RCC) usually originates from the cortex of the kidney.
- It is mostly seen in men between 50-70 years of age.
- The most common sites for the metastases of RCC include the lung, bone, liver, and brain.
- Although infrequent, yet the metastatic presentation of such lesions more than five years after nephrectomy is not an uncommon finding [2].

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Renal Carcinoid

- Carcinoid tumors are a rare subset of neuroendocrine tumors with an incidence of 38 for every 1 million persons in the United States [1,2].
- Carcinoid tumors are neuroendocrine neoplasms arising most commonly in the gastrointestinal tract and the lungs [3].
- When these tumors occur, the ability to metastasize is low. In a review of the literature, only 23% were found to metastasize, with lymph node (LN) and liver involvement being the most common locations at 18% each [8].

Kelly E F, Connelly Z M, Noonan M J, et al. (March 15, 2021) Primary Renal Carcinoid: Two Rare Cases at a Single Center. Cureus 13(3): e13907. DOI 10.7759/cureus.13907

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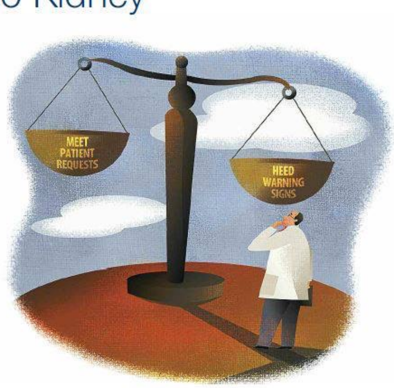
D.C.s need to be ever-vigilant to detect serious conditions that present as back pain. Dr. James Demetrious shares a real-life case example below.

Lower Back Pain Due to Kidney Carcinoid Metastasis: **A Case Study**

By James Demetrious, D.C., FACO



Following a busy weekend, a 49-year-old gentleman presented for chiropractic care. He reported moderate lower back pain that began two days earlier after lifting light objects at his home. He denied any recent injuries or illnesses. He reported bouts of lower back pain in the past for which he attained relief via chiropractic care.

The patient's medical history was notable for renal carcinoid tumor for which he underwent kidney resection five years earlier. Two years later, he underwent partial liver resection due to related metastatic disease. He reported

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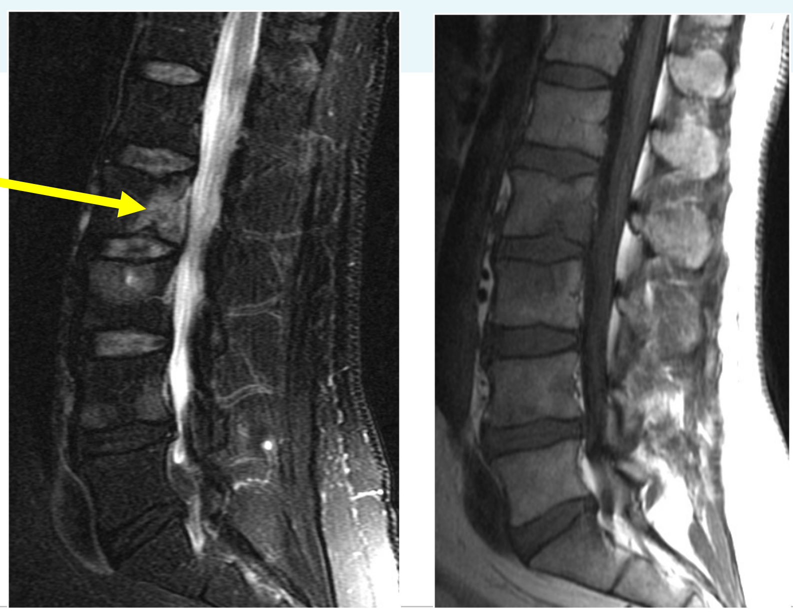

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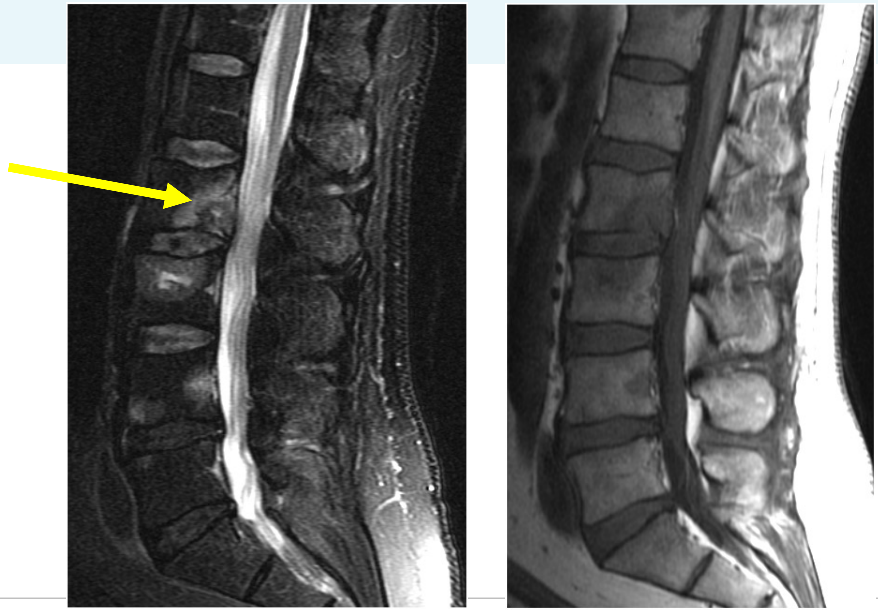

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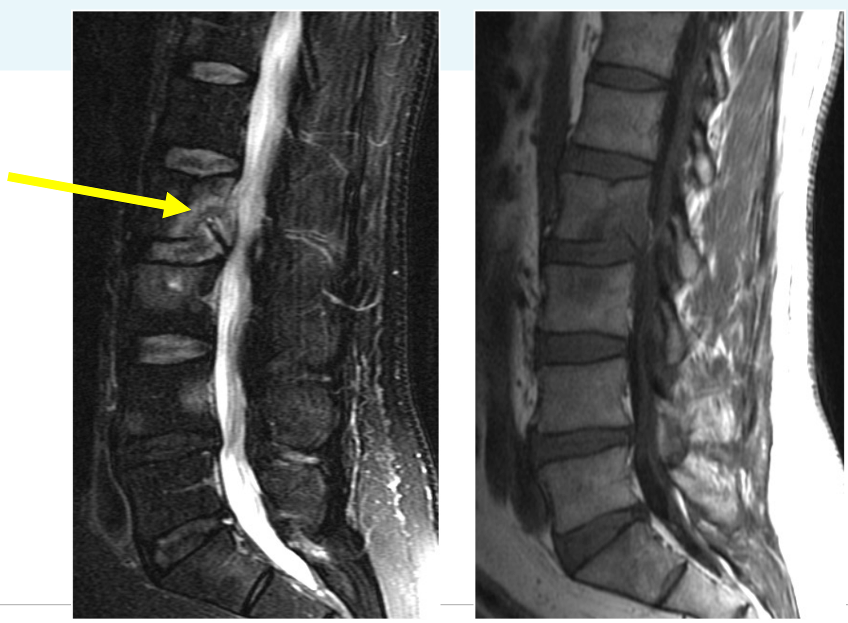

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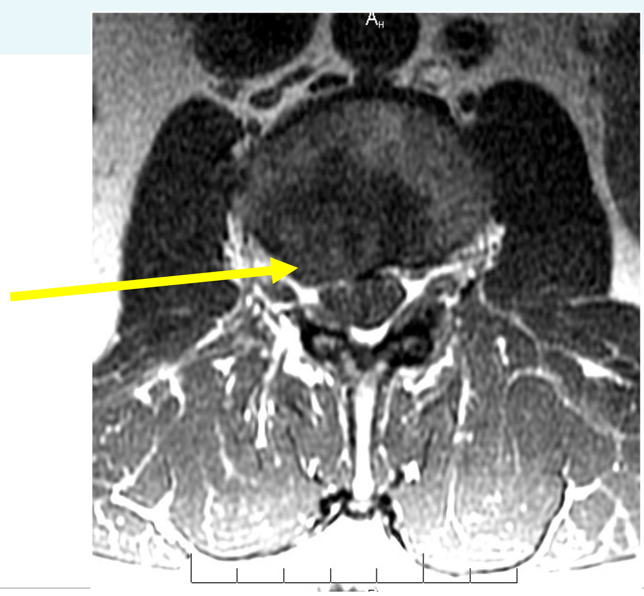

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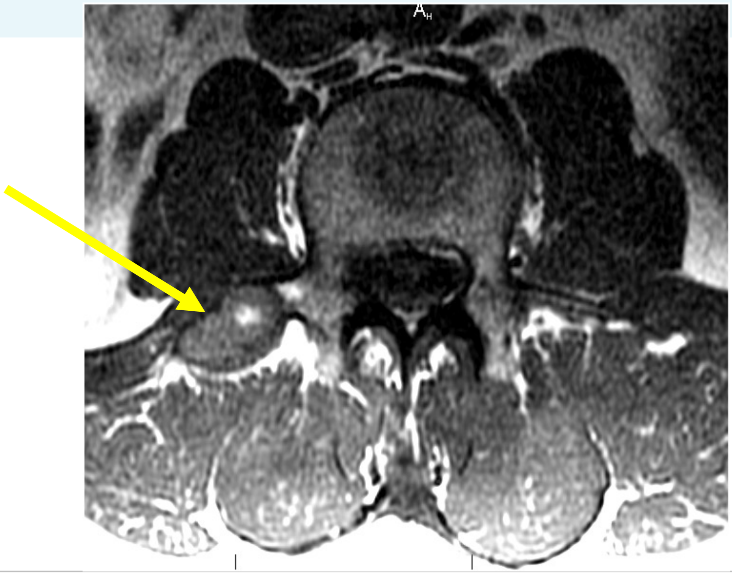

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What Can We Learn?

- **Take proper history and identify contraindications to chiropractic care.** Proper and thorough evaluation of patients' past history is vitally important. Patients with a prior history of cancer need to be identified and carefully assessed.
- **Resist the urge to provide chiropractic care for patients who may have a contraindication to care.** While the patient in this case appeared to have an uncomplicated mechanical lower back pain, review of his past history revealed a possible contraindication to chiropractic care. The urge and desire to negate the recurrence of cancer should not supersede clinical need.
- **Do not accept the waivers of liability from patients.** Despite the patient's willingness to provide a waiver of liability to the chiropractor, ultimately, clinical assessment and decision-making should supersede such requests.
- **Consider complicated diagnostic issues and integrative discussion with attending physicians.** Intrinsic issues related to specific patients must be identified and managed. In this case, the patient's had one kidney due to a prior surgery. Due to inherent susceptibility of complications related to gadolinium contrast, careful assessment and medical integration should be considered when ordering advanced diagnostic testing.
- **Seek continuing education to stay apprised of complicated courses of action.** NCMIC provides expert continuing education on behalf of the chiropractic profession.
- **Follow up.** Make proper recommendations and referrals. Follow-up with telephone calls and written letters to assure that the patient understands their condition and your referral recommendations.

