1) Findings include disk extrusion and inferior stripping of posterior longitudinal ligament at C5-6 and C6-7.

2) Tear of posterior longitudinal ligament and annulus fibrosus at C6-7.

3) Filum ligament tear at C6-7.

4) Splaying of spinous processes and interspinous ligament tear at C6-7.

5) Fracture of C6 spinous process.

6) Mild superior endplate impaction fractures of T1, T2, and T3 vertebral bodies.

Intersegmental Instability; MRI

Findings include disk extrusion and inferior stripping of posterior longitudinal ligament at C5-6 and C6-7.

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Splaying of spinous processes and interspinous ligament tear at C6-7.

Fracture of C6 spinous process.

Mild superior endplate impaction fractures of T1, T2, and T3 vertebral bodies.

Compression Injury

Jefferson Fracture of C1

Burst Fracture
Compression

• Burst fracture of C7 in 30-year-old woman who was unrestrained driver in motor vehicle crash. Sagittal fast spin-echo inversion-recovery MR image (TR/TE, 3000/15; inversion time, 140 msec) obtained on 1.5-T MR scanner.

  1) burst fracture of C7. Also note signal hyperintensity caused by bone marrow edema in vertebral bodies of C6 and T1.
  2) prevertebral edema or hemorrhage
  3 & 4) flaval and interspinous ligament tears
  5) distraction of dorsal spinous and spinal cord contusion

Compression

• Burst fracture of C4 with retropulsion in 17-year-old boy after motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 650/13; flip angle, 15°) obtained on 1.5-T MR scanner.

  1) anterior longitudinal ligament tear
  2) hypointense hemorrhagic cord contusion
  3) posterior longitudinal ligament tear at C3-4
  4) flaval ligament tear at C4-5

Flexion Injury

• Simple wedge fx

Flexion Injury

• Odontoid Type III

• Odontoid Type II
Odontoid Fx: Type II

• Type II dens fracture in 14-year-old boy who was unrestrained passenger in motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 500/9; flip angle, 15°) obtained on 1.5-T MR scanner shows intact occipitoatlantal membrane (1), anterior dislocation of fractured dens (2), anterior arch of C1 (3), partial tear of anterior atlantoaxial membrane (4), cord contusion (5), intact dura (6), medullary contusion or edema (7), torn tectorial membrane (8), intact posterior occipitoatlantal membrane (9), posterior arch of C1 (10), torn or attenuated posterior atlantoaxial membrane (11), intact dura (12), and intact flaval ligaments (13).

Odontoid Fx: Type II

• —Type II dens fracture, Same patient as on previous sagittal image. Axial gradient-echo MR image (280/15; flip angle, 15°) obtained on 1.5-T MR scanner.
  • 1) right lateral mass of C1
  • 2) anteriorly dislocated dens
  • 3) body of C2 at fracture site
  • 4) compressed and contused spinal cord
  • 5) anterior arch of C1
  • 6) intact alar ligaments
  • 7) intact transverse ligament

Flexion Injury

• Teardrop Fracture
• Most serious and unstable of cervical spine injuries.
• Teardrop fx of anterior inferior of vertebra with fx of posterior arch as well.
• Vertebra is posteriorly displaced into canal.
• Ligament and cord disruption.

Flexion Teardrop Fracture

• —Teardrop fracture of C7 in 27-year-old man involved in motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 510/35; flip angle, 20°) obtained on 0.3-T MR scanner.
  • 1) extensive posterior paravertebral edema or hemorrhage and probable tearing of interspinous ligaments
  • 2) partial tear of nuchal ligament
  • 3) flaval ligament tear
  • 4) partial tear of posterior longitudinal ligament
  • 5) anterior superior corner fracture of C7 vertebral body
  • 6) stripping of anterior longitudinal ligament from anterior surface of C7 vertebral body
  • 7) prevertebral edema or hemorrhage

Tear Drop Fracture: MRI

• —Teardrop fracture of C7 in 27-year-old man involved in motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 510/35; flip angle, 20°) obtained on 0.3-T MR scanner.
  • 1) extensive posterior paravertebral edema or hemorrhage and probable tearing of interspinous ligaments
  • 2) partial tear of nuchal ligament
  • 3) flaval ligament tear
  • 4) partial tear of posterior longitudinal ligament
  • 5) anterior superior corner fracture of C7 vertebral body
  • 6) stripping of anterior longitudinal ligament from anterior surface of C7 vertebral body
  • 7) prevertebral edema or hemorrhage

Flexion - Rotation Injury
Bilateral Interfacetal Dislocation

- Bilateral interfacetal dislocation at C4-5 in 62-year-old man involved in motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 510/35; flip angle, 20°) obtained on 0.3-T MR scanner.
  - 1) prevertebral edema or hemorrhage
  - 2) posterior longitudinal ligament tear
  - 3) anterior longitudinal ligament tear
  - 4) large traumatic posterior disk extrusion
  - 5) cord contusion and compression
  - 6) posterior paravertebral edema or hemorrhage, and probable interspinous ligament injury