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Instructive Case

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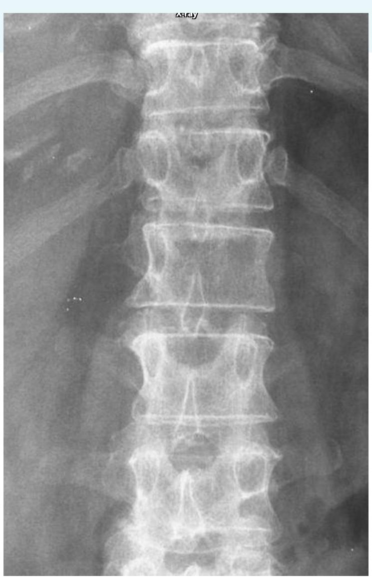

Winking Owl Sign Etiologies:

- destroyed pedicle
  - spinal metastases
  - intraspinal malignancies
  - tuberculosis and other infections
  - uncommon: primary bone lesion; lymphoma
- congenital absence/hypoplasia of a pedicle
- neurofibromatosis
- poorly-visualized
- radiation therapy

Schubert, R., Bickle, I. Winking owl sign (spine). Reference article, Radiopaedia.org. (accessed on 22 Sep 2021) https://radiopaedia.org/articles/14693

472

Instructive Case

- A 66-year-old gentleman presents for chiropractic care with a chief complaint of thoraco-lumbar pain that begin insidiously 5-months earlier.
- He denied any recent trauma or other illnesses. Pain is progressively worsening causing him to use a cane.
- No radicular, bowel/bladder issues, saddle dysesthias, or weakness reported.
- He reports a history of prostate cancer for what he is under care.
- He is a lifelong chiropractic patient who is seeking relief.

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Multiple Myeloma

- Due to progressively worsening pain and history of prostate cancer, patient was referred back to his primary care physician and oncologist for assessment.
- Chiropractic care was not administered to the patient pending these examinations.
- Medical assessment revealed elevated serum calcium, renal insufficiency, anemia and elevated serum M protein.
- Whole body MRI was performed revealing multifocal, diffuse and heterogenous T1 marrow hypo-intensities.
- The patient was provided a diagnoses of multiple myeloma and received chemotherapy and bone marrow transplant.

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Multiple Myeloma

Terminology

- As per the WHO classification of tumors of hematopoietic and lymphoid tissues, multiple myeloma is called plasma cell myeloma. Historically, it was sometimes known as Kahler disease or myelomatosis [13].
- Four main patterns are recognized:
  - disseminated form: multiple well-defined "punched out" lytic lesions: predominantly affecting the axial skeleton
  - disseminated form: diffuse skeletal osteopenia
  - solitary plasmacytoma: a single large/expansile lesion most commonly in a vertebral body or in the pelvis
  - osteosclerosing myeloma

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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Multiple Myeloma

Epidemiology

- Multiple myeloma is a common malignancy in patients above 40 (70% of cases are diagnosed between ages 50 and 70 with a median age of diagnosis being 69 years) with a male predilection (M: F 2:1) [7,12].
- It accounts for 1% of all malignancies and 10% of all hematological disease [12].
- Multiple myeloma and osteosarcoma combined account for approximately 50% of all primary bone malignancies [7].

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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Multiple Myeloma

Clinical Presentation

- Clinical presentation of patients with multiple myeloma is varied, and includes [1,2,7]:
  - bone pain
    - initially intermittent, but becomes constant
    - worse with activity/weight-bearing, and thus is worse during the day
  - anemia
    - typically normochromic/normocytic
  - renal failure
  - proteinuria
  - hypercalcemia

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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Multiple Myeloma

The **typical clinical manifestations of multiple myeloma** can be recalled using the **mnemonic**:

- **CRAB Mnemonic**
  - **C:** hypercalcemia
  - **R:** renal failure
  - **A:** anemia
  - **B:** bone disease

Knipe, H., Bell, D. Typical clinical manifestations of multiple myeloma (mnemonic). Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/70874

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Multiple Myeloma

Distribution

- Distribution of multiple myeloma mirrors that of red marrow in the older individual, and thus this is mostly encountered in the axial skeleton and proximal appendicular skeleton:
  - vertebrae (most common)
  - ribs
  - skull
  - shoulder girdle
  - pelvis
  - long bones
  - extraskeletal structures (extraosseous myeloma): rare

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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Multiple Myeloma

MRI

- MRI is more sensitive in detecting multiple lesions compared to the standard plain film skeletal survey and CT [8,12]. Five patterns have been described [12]:
  - normal bone marrow signal
  - diffuse involvement
  - focal involvement
  - combined diffuse and focal involvement
  - variegated ("salt and pepper")

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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Multiple Myeloma

Differential diagnosis

- The main differential is that of widespread bony metastases
- Findings that favor the diagnosis of bone metastases over that of multiple myeloma include:
  - more commonly affect the vertebral pedicles rather than vertebral bodies
  - rarely involve mandible, distal axial skeleton
  - although both entities have variable bone scan appearances (both hot and cold) unlike myeloma, extensive bony metastases rarely have a normal appearance

Yap, K., Bell, D. Multiple myeloma. Reference article, Radiopaedia.org. (accessed on 18 Oct 2021) https://radiopaedia.org/articles/9555

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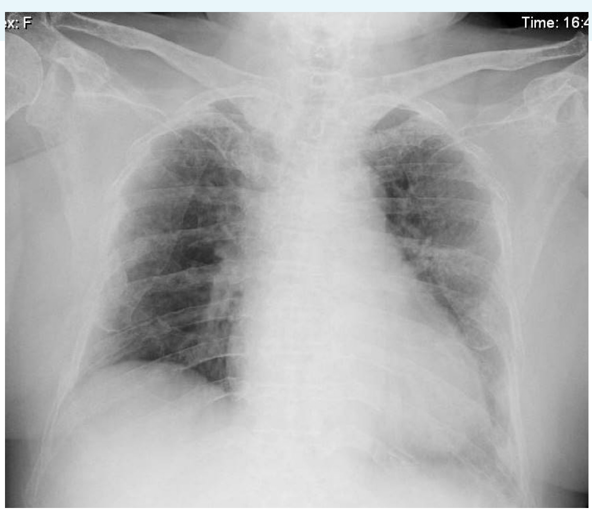

Case courtesy of Dr Paresh K Desai, Radiopaedia.org, rID: 10036

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Sagittal T1 (left) and T2 (right) MR images of the thoracic spine show the typical pattern of diffuse involvement by multiple myeloma (MM) with low T1 signal from all marrow. Multiple areas of extraosseous extension → are present in the ventral epidural space. Note the compression fracture involving the superior endplate ↷.

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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Sagittal STIR MR increases the conspicuity of the variegated marrow. Hyperintense foci are noted in spinous processes ↷. Larger lesions are seen in the T2 and T6 vertebral bodies →.

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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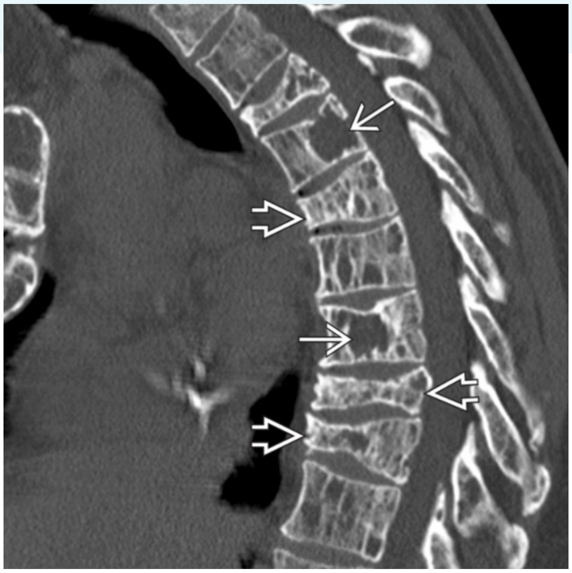

Sagittal CT shows diffuse osteopenia with multiple vertebral body lytic lesions ➙. Pathologic compression fractures ⇨ are seen in multiple midthoracic vertebral bodies. Compression fractures can cause variable central canal narrowing.

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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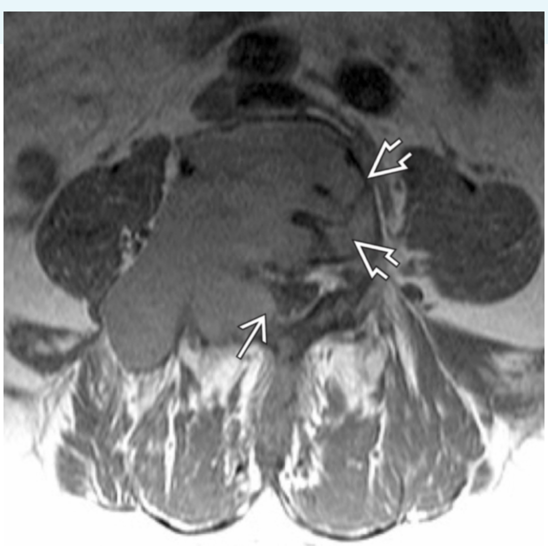

Axial T1 MR shows the large, homogeneous myelomatous mass involving the right side of the vertebral body and posterior elements with epidural extension ➙. Note the convoluted pattern of bone destruction described as minibrain pattern ⇨.

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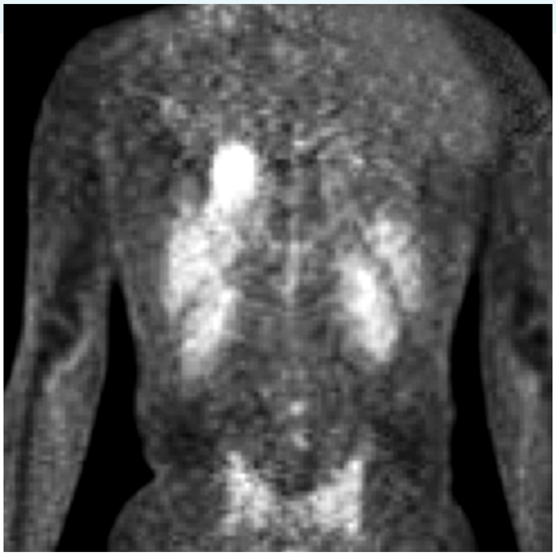

Coronal F-18 FDG PET demonstrates the same metabolically active right rib lesion.

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Instructive Case

- 52-year-old male presents for chiropractic care with progressively worsening thoraco-lumbar pain that began insidiously.
- Patient reports 8/10 pain that is not alleviated by any means.
- Lower extremity weakness, difficulty ambulating and bladder incontinence.