Bilateral Interfacetal Dislocation

- Bilateral interfacetal dislocation in 42-year-old woman involved in motor vehicle crash. Sagittal T2-weighted MR image (TR/TE, 4500/117) obtained on 0.3-T MR scanner.
  - 1) tear of dura and posterior atlantoaxial membrane
  - 2) partial tear of nuchal ligament
  - 3) distraction of C5-6 spinous process and torn interspinous ligaments
  - 4) torn flaval ligaments
  - 5) torn posterior longitudinal ligament
  - 6) torn anterior longitudinal ligament

Flexion-Distraction Lumbar Spine

- 11-year-old boy who suffered flexion-distraction injury from lap belt during motor vehicle crash with fractures at L4 level. Sagittal gradient-echo MR image (TR/TE, 500/13; flip angle, 15°) obtained on 1.5-T MR scanner.
  - 1) large presumed cerebrospinal fluid leak into posterior subcutaneous tissues
  - 2) distracted fracture fragments of left L4 articular processes (similar fracture was also present on right)
  - 3) distracted fracture, near horizontal in orientation, involving posterior posteriort portion of L4 vertebral body

Flexion-Distraction Lumbar Spine

- Sagittal gradient-echo MR image (500/13; flip angle, 15°) obtained on 1.5-T MR scanner of midline shows;
  - 1) distraction of spinous process of L3 and L4
  - 2) supraspinous ligament tear
  - 3) flaval ligament tear (3)

Ligament Stripping

- Ligament stripping in 496-lb (222.5-kg) 35-year-old man ejected from motor vehicle. Lateral radiographs (not shown) were nondiagnostic. Sagittal gradient-echo MR image (TR/TE, 510/35; flip angle, 20°) obtained on 0.3-T MR scanner.
  - 1) anterior longitudinal ligament stripped completely away from anterior surface of midthoracic spine vertebral body
  - 2) Similarly, posterior longitudinal ligament is stripped away from posterior vertebral body surface at level of fracture-subluxation
  - 3) Adjacent intervertebral disk is disrupted
  - 4) thoracic spinal cord is compressed

Classification by Mechanism

- Extension Injuries:
  - Posterior arch C1 fracture (stable)
  - Hangman Fracture C2 (unstable)
  - Extension TearDrop Fracture (stable)
  - Hyperextension fracture/dislocation or severe hyperextension strain (unstable)
Extension Injury

- Hangman’s Fracture

Extension Injury

- Extension Tear-drop fx

Hyperextension Injury: MRI

- Hyperextension injury in 71-year-old man who fell from bicycle and presented with central cord syndrome. Sagittal T2-weighted MR image (TR/TE, 4500/117) obtained on 0.3-T MR scanner
  1) flaval ligament hypertrophy
  2) C5-6 posterior disk protrusion
  3) anterior longitudinal ligament tear, and partial disruption of C5-6 intervertebral disk.

Hyperextension Injury: MRI

- 6-year-old boy with cervical spine hyperextension injury during motor vehicle crash. Sagittal fast spin-echo inversion-recovery MR image (TR/TE, 3000/51; inversion time, 140 msec) obtained on 1.5-T MR scanner
  1) horizontal fracture through inferior endplate of C5
  2) posterior longitudinal ligament tear
  3) cord contusion
  4) anterior longitudinal ligament tear
  5) prevertebral hemorrhage or edema
  6) extradural hemorrhage

MR imaging findings guided therapy resulting in anterior surgical fusion.
Extension Injury

- C1 posterior arch fx.

Figure 9.27. POSTERIOR ARCH FRACTURE ATLAS. Bilateral sacral fractures are seen at the junction of the posterior arch with the sacrum (right). Bilateral fracture of the posterior arch of the first vertebra, which may be found in the fracture.

Posterior Arch C1 Fx

- Elderly lady tripped over a log and landed on anterior shoulder and forehead. Forehead abrasions.

Classification by Mechanism

- Rotation Injury:
  - Fracture-Dislocation (unstable).
  - Facet and Pillar fractures (stability varied).

- Distraction Injury:
  - Atlanto-Occipital Subluxation (stability varied).

- Other:
  - Atlanto-Occipital Disassociation (unstable).

Classification by Mechanism

- Shearing Injury:
  - Lateral vertebral compression (stable).
  - Lateral dislocation (unstable).
  - Isolated transverse process fracture (stable).
  - Lateral mass fracture (usually stable; depends on extent of injury).