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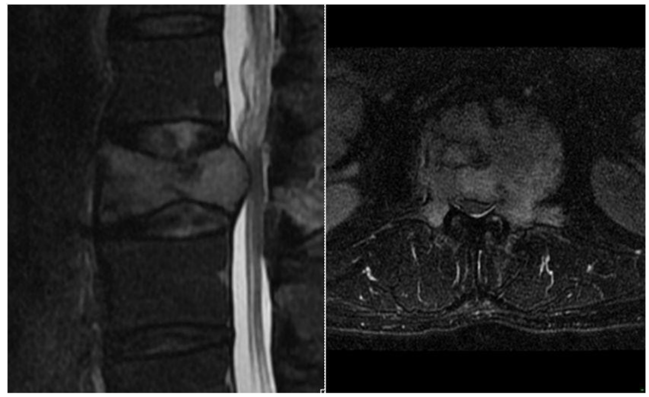
Salient examination findings:

- Midline, spinous process tenderness on palpation affecting L1.
- Bilateral motor, reflex and sensitivity deficits.
- Due to profound cauda equina presentation, patient was referred to his primary care physician with a prescription for x-rays and MRI of the thoraco-lumbar spine.



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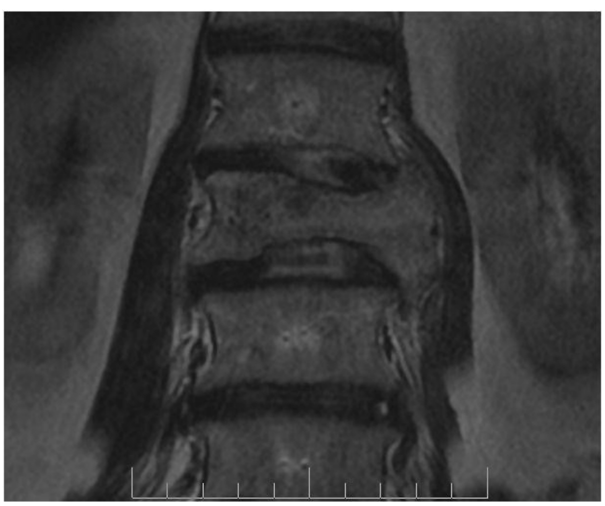

- MRI revealed an expansile solitary tumor that infiltrated the L1 vertebra with retropulsion and spinal canal compromise.
- Oncologic assessment revealed Plasmacytoma.

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Plasmacytoma

Presentation

- Most common signs/symptoms
  - Clinical manifestations related to anatomic sites
    - Most common symptom = pain due to bone destruction
      - Painful phase with mean of 6 months
    - Can be asymptomatic
    - Epidural extension may cause compression of cord or nerve root
    - Pathologic fracture may cause cord compression
  - Other signs/symptoms
    - Low levels of serum/urine monoclonal proteins (25-75%)
      - M protein has been reported in 24-72%
    - Uncommon presentation of demyelinating polyneuropathy
      - Consider POEMS (**p** olyneuropathy, **o** rganomegaly, **e** ndocrinopathy, **M** protein, **s** kin changes) syndrome

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Plasmacytoma

Imaging

- Axial skeleton > extremities
  - Thoracic vertebral body most common site
- Radiographs/CT
  - Lytic, multicystic-appearing lesion ± vertical dense striations
  - Pathologic compression fracture common
- T1-hypointense, T2-/STIR-hyperintense marrow with low-signal, curvilinear areas
  - Posterior elements involved in most cases
  - ± associated soft tissue mass (paraspinous or epidural with draped curtain sign)

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Plasmacytoma

Differential Diagnosis:

- **Multiple Myeloma**
  - 2nd lesion found in 33% of cases with presumed spine SBP
- **Metastasis**
  - May be indistinguishable from SBP
  - Posterior element involvement not useful in differentiating from SBP
  - Does not involve disc or adjacent vertebrae
- **Benign (Osteoporotic) Compression Fracture**
  - Common in older patients, including those with SBP and MM
  - 50-60% of compression fractures in MM appear benign on MR
  - Signal intensity (subacute/chronic fractures) like normal marrow
- **Vertebral Hemangioma (VH)**
  - Aggressive VHs may mimic SBP, metastases are rare
  - Marrow signal of aggressive VH may resemble SBP
  - Most benign VHs are T1/T2 hyperintense
  - Intense enhancement
- **Paget Disease**
  - Vertebral body expansion with thickened trabeculae

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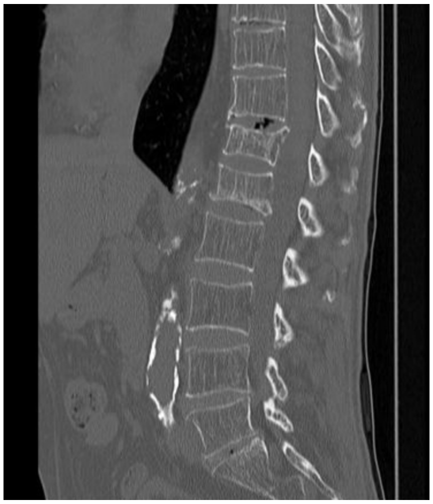

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Osteoporosis

APPROPRIATE USE CRITERIA

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ACR Appropriateness Criteria® Osteoporosis and Bone Mineral Density

Expert Panel on Musculoskeletal Imaging: *Robert J. Ward, MD[a], Catherine C. Roberts, MD[b], Jenny T. Bencardino, MD[c], Erin Arnold, MD[d], Steven J. Baccei, MD[e], R. Carter Cassidy, MD[f], Eric Y. Chang, MD[g], Michael G. Fox, MD[h], Bennett S. Greenspan, MD, MS[i], Soterios Gyftopoulos, MD[j], Mary G. Hochman, MD[k], Douglas N. Mintz, MD[l], Joel S. Newman, MD[m], Charles Reitman, MD[n], Zehava S. Rosenberg, MD[o], Nehal A. Shah, MD[p], Kirstin M. Small, MD[p], Barbara N. Weissman, MD[q]*

Abstract

Osteoporosis is a considerable public health risk, with 50% of women and 20% of men >50 years of age experiencing fracture, with mortality rates of 20% within the first year. Dual x-ray absorptiometry (DXA) is the primary diagnostic modality by which to screen women >65 years of age and men >70 years of age for osteoporosis. In postmenopausal women <65 years of age with additional risk factors for fracture, DXA is recommended. Some patients with bone mineral density above the threshold for treatment may qualify for treatment on the basis of vertebral body fractures detected through a vertebral fracture assessment scan, a lateral spine equivalent generated from a commercial DXA machine. Quantitative CT is useful in patients with advanced degenerative bony changes in their spines. New technologies such as trabecular bone score represent an emerging role for qualitative assessment of bone in clinical practice. It is critical that both radiologists and referring providers consider osteoporosis in their patients, thereby reducing substantial morbidity, mortality, and cost to the health care system.

The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed annually by a multidisciplinary expert panel. The guideline development and revision include an extensive analysis of current medical literature from peer reviewed journals and the application of well-established methodologies (RAND/UCLA Appropriateness Method and Grading of Recommendations Assessment, Development, and Evaluation or GRADE) to rate the appropriateness of imaging and treatment procedures for specific clinical scenarios. In those instances where evidence is lacking or equivocal, expert opinion may supplement the available evidence to recommend imaging or treatment.

Key Words: Appropriateness Criteria, Appropriate Use Criteria, AUC, DXA, fracture, osteoporosis, screening

J Am Coll Radiol 2017;14:S189-S202.

- Osteoporosis has been defined as a skeletal disorder characterized by compromised bone strength, predisposing a person to an increased risk for fracture [1].
- Both quantitative (bone mineral density [BMD]) and qualitative (trabecular microarchitecture) components contribute to overall bone strength.
- The measurement of BMD is the consensus approach to screening and monitoring osteoporosis in the population.
- Fifty percent of women and 20% of men >50 years of age will experience bone fracture, with mortality rates of 20% within the first year [2].
- The annual direct cost of hip fracture in the United States is $30 billion and projected to rise to $67.7 billion by 2020 [3].

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Variant 1. Asymptomatic BMD screening or individuals with established or clinically suspected low BMD.

Radiologic Procedure	Rating	Comments	RRL
DXA lumbar spine and hip(s)	9		☢
QCT lumbar spine and hip	6		☢☢☢
DXA distal forearm	5		☢
TBS lumbar spine	4		☢
QUS calcaneus	2		O
SXA distal forearm	2		☢
pQCT distal forearm	2		☢
X-ray axial skeleton	1		Varies
X-ray appendicular skeleton	1		☢☢

Note: Rating Scale 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; pQCT = peripheral QCT; QCT = quantitative CT; QUS = peripheral ultrasound; RRL = relative radiation level; SXA = single x-ray absorptiometry; TBS = trabecular bone score.

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Osteoporosis

Variant 3. Follow-up. Patients demonstrated to have risk for fracture or low density.			
Radiologic Procedure	Rating	Comments	RRL
DXA lumbar spine and hip(s)	9		☢
QCT lumbar spine and hip	7		☢☢☢
DXA VFA	5		☢
pQCT distal forearm	3		☢
TBS lumbar spine	2		☢
QUS calcaneus	1		O
SXA distal forearm	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; QCT = quantitative CT; QUS = quantitative ultrasound; RRL = relative radiation level; SXA = single x-ray absorptiometry; TBS = trabecular bone score; VFA = vertebral fracture assessment; pQCT = peripheral QCT.

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Osteoporosis

Variant 4. Identify low BMD. Premenopausal females with risk factors. Males 20–50 years of age with risk factors.			
Radiologic Procedure	Rating	Comments	RRL
DXA lumbar spine and hip(s)	9		☢
DXA distal forearm	8		☢
QCT lumbar spine and hip	3		☢☢☢
pQCT distal forearm	3		☢
QUS calcaneus	1		O
SXA distal forearm	1		☢

Note: Rating Scale = 1,2,3 usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; pQCT = peripheral QCT; QCT = quantitative CT; QUS = quantitative ultrasound; RRL = relative radiation level; SXA = single x-ray absorptiometry.

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Osteoporosis

Variant 7. Suspected fracture (nonscreening) of a vertebral body based on acute or subacute symptomatology in a patient with suspected osteoporosis or a patient treated with corticosteroids (>3 months). First examination.

Radiologic Procedure	Rating	Comments	RRL
X-ray spine area of interest	9	This procedure includes 2 views.	Varies
CT spine area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	Varies
MRI spine area of interest without IV contrast	2		○
CT spine area of interest with IV contrast	1		Varies
CT spine area of interest without and with IV contrast	1		Varies
MRI spine area of interest without and with IV contrast	1		○
DXA VFA	1		☢

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; RRL = relative radiation level; VFA = vertebral fracture assessment.

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Variant 9. Patients on long-term treatment (3–5 years) of bisphosphonates with thigh or groin pain. First examination.

Radiologic Procedure	Rating	Comments	RRL
X-ray femur	9		☢
DXA extended femur scan	1		☢
CT thigh without IV contrast bilateral	1		☢☢
CT thigh with IV contrast bilateral	1		☢☢
CT thigh without and with IV contrast bilateral	1		☢☢☢
MRI thigh without IV contrast bilateral	1		○
MRI thigh without and with IV contrast bilateral	1		○
Tc-99m bone scan whole body	1		☢☢☢
US thigh bilateral	1		○

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; IV = intravenous; RRL = relative radiation level; US = ultrasound.

Variant 10. Patients on long-term treatment (3–5 years) of bisphosphonates with thigh or groin pain and negative radiographs.

Radiologic Procedure	Rating	Comments	RRL
MRI thigh without IV contrast bilateral	9		○
CT thigh without IV contrast bilateral	8		☢☢
Tc-99m bone scan whole body	7		☢☢☢
DXA extended femur scan	1		☢
CT thigh with IV contrast bilateral	1		☢☢
CT thigh without and with IV contrast bilateral	1		☢☢☢
MRI thigh without and with IV contrast bilateral	1		○
US thigh bilateral	1		○

Note: Rating Scale: 1,2,3 = usually not appropriate; 4,5,6 = may be appropriate; 7,8,9 = usually appropriate. DXA = dual-energy x-ray absorptiometry; IV = intravenous; RRL = relative radiation level; US = ultrasound.

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Dual-Energy X-ray Absorptiometry (DXA)

Overview of Imaging Modalities

- Dual-energy x-ray absorptiometry (DXA) is a projectional x-ray-based technology that has been shown to accurately and precisely measure BMD at specific sites: the lumbar spine, hip, and distal forearm.
- Two x-ray beams at different energy levels are used to subtract out the patient's soft-tissue absorption, providing a measurement of the skeletal BMD.
- The effective radiation dose for both lumbar spine and hip scanning is approximately equivalent to a chest x-ray [4].

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During Dual-Energy X-ray Absorptiometry (DXA)

- During dual-energy x-ray absorptiometry (DXA), you lie on an examination table. An x-ray detector scans a bone region, and the amount of x-rays that pass through bone are measured and displayed as an image that is interpreted by a radiologist or metabolic bone expert.
- The results of a bone density test are expressed either as a "T" or a "Z" score. T-scores represent numbers that compare the condition of your bones with those of an average young person with healthy bones.
- T-score is usually the most important. T-scores are usually in the negative or minus range. The lower the bone density T-score, the greater the risk of fracture (table 1).

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Bone Density

Definitions of normal bone density, osteopenia, and osteoporosis

T-score	Bone density
+1 to –1	**Normal bone density** Bone density that is between 0 and 1 SD below the mean is considered to be normal. This may be reported as a T-score of +1 to –1. Treatment is not usually recommended for people with normal bone density, although preventive measures (eg, calcium supplements, weightbearing exercise) are recommended to prevent osteopenia and osteoporosis.
Between –1 and –2.5	**Osteopenia** Bone density that is between 1 and 2.5 SD below the mean is called osteopenia. A person with osteopenia does not yet have osteoporosis but is at risk of developing it if not treated.
–2.5 or less	**Osteoporosis** Osteoporosis is defined as a BMD 2.5 or more SD below the mean of normal young women. The lower the bone density, the greater the risk of fracture.

The WHO has defined normal bone density as a value within 1 SD from average peak bone mass. SD is a statistical measure that defines how much a patient's result varies from the "average" young adult.

SD: standard deviation; BMD: bone mineral density; WHO: World Health Organization.

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The T-Score

- **Normal bone density** — People with normal bone density have a T-score between +1 and -1. People who have a score in this range do not typically need treatment, but it is useful for them to take steps to prevent bone loss, such as having adequate amounts of calcium and vitamin D and doing weightbearing exercise. (See "Patient education: Osteoporosis prevention and treatment (Beyond the Basics)".)

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The T-Score

- **Low bone mass (osteopenia)** — Low bone mass (osteopenia) is the term health care providers use to describe bone density that is lower than normal but that has not yet reached the low levels seen with osteoporosis.
- A person with osteopenia does not yet have osteoporosis but is at risk of developing it. People with osteopenia have a T-score between -1.1 and -2.4.
- If you have other risk factors for fracture (see 'Risk factors for fracture' above) and have a T-score in the osteopenic range, you may be at high risk for fracture. People with low bone mass are usually advised to take steps to prevent osteoporosis. Sometimes that includes taking medications. (See "Patient education: Osteoporosis prevention and treatment (Beyond the Basics)".)

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The T-Score

- **Osteoporosis** — People with osteoporosis have a T-score of -2.5 or less. Larger numbers (eg, -3.0) indicate lower bone density because this is a negative number.
- The lower the bone density, the greater the risk of fracture. If you discover that you have osteoporosis, there are several things you can do to reduce the chances that you will break a bone. For instance, you can take osteoporosis medications combined with calcium and vitamin D supplements, and you can do an exercise program. (See "Patient education: Calcium and vitamin D for bone health (Beyond the Basics)" and "Patient education: Osteoporosis prevention and treatment (Beyond the Basics)".)
- Note that if you have previously had a low trauma bone fracture, you are also classified as having osteoporosis and need to take osteoporosis medications, regardless of your bone density T-score.

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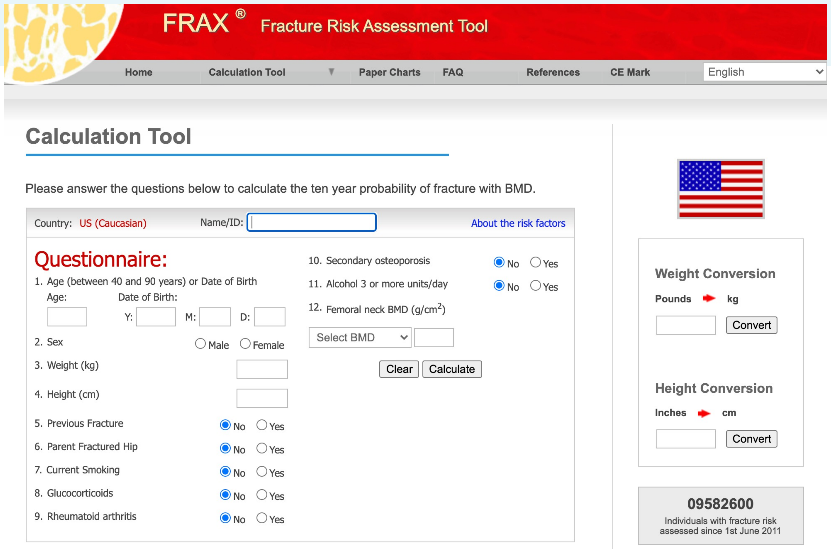

https://www.sheffield.ac.uk/FRAX/tool.aspx?country=9

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Frax Tool

- FRAX stands for Fracture Risk Assessment Tool. A research group at the University of Sheffield developed the tool to predict the risk of fractures in a person with osteoporosis within the next 10 years.
- The tool consists of questions relating to 12 factors that can increase the risk of fractures.
  - age
  - weight
  - height
  - sex
  - smoking
  - history of fractures
  - parental history of fractures
  - presence of rheumatoid arthritis
  - use of glucocorticoid medications
  - having secondary osteoporosis
  - drinking three or more units of alcohol per day
  - bone mineral density

Medical News Today. Reviewed by Angela M. Bell, MD, FACP — Written by Aaron Kandola on March 12, 2020

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Frax Tool

Lifestyle changes

- Some FRAX scores indicate that lifestyle changes should be sufficient to manage the risk of fractures.
- These changes might include:
  - stopping smoking
  - reducing alcohol intake
  - keeping physically active
  - getting enough calcium and vitamin D
  - eating a healthful diet
  - limiting the use of some long-term medications, such as glucocorticoids, whenever possible
- Calcium and vitamin D supplements may be necessary.
  - People generally need 200–1,300 milligrams of calcium per day, depending on their age.
  - About 600–800 international units of vitamin D are necessary for most people.

Medical News Today. Reviewed by Angela M. Bell, MD, FACP — Written by Aaron Kandola on March 12, 2020

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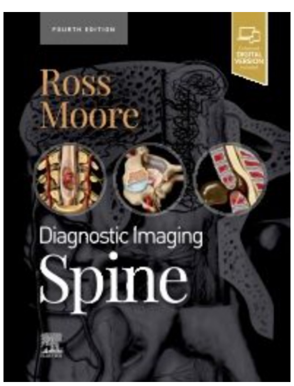

Differential Diagnosis

Lytic Osseous Metastases

- Primary tumor extends to spine with bone destruction > bone production

Blastic Osseous Metastases

- Discrete nodular, mottled, or diffuse areas of sclerosis

Multiple Myeloma

- Multifocal, diffuse, or heterogeneous T1 hypointensity/STIR hyperintensity

Hyperparathyroidism

- Osteopenia, cortical thinning
- Subperiosteal bone resorption

Sacral Traumatic Fracture

- Fractures ± ligament injuries through anterior and posterior portions of pelvis
- Disruption of sacral arcuate lines
- Soft tissue edema and hematoma
- History of trauma

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Spinal Fracture Classifications – Thoracolumbar Fracture

Thoracolumbar Injury Classification and Severity Score (TLICS) (Vaccaro 2006)

- 3 components give final numeric score that directs treatment
- Injury mechanism, integrity of posterior ligamentous complex, and neurologic status (see table 2)

Ross JS, Moore KR. Diagnostic Imaging Spine, 4th Edition. Elsevier; 2021.

Thoracolumbar Injury Severity Score

Description	Qualifier	Points
Injury Mechanism		
Compression		
	Simple	1
	Lateral angulation > 15°	1
	Burst	1
Translational/rotational		3
Distraction		4
Posterior Ligamentous Complex		
Intact		0
Suspected/indeterminate for disruption		2
Injured		3
Neurologic Status		
Nerve root involvement		2
Cord, conus involvement (incomplete)		3
Cauda equina involvement		3
Cord, conus involvement (complete)		2

Score is a total of 3 components. Score ≤ 3 suggests nonoperative treatment, while score of 4 is indeterminate. Score ≥ 5 suggests operative treatment. For injury mechanism, the worst level is used and the injury is additive. An example is distraction injury with burst without angulation is 1 (simple compression) + 1 (burst) + 4 (distraction) = 6 points. (Vaccaro 2006.)

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TL Compression Fracture

Spine
SPINE Volume 38, Number 23, pp 2028-2037
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DIAGNOSTICS

AOSpine Thoracolumbar Spine Injury Classification System

Fracture Description, Neurological Status, and Key Modifiers

Alexander R. Vaccaro, MD, PhD,* Cumhur Oner, MD, PhD,† Christopher K. Kepler, MD, MBA,* Marcel Dvorak, MD,‡ Klaus Schnake, MD,§ Carlo Bellabarba, MD,¶ Max Reinhold, MD,|| Bizhan Aarabi, MD,** Frank Kandziora, MD, PhD,§ Jens Chapman, MD,†† Rajasekaran Shanmuganathan, MD, PhD,‡‡ Michael Fehlings, MD, PhD,§§ Luiz Vialle, MD, PhD,¶¶ and for the AOSpine Spinal Cord Injury & Trauma Knowledge Forum

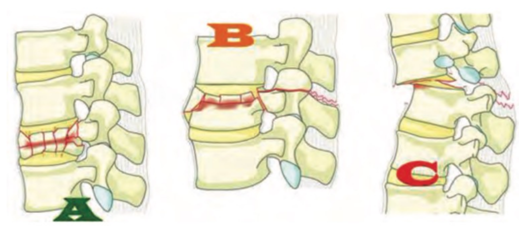

Figure 1. *The 3 basic types*—Type A: Compression injuries. Failure of anterior structures under compression with intact tension band. Type B: Failure of the posterior or anterior tension band. Type C: Failure of all elements leading to dislocation or displacement.

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TL Compression Fracture

Thoracolumbar Fracture Classification • Vaccaro et al

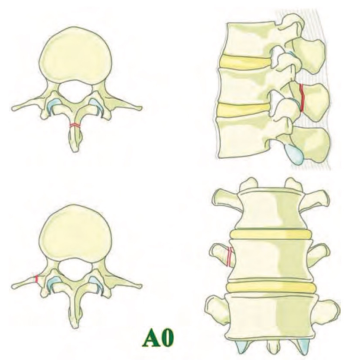
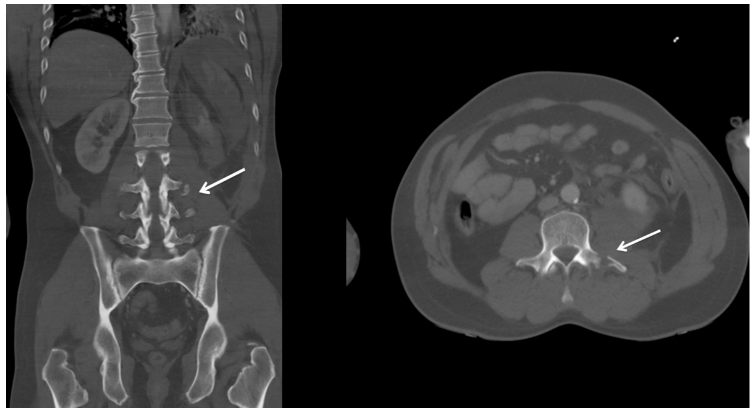


Figure 3. *Subtype A0—Minor injuries*: Injuries such as transverse process or spinous process fractures, which do not compromise the mechanical integrity of the spinal column. Figure 3 demonstrates schematic drawing of this injury while Figure 3.2 available at Supplemental Digital Content http://links.lww.com/BRS/A813 shows a CT scan of a patient with this injury. CT indicates computed tomography.



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TL Compression Fracture

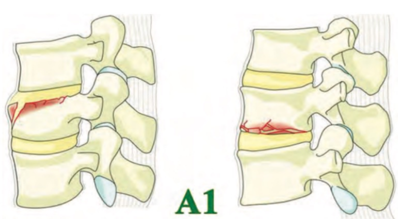

Figure 4. *Subtype A1—Wedge Compression*: Fracture of a single endplate without involvement of the posterior wall of the vertebral body. Vertebral canal is intact. Figure 4 demonstrates schematic drawing of this injury while Figure 4.2 available at Supplemental Digital Content http://links.lww.com/BRS/A814 shows a CT scan of a patient with this injury. CT indicates computed tomography.

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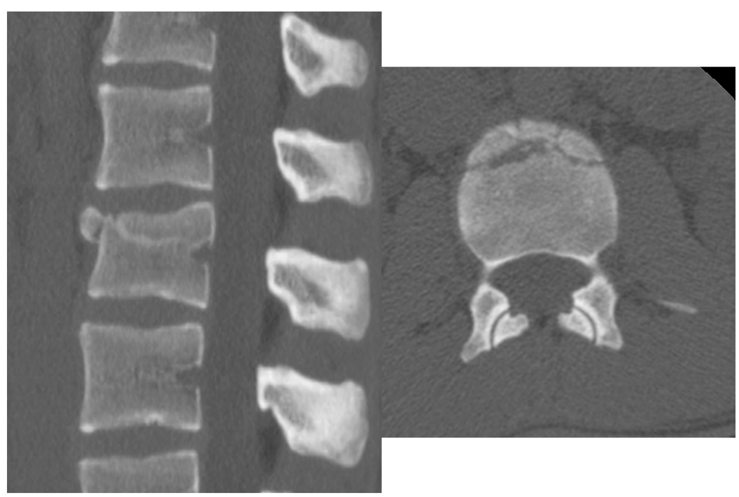

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TL Compression Fracture

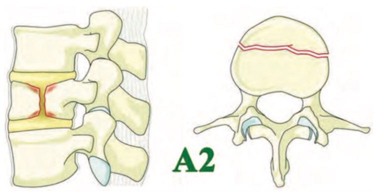

Figure 5. *Subtype A2—Split or pincer-type:* Fracture of both endplates without involvement of the posterior wall of the vertebral body. Figure 5 demonstrates schematic drawing of this injury while Figure 5.2 available at Supplemental Digital Content http://links.lww.com/BRS/A815 shows a CT scan of a patient with this injury. CT indicates computed tomography.

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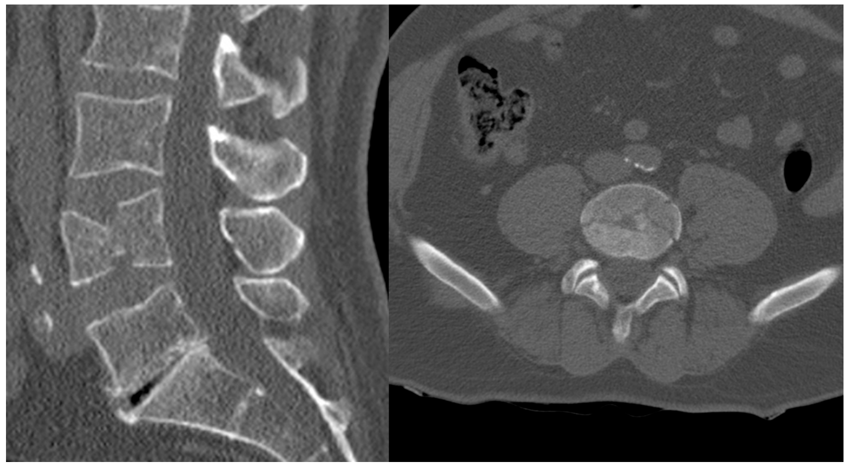

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TL Compression Fracture

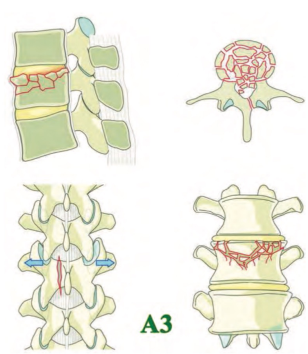

Figure 6. *Subtype A3—Incomplete burst:* Fracture with any involvement of the posterior wall of the vertebral body. Only a single endplate fractured. Vertical fracture of the lamina is usually present and does not indicate a tension band failure. Figure 6 demonstrates schematic drawing of this injury while Figure 6.2 available at Supplemental Digital Content http://links.lww.com/BRS/A816 shows a CT scan of a patient with this injury. CT indicates computed tomography.

SPINE Volume 38, Number 23, pp 2028-2037

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TL Compression Fracture

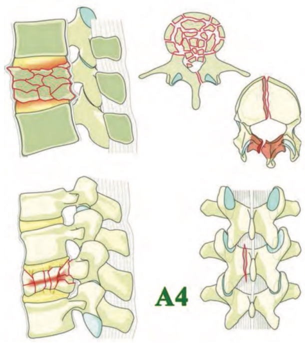
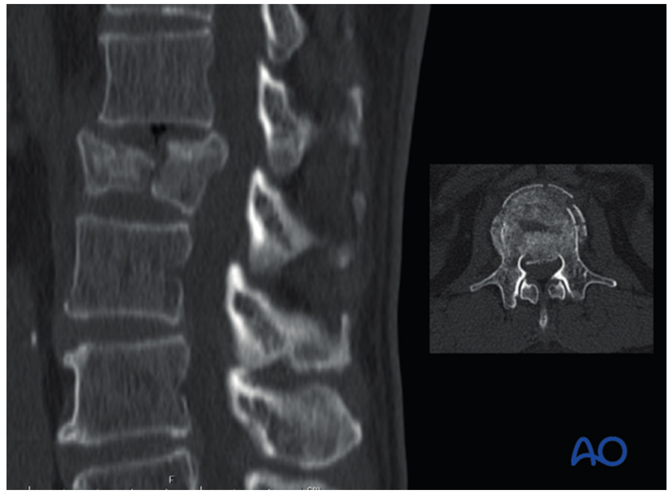


Figure 7. *Subtype A4—Complete burst:* Fracture with any involvement of the posterior wall of the vertebral body and both endplates. Vertical fracture of the lamina is usually present and does not indicate a tension band failure. Figure 7 demonstrates schematic drawing of this injury while Figure 7.2 available at Supplemental Digital Content http://links.lww.com/BRS/A817 shows a CT scan of a patient with this injury. CT indicates computed tomography.

SPINE Volume 38, Number 23, pp 2028-2037



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TL Compression Fracture

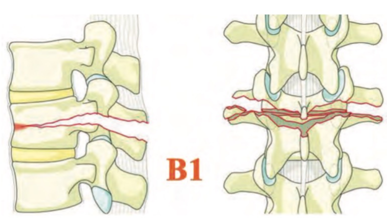

Figure 8. *Subtype B1—Monosegmental bony posterior tension band injury:* Transosseous failure of the posterior tension band. The classical "chance fracture." Figure 8 demonstrates schematic drawing of this injury while Figure 8.2 available at Supplemental Digital Content http://links.lww.com/BRS/A818 shows a CT scan of a patient with this injury. CT indicates computed tomography.

SPINE Volume 38, Number 23, pp 2028-2037

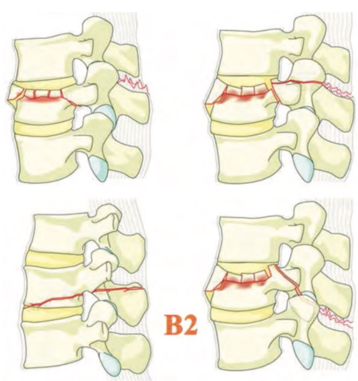

Figure 9. *Subtype B2—Posterior tension band disruption:* Bony and/or ligamentary failure of the posterior tension band together with a type A fracture. type A fracture should be classified separately. This example should be classified as: T12–L1 "type B2" with T12 "A4" according to the combination rules. Figure 9 demonstrates schematic drawing of this injury while Figure 9.2 available at Supplemental Digital Content http://links.lww.com/BRS/A819 shows a CT scan of a patient with this injury. CT indicates computed tomography.

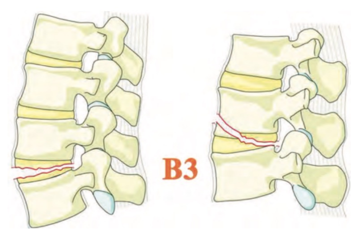

Figure 10. *Subtype B3—Hyperextension injury:* Injury through the disc or vertebral body leading to a hyperextended position of the spinal column, which is commonly seen in ankylotic disorders. Anterior tension band, notably the ALL is ruptured but there is a posterior hinge preventing further displacement. Figure 10 demonstrates schematic drawing of this injury while Figure 10.2 available at Supplemental Digital Content http://links.lww.com/BRS/A820 shows a CT scan of a patient with this injury. CT indicates computed tomography. CT indicates computed tomography.

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TL Compression Fracture

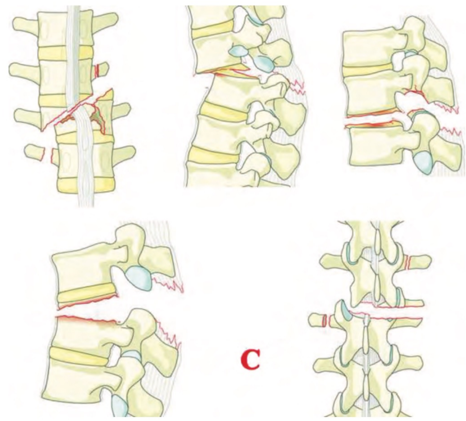

Figure 11. *Type C—Translation/displacement:* There are no subtypes as because of the dissociation between cranial and caudal segments various configurations are possible in different images, which are not relevant. Is combined with subtypes of A to denote the associated vertebral body fractures if necessary. Figure 11 demonstrates schematic drawing of this injury while Figure 11.2 available at Supplemental Digital Content http://links.lww.com/BRS/A821 shows a CT scan of a patient with this injury. CT indicates computed tomography.

SPINE Volume 38, Number 23, pp 2028-2037

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TL Compression Fracture

Spine
DIAGNOSTICS

SPINE Volume 38, Number 23, pp 2028-2037

AOSpine Thoracolumbar Spine Injury Classification System

Fracture Description, Neurological Status, and Key Modifiers

Alexander R. Vaccaro, MD, PhD,* Cumhur Oner, MD, PhD,† Christopher K. Kepler, MD, MBA,* Marcel Dvorak, MD,‡ Klaus Schnake, MD,§ Carlo Bellabarba, MD,¶ Max Reinhold, MD,|| Bizhan Aarabi, MD,** Frank Kandziora, MD, PhD,§ Jens Chapman, MD,†† Rajasekaran Shanmuganathan, MD, PhD,‡‡ Michael Fehlings, MD, PhD,§§ Luiz Vialle, MD, PhD,¶¶ and for the AOSpine Spinal Cord Injury & Trauma Knowledge Forum

SPINE Volume 38, Number 23, pp 2028-2037
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GRADING OF NEUROLOGICAL DEFICITS

Neurological status is graded according to a 5-part system:

- ***N0*** is used to designate patients who are neurologically intact.
- ***N1*** means that a patient had a transient neurological deficit, which is no longer present.
- ***N2*** denotes patients with symptoms or signs of radiculopathy.
- ***N3*** incomplete spinal cord injury or cauda equina injury.
- ***N4*** complete spinal cord injury (American Spinal Injury Association grade A17).
- ***NX*** is used to designate patients who cannot be examined because of head injury or another condition, which limits their ability to complete a neurological examination such as intoxication, multiple trauma, or intubation/sedation.

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TL Compression Fracture

Table 1. TLISS System

1. Injury mechanism: worst level is used and injury is additive (*e.g.,* a distraction injury with a burst component without lateral angulation would receive 1 [simple compression] + 1 [burst] + 4 [distraction] = 6)

Description	Qualifier	Points
a. Compression	Simple compression	1
	Lateral angulation >15°	1
	Burst	1
b. Translational/rotational		3
c. Distraction		4
2. PLC disrupted in tension, rotation, or translation		
a. Intact		0
b. Suspected/indeterminate		2
c. Injured		3
3. Neurologic status		
Nerve root involvement		2
Cord, conus medullaris involvement	Incomplete	3
	Complete	2
Cauda equina involvement		3

The score is the total of 3 components: injury mechanism, neurologic status, and PLC disruption. A score of ≤3 suggests nonoperative treatment, 4, operative or nonoperative treatment, and ≥5 suggests operative treatment.

SPINE Volume 31, Number 11 Suppl, pp S62–S69
©2006, Lippincott Williams & Wilkins, Inc.

Reliability of a Novel Classification System for Thoracolumbar Injuries: The Thoracolumbar Injury Severity Score

Vaccaro, 2006

PLC = Posterior Ligamentous Complex

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AO Foundation

- *Arbeitsgemeinschaft für Osteosynthesefragen* (German for "working group for bone fusion issues") or **AO**, founded in Switzerland in 1958.
- Scientists working in the AO research facilities located in the Swiss city of Davos conduct fundamental and applied research in the fields of biomechanics and biology of bone, disc and cartilage (including tissue engineering and musculoskeletal infections), and biomaterials science (such as degradable polymers and polymer-based transport systems).
- The institute also conducts research in the field of new surgical techniques, tools, and devices, such as "smart" implants, and intracorporeal navigation and tools for surgical teams and surgeons.[19]

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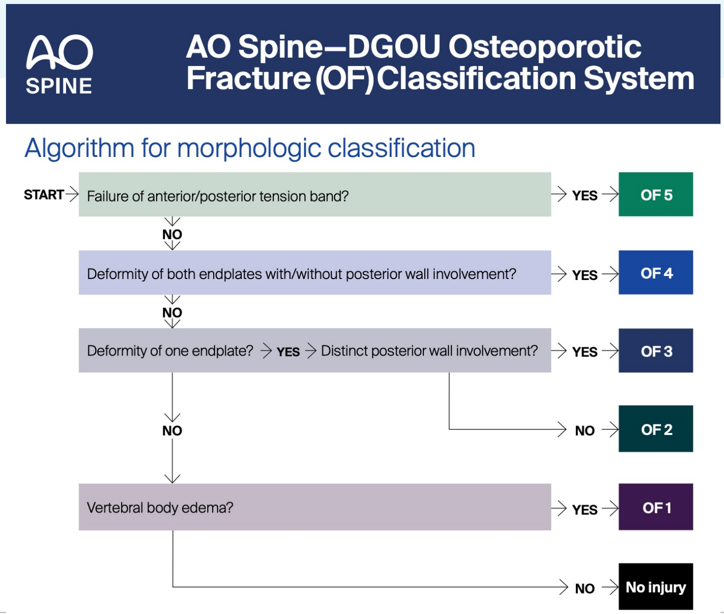
If DXA T-Score > -2.5 DGOU OF Classification System



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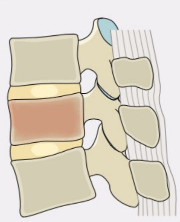
AO Spine Osteoporosis Fracture (OF) Classification

OF 1

No deformation (vertebral body edema in MRI-STIR)

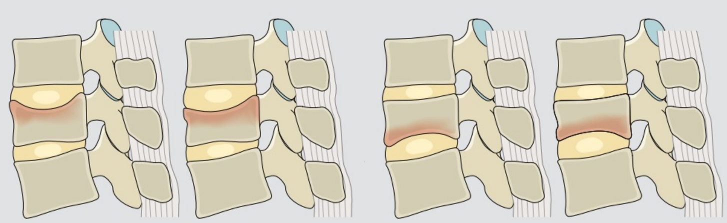
- Typically not visible on x-rays: chance to find on MRI



OF 2

Deformation of one endplate without or with only minor posterior wall involvement

- With posterior wall < 1/5 involvement



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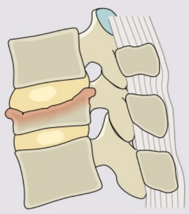
AO Spine Osteoporosis Fracture (OF) Classification

OF 3

Deformation of one endplate with distinct posterior wall involvement

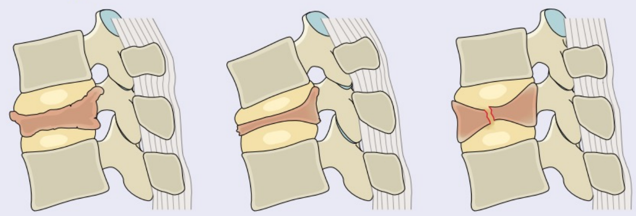
- With posterior wall > 1/5 involved



OF 4

Deformation of both endplates with/without posterior wall involvement

- Loss of vertebral frame structure
- Vertebral body collapse
- Pincer type fracture



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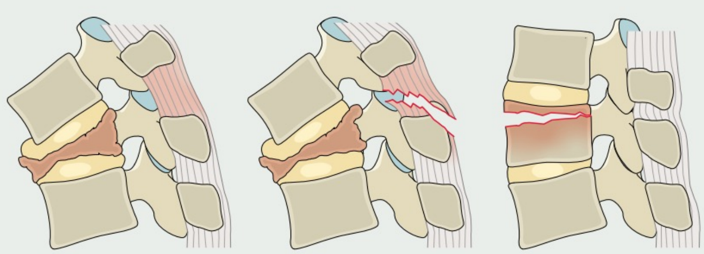
AO Spine Osteoporosis Fracture (OF) Classification

OF 5

Injuries with anterior or posterior tension band failure

- Injuries with signs of distraction, rotation, or translation
- Hyperextension with anterior tension band failure



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AO Spine Osteoporosis Fracture (OF) Classification

Modified score for therapeutic decision making in OF*

Parameter	Grade	Points
Morphology (OF 1-5)	1-5	2-10
Severity of Osteoporosis	T-Score <-3 or qCT: HU ≤90	1
Deformity Progression	Yes, No	1, -1
Pain (under analgesia)**	VAS ≥5, <5	1, -1
Neurological Symptoms (N2-N4)	Yes	2
Mobilisation (under analgesia)	No, Yes	1, -1
Health Status	ASA >3, ***mFI >2, Anticoagulation	Each -1, Maximum -2

0 points if a parameter is unknown or not determinable;
0-5 points = Conservative therapy;
6 points = Conservative therapy or surgery;
> 6 points = Surgery.

* The severity score system has not been validated yet and should be used as a reference only.
** According to step II WHO pain ladder.
*** 5-item modified frailty index (mFI) = COPD, or recent pneumonia; Congestive heart failure; Functional status (not independent); Hypertension requiring medication; Diabetes mellitus.

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Compression Fracture

Imaging

- Vertebral body shorter anteriorly than posteriorly
  - < 40-50% loss of height in patients with normal bone density
- ± vertebral body endplate abnormality
- ± anterior cortical irregularity
- Normal middle and posterior vertebral column
- Most common in middle and lower thoracic spine

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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Compression Fracture

Clinical Issues

- •Most common type of thoracic spine fracture due to blunt trauma
  - Young patients: Due to significant fall
  - Osteoporotic patients: Insufficiency fracture
- American Academy of Orthopaedic Surgeons (AAOS) practice guidelines (2011)
  - Against vertebroplasty for osteoporotic spinal compression fracture in patients who are neurologically intact
- AAOS guidelines recommend calcitonin for 4 weeks
  - Ibandronate and strontium ranelate are options to prevent additional symptomatic fractures

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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Compression Fracture

Top Differential Diagnoses

- Compression-distraction injury (Chance fracture)
- Burst fracture
- Pathologic fracture due to tumor
- Schmorl node
- Scheuermann kyphosis
- Physiologic vertebral wedging
- Limbus vertebra

Ross and Moore. Diagnostic Imaging Spine, 4th Edition

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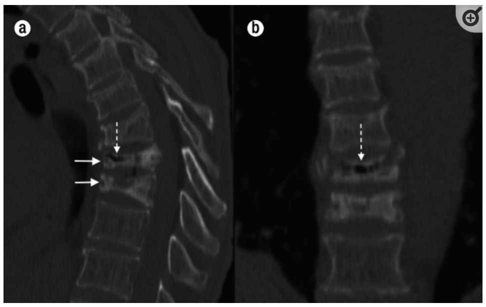
Kummell Disease

Baylor University Medical Center Proceedings
Taylor & Francis

Proc (Bayl Univ Med Cent). 2013 Jul; 26(3): 300–301.
doi: 10.1080/08998280.2013.11928991
PMCID: PMC3684306
PMID: 23814399

Kummell disease

Larry T. Nickell, MD, William G. Schucany, MD, and Michael J. Opatowsky, MD



- Kummell disease, or avascular necrosis of a vertebral body, presents as vertebral osteonecrosis typically affecting a thoracic vertebra with compression deformity, intravertebral vacuum cleft, and exaggerated kyphosis weeks to months after a minor traumatic injury.
- This rare disease is increasing in prevalence secondary to an aging population and the associated rise in osteoporosis.
- Back pain is a common presenting complaint of patients in the emergency department and outpatient clinics and is a source of frustration for physicians and patients.

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Journal of Bone and Mineral Research
JBMR
ASBMR
The American Society for Bone and Mineral Research

Original Article | Free Access

The Efficacy and Safety of Vertebral Augmentation: A Second ASBMR Task Force Report

Peter R Ebeling, Kristina Akesson, Douglas C Bauer, Rachelle Buchbinder, Richard Eastell, Howard A Fink, Lora Giangregorio, Nuria Guanabens, Deborah Kado, David Kallmes, ... See all authors

First published: 24 January 2019 | https://doi.org/10.1002/jbmr.3653 | Citations: 41

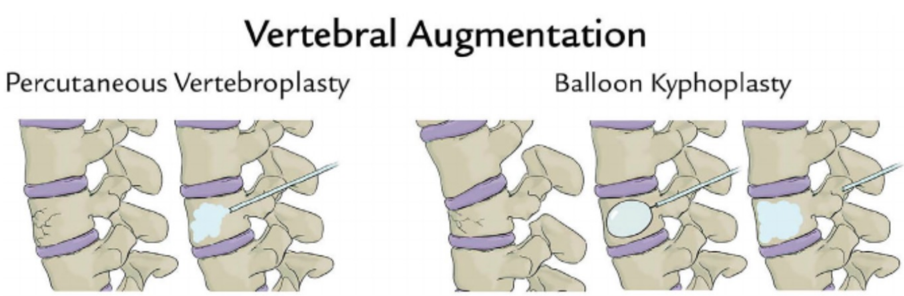

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Table 2. Summary of ASBMR Task Force Recommendations and Findings of Key Questions for Patients With Acutely Painful Vertebral Fractures

Key question addressed	Task Force recommendation/finding	Quality of evidence	Strength of findings	Strength of recommendation
1. Efficacy of percutaneous vertebroplasty on outcomes of pain, physical function, and quality of life	Percutaneous vertebroplasty provides no demonstrable clinically significant benefit over placebo or sham procedure. Results did not differ according to duration of pain.	High to moderate	High—5 randomized trials that compared vertebroplasty with placebo ($n = 535$). Follow-up period 2 years.	High to moderate
2. Efficacy of balloon kyphoplasty on outcomes of pain, physical function, and quality of life	Balloon kyphoplasty provides a small clinical benefit over nonsurgical management, percutaneous vertebroplasty, vertebral body stenting, or KIVA. There is also insufficient evidence versus placebo for KIVA.	Low	Low—1 randomized trial versus nonsurgical management. No placebo ($n = 300$). Follow-up period 2 years.	Weak
3. Harms of percutaneous vertebroplasty, including possible risk of new vertebral fractures	It is uncertain whether percutaneous vertebroplasty increases risk of incident or radiographic vertebral fractures or related serious AEs.	Moderate	Moderate—8 randomized trials (placebo control in 4 trials and usual care in 4 trials) ($n = 804$). Low number of events ($n = 203$ fractures; 57 SAEs). Follow up period 1–2 years.	Moderate
4. Harms of balloon kyphoplasty, including possible risk of new vertebral fractures	It is uncertain whether kyphoplasty increases risk of incident or radiographic vertebral fractures or serious AE related to kyphoplasty.	Low	Low—1 randomized trial versus nonsurgical management ($n = 223$) and case reports. Low number of events ($n = 101$ fractures; 157 SAEs). Follow-up period 2 years.	Weak
5. Efficacy and harms of spinal bracing after vertebral fracture	Spinal bracing may improve pain, spinal strength, kyphosis, pulmonary volume and quality of life at 6 months. Bracing may improve physical function, disability, or quality of life.	Low	Low—4 randomized trials comparing orthoses ($n = 281$). High risk of bias due to absent blinding of subjects and investigators. Low numbers of fractures and AEs. Follow-up period 3 weeks to 6 months.	Weak
6. Efficacy and harms of exercise interventions after vertebral fracture	Exercise may improve mobility and reduce pain and fear of falling. It is uncertain whether exercise improves balance, back extensor strength, reduces falls, and was safe.	Moderate	Moderate—9 randomized trials comparing exercise with usual care ($n = 749$). Low to high risk of bias due to absent blinding of subjects and investigators. Low numbers of events ($n = 15$ fractures; 5 SAEs). Follow-up period 4 weeks to 2 years.	Moderate

JBMR
Original Article | Free Access

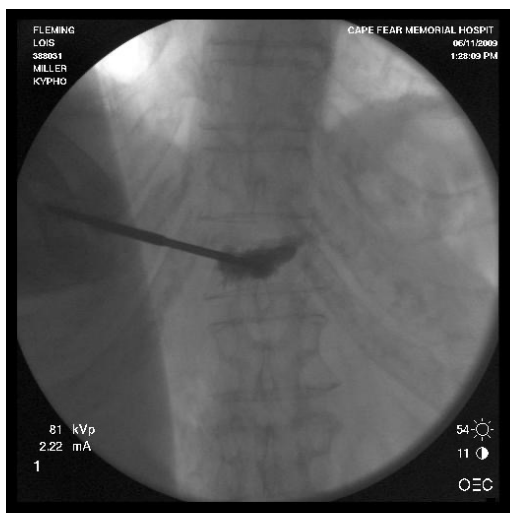
The Efficacy and Safety of Vertebral Augmentation: A Second ASBMR Task Force Report

Peter R Ebeling, Kristina Akesson, Douglas C Bauer, Rachelle Buchbinder, Richard Eastell, Howard A Fink, Lora Giangregorio, Nuria Guanabens, Deborah Kado, David Kallmes, ... See all authors

First published: 24 January 2019 | https://doi.org/10.1002/jbmr.3653 | Citations: 41

533

Instructive Case



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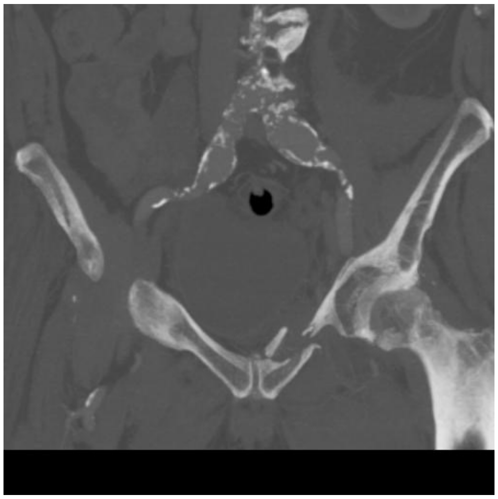
Instructive Case



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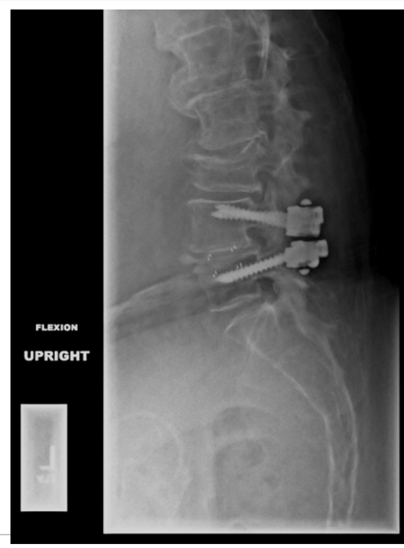
Instructive Case



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Cureus. 2021 Aug; 13(8): e17519.
Published online 2021 Aug 28. doi: 10.7759/cureus.17519

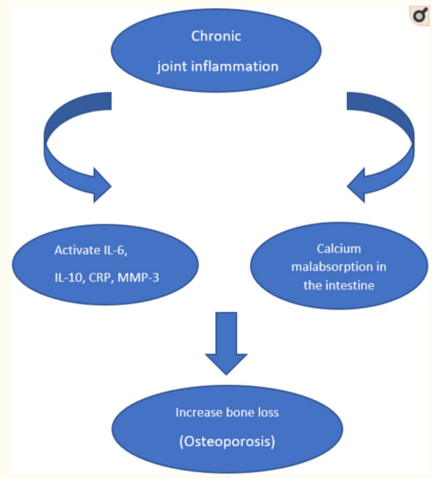
PMCID: PMC8476196
PMID: 34603889

The Impact of Rheumatoid Arthritis on Bone Loss: Links to Osteoporosis and Osteopenia

Monitoring Editor: Alexander Muacevic and John R Adler

Roaa Kareem,[1] Rinky A Botleroo,[2] Renu Bhandari,[1,3] Opemipo D Ogeyingbo,[1,4,5] Rowan Ahmed,[1] Mallika Gyawali,[1] Nanditha Venkatesan,[6,1] and Abeer O Elshaikh[1]

Figure 1



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Effect of chronic joint inflammation on bone loss

IL-6: interleukins 6; IL-10: interleukins 10; CRP: C reactive protein; MMP-3: Matrix metalloproteinase-3

Cureus. 2021 Aug; 13(8): e17519.
Published online 2021 Aug 28. doi: 10.7759/cureus.17519

PMCID: PMC8476196
PMID: 34603889

The Impact of Rheumatoid Arthritis on Bone Loss: Links to Osteoporosis and Osteopenia

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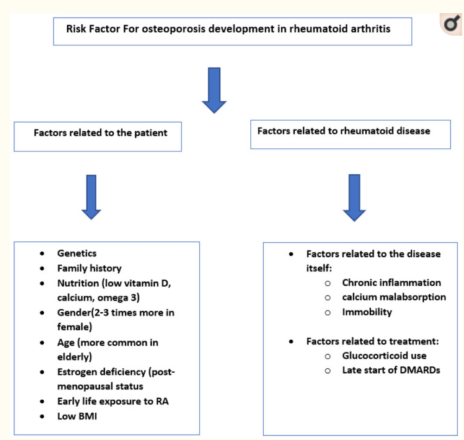
Figure 2



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Risk factors for osteoporosis development in rheumatoid arthritis patients

RA: rheumatoid arthritis; DMARDs: disease-modifying anti-rheumatology drugs

Review > Curr Opin Rheumatol. 2021 May 1;33(3):270-276.
doi: 10.1097/BOR.0000000000000789.

Osteoporosis and fractures in rheumatoid arthritis

Katherine D Wysham [1], Joshua F Baker [2], Dolores M Shoback [3]

Affiliations – collapse

Affiliations

1. Rheumatology Section, VA Puget Sound Healthcare System, Division of Rheumatology, University of Washington, Seattle, Washington.
2. Rheumatology and Epidemiology, Corporal Michael J. Crescenz VA Medical Center, University of Pennsylvania, Philadelphia, Pennsylvania.
3. Endocrine Research Unit, SFVAMC, UCSF, UCSF Training Program in Diabetes, Endocrinology and Metabolism, San Francisco, California, USA.

- Rheumatoid arthritis (RA) is associated with increased risk for osteoporotic fracture.
- Studies have found reduced BMD in individuals on low doses of glucocorticoids (GCs).

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METABOLIC BONE DISEASE: EDITED BY STEPHEN HONIG

Glucocorticoid-induced osteoporosis update

Adami, Giovanni[a,b]; Saag, Kenneth G.[a]

Author Information

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[b]Rheumatology Unit, University of Verona, Verona, Italy

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Current Opinion in Rheumatology: July 2019 - Volume 31 - Issue 4 - p 388-393
doi: 10.1097/BOR.0000000000000608

- Steroid-induced osteoporosis or glucocorticoid-induced osteoporosis (GIOP) is a common form of secondary osteoporosis and is a cause of increased morbidity and mortality.
- The pathogenesis of GIOP includes decreased bone formation and increased bone resorption.

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Journal of Clinical Medicine
MDPI

Review

Bone Loss, Osteoporosis, and Fractures in Patients with Rheumatoid Arthritis: A Review

Patrice Fardellone [1,*], Emad Salawati [2], Laure Le Monnier [1] and Vincent Goëb [1]

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2 Assistant Professor, Faculty of Medicine, King Abdulaziz University, 21589 Jeddah, Saudi Arabia; esalawati@kau.edu.sa
* Correspondence: fardellone.patrice@chu-amiens.fr

Received: 28 August 2020; Accepted: 15 October 2020; Published: 20 October 2020

check for updates

- In the Canadian Early Arthritis Cohort (CATCH), there was a significant correlation between increased fracture risk groups measured by the FRAXtool® and oral glucocorticoid use ($p = 0.012$) and baseline erosions ($p = 0.040$) [49].

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Bisphosphonates and Osteonecrosis

RadioGraphics 2009; 29:1971–1986

- The widespread use of bisphosphonate (BP) to treat various medical conditions led to increased recognition of their **possible association with osteonecrosis (ON) of the jaw.**[1]
- Bisphosphonates are **highly efficient antiresorptive drugs** used to treat diseases with increased osteoclast activity such as cancer-related conditions, osteoporosis, multiple myeloma, Paget disease, osteosclerosis, and fibrous dysplasia.[2]

Gupta M, Gupta N. Bisphosphonate Related Jaw Osteonecrosis. [Updated 2021 Jul 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-.

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Bisphosphonates and Osteonecrosis

Osteoporosis Medications (Bisphosphonates)

- Risedronate (Actonel)
- Alendronate (Fosamax)
- Ibandronate (Boniva)
- Zoledronic Acid (Reclast)
- Pamidronate (Aredia)
- Etidronate (Didronel)

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Bisphosphonates and Osteonecrosis

- Bisphosphonates **inhibit bone resorption by causing osteoclast cell apoptosis,** impairing the osteoclast's resorptive capacity, and preventing osteoclast formation.[5]
- They have a high affinity for bone minerals and **accumulate mainly in the sites of osteoclast activity**.[5]
- **Without resorption and new bone formation, old bone survives beyond its lifespan, and its capillary network is not maintained, leading to avascular necrosis of the jaw.**
- Also, high potency biphosphonates can lead to **necrosis by the toxicity of soft tissue and bone cells**, further complicated by infection.[6]
- Due to altered wound healing, delayed epithelial closure of a mucosal opening in the mouth leads to **chronic infection and the necrosis of bone**.[7]
- Osteonecrosis develops in the **jaw** because this bone has a **higher remodeling rate than other bones, making it more prone to the effect of bisphosphonates.**

Gupta M, Gupta N. Bisphosphonate Related Jaw Osteonecrosis. [Updated 2021 Jul 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-.

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Bisphosphonates and Osteonecrosis

- Most cases of **Bisphosphonate-Related Osteonecrosis of the Jaw (BRONJ)** occur after a dental intervention that affects bone, but osteonecrosis can also present spontaneously.[4]
- The **necrotic bone may remain asymptomatic for a prolonged period or develop symptoms, mainly due to localized inflammation of soft tissue.**[29]

Jaw Osteonecrosis. Image courtesy S Bhimji MD

Gupta M, Gupta N. Bisphosphonate Related Jaw Osteonecrosis. [Updated 2021 Jul 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-.

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Bisphosphonates and Osteonecrosis

Epidemiology

- Intravenous (IV) Versus Oral Biphosphonates
  - Osteonecrosis of the jaw is mainly reported with the use of more potent nitrogen-containing BPs like pamidronate and zoledronic acid. However, the incidence is higher with the latter - zoledronic acid causes a higher antiresorptive activity, leading to decreased bone turnover.[8]
  - **Oral biphosphonates rarely cause osteonecrosis of the jaw.** They are **less aggressive than intravenous BP,** and the osteonecrosis caused by oral BP responds better to treatment. Oral BPs are less liposoluble, limiting their intestinal absorption, resulting in a lower accumulation in the bone.[9]

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Bisphosphonates and Osteonecrosis

Signs and Symptoms

- None/asymptomatic
- Pain
- Soft tissues infection with inflammation, ulceration, and suppuration
- Formation of intra-and extraoral sinus tracts and fistulas
- Paresthesia or anesthesia of an associated nerve
- Fracture
- Chronic maxillary sinusitis
- A radiographic appearance from no alterations to varying radiolucencies and radiopacities

Gupta M, Gupta N. Bisphosphonate Related Jaw Osteonecrosis. [Updated 2021 Jul 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-.

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Bisphosphonates and Osteonecrosis

Differential Diagnosis

- The presence of exposed bone characterizes **Bisphosphonate-related osteonecrosis of the jaw (BRONJ)**. In the absence of exposed bone, BRONJ should be differentiated from the following:
  - Periodontal and periapical pathosis
  - Sinusitis
  - Gingivitis or mucositis
  - Temporomandibular disorders
  - Osteomyelitis
  - Metastatic bone tumors
  - Osteonecrosis induced by neuralgia
  - Osteoradionecrosis

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Bisphosphonates and Osteonecrosis

Recommendations for Patients Receiving BP Therapy

- After 4 to 6 doses of BP, bone turnover is significantly suppressed, making bone healing unpredictable and risky for ON.
- Educate patients regarding the risk of BRONJ with bisphosphonate therapy.
- Educate patients regarding home hygiene and self-maintenance.
- Oral surgical procedures like extractions, bone contouring, grafting, periodontal, and apical surgeries should be avoided.[17]
- If possible, endodontic treatment is preferred over extractions and periapical surgery.
- Noninvasive restorative procedures like crowns, bridges, removable partial and complete dentures are recommended to prevent future surgical procedures.
- Orthodontic procedures are not recommended.
- Elective dentoalveolar surgical procedures like asymptomatic teeth extraction, implant placement, tori reduction are not recommended.
- Unrestorable teeth preferably should be treated with root canals and crown amputation; mobile teeth are best splinted, failed root canals should be retreated.
- If tooth extraction is unavoidable, the patient should be educated regarding the risk of developing BRONJ, and informed consent should be signed before the procedure.
- It is necessary to stratify the risk for patients on BP requiring extensive invasive oral surgery and patients with accompanying multiple risk factors like steroid treatment, immunodeficiency, or diabetes mellitus.
- Drug holiday: dental practitioners should not indicate discontinuing bisphosphonate drugs since there is no evidence that the risk of BRONJ reduces when stopping the medication before dental procedures because they stay in the bone for years.[7]

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Bisphosphonates and Osteonecrosis

Cochrane Database of Systematic Reviews | Review - Intervention

Interventions for treating bisphosphonate-related osteonecrosis of the jaw (BRONJ)

Victoria Rollason, Alexandra Laverrière, Laura CI MacDonald, Tanya Walsh, Martin R Tramèr, Nicole B Vogt-Ferrier

Authors' declarations of interest

Version published: 26 February 2016 Version history

https://doi.org/10.1002/14651858.CD008455.pub2

Authors' Conclusions

- There is insufficient evidence to conclude whether hyperbaric oxygen therapy is a useful add-on to standard care in the treatment of BRONJ.
- There are two ongoing trials of teriparatide, a hormonal treatment for BRONJ.
- We found no randomised controlled trials of any other treatments for BRONJ.
- As there is a lack of good quality scientific evidence to decide how best to treat BRONJ, high quality trials are needed.

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Original Article | Published: 16 July 2018

Prevalence and Risk Factors of Atypical Femoral Fracture Bone Scintigraphic Feature in Patients Experiencing Bisphosphonate-Related Osteonecrosis of the Jaw

Chang-Hee Lee, Seung Hyun Son, Chae Moon Hong, Ju Hye Jeong, Shin Young Jeong, Sang-Woo Lee, Jaetae Lee, Tae-Geon Kwon & Byeong-Cheol Ahn

Nuclear Medicine and Molecular Imaging **52**, 311–317 (2018) | Cite this article

Conclusion

The incidence of AFF features on bone scintigraphy was relatively high in patients with BRONJ. A careful observation of patients presenting with the AFF features on bone scintigraphy may be needed, particularly for female BRONJ patients with osteoporosis who have been on BP medication for over 34 months.

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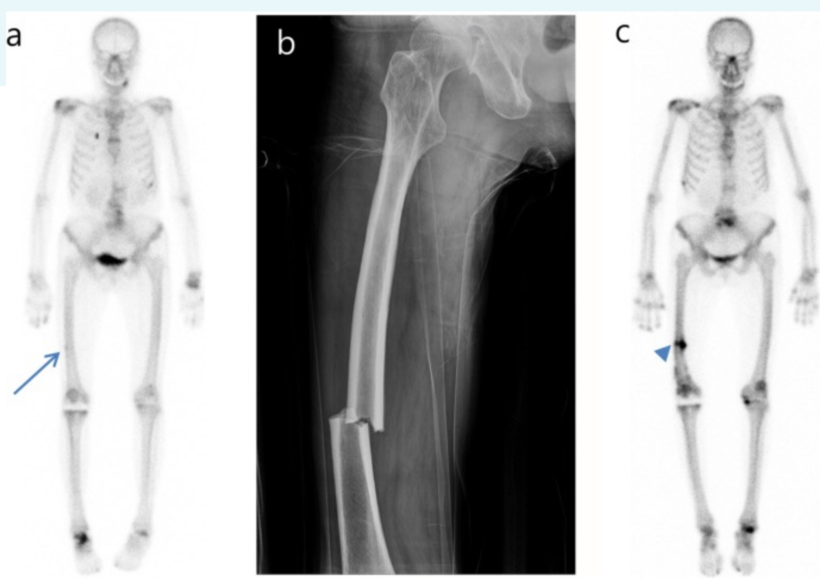

Nuclear Medicine and Molecular Imaging **52**, 311–317 (2018)

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Thank you.

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