Upper Cervical Check Ligament Damage

- Mechanism of injury: lateral flexion and rotational
- Signs and symptoms of injury of the "Accessory Check Ligaments;
  - result form C1/C2 injury and result in hypermobility
  - vertebral artery insufficiency, vertigo and dizziness
  - pain
  - cervical nystagmus.
  - Reproduced or aggravated by rotation or lateral bending of the head and neck. (+Ext/rotation component of George’s)

Upper Cervical Check Ligament Damage

- Occ/C1 jt
- Transverse ligament of C1
- Accessory C1/C2 ligament
  - Atlanto-Occipital ligament
  - Dens-C1 ligament
Upper Cervical Check Ligament Damage

Dr. Joseph Howe, from Case Studies in Chiropractic Radiology

• Alar ligament; (limits craniocervical axial rotation)
  – Attach: upper lateral portion of odontoid and insert at occipital condyles and atlas.
  – Right alar ligament would become taut upon left rotation and lateral bending of the head. C2 spinous process must rotate to the convexity (opposite lateral bending and rotation).

• Accessory Atlantoaxial ligament;
  – Attach: posterior aspect body of C2 (near base of dens) and insert at inner portion of lateral masses near transverse lig. attachment.
  – Support the atlantoaxial capsular ligaments.
  – Prevent lateral side-slip of C1 on C2 on the same side of lateral bending.
  – Normal amount of lateral deviation of C1 on C2 is no greater than 2mm.

Upper Cervical Ligaments MRI

– Normal anatomy in 21-year-old man. Sagittal T1-weighted MR image (TR/TE, 510/25) obtained on 0.3-T scanner.
  1) normal apical ligament
  2) anterior atlantoaxial membrane

Alar Ligament Tear

– 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). CT of C1-2 rotatory subluxation was suspected. Axial T2-weighted MR image (TR/TE, 4000/90) obtained on 1.0-T MR scanner shows 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.

Occipitoatlantal Dislocation with Alar Ligament Tear

– Occipitoatlantal dislocation in 11-year-old boy who was neurologically intact after motor vehicle crash. Sagittal gradient-echo MR image (TR/TE, 510/35, flip angle, 20°) obtained on 0.3-T MR scanner shows intact (1) and torn (2) portions of anterior occipitoatlantal membrane.
  3), anterior arch of C1
  4), intact anterior atlantoaxial membrane
  5), prevertebral volume or hemorrhage
  6), torn tectorial membrane
  7), torn posterior occipitoatlantal membrane
  8), torn posterior atlantoaxial membrane
  9), intact dural reflection
  10), intact meniscal ligament
  Before MR imaging, full extent of injury and degree of instability were not appreciated either clinically or from results of radiographic or CT scans. Patient underwent surgical fusion shortly thereafter.
Occipitoatlantal dislocation with Alar Ligament Tear

- Occipitoatlantal dislocation in 11-year-old boy who was neurologically intact after motor vehicle crash. Axial gradient-echo MR image (510/35; flip angle, 20°) obtained on 0.3-T MR scanner
  1) torn right alar ligament
  2) displacement of dens to the left with respect to lateral masses of C2
  3) intact transverse ligament

Atlanto Axial Rotatory Fixation
“AARF”

- MRI will detail soft tissues to best advantage

“The C-Spine’s Cleared”

- This is a clinical decision, not a radiographic diagnosis.
- Conventional radiographs do not demonstrate all fractures.
- CT can demonstrate more fractures: ? significance of these smaller injuries.
  Some fractures are subtle on CT.
- MRI will detail soft tissues to best advantage

“Severe and Unstable injuries may be present with little to no bone injury.”
- Additional Imaging Modalities?
  - MRI
  - Flexion/Extension Views
  - Myelography
- Don’t Ignore a Patient’s Symptoms. Don’t Ignore a Patient Unable to Voice Symptoms.
Grading of CAD Injuries

- **Grade I**
  - Minimal; normal ROM, no ligamentous injury, no neurologic s&s
- **Grade II**
  - Slight; Limited ROM, no ligamentous and no neurologic findings
Grading of CAD Injuries

- Grade III
  - Moderate; Limited ROM, some ligamentous and Neuro S&S present.

- Grade IV
  - Moderate to Severe; Limited ROM, ligamentous instability,
  - neuro. findings present, fracture or disc degrangement.

- Grade V
  - Severe; Requires surgical treatment and stabilization

Staging of CAD Injuries

- Staging of Injury
  - I: Acute Inflammatory stage (0-72 hours)
  - II: Repair Stage (72 hours - 14 wks)
  - III: Remodeling Stage (14 wks - 12 months or greater)
  - IV: Chronic or Permanent Stage.

Management of CAD Injuries

- Spinal Manipulation
- Physiotherapies
- Home Exercises
- Diet (antioxidant vitamins for tissue repair and brain trauma)
  - Protein for tissue repair
- Rehabilitation exercises for remodeling stage and chronic cases

Management of CAD Injuries

- "Conclusion: Whiplash injuries are common. Chiropractic is the only proven effective treatment in chronic cases. Our study enables patients to be classified at initial assessment in order to target those patients who will benefit from such treatment."
  - The Journ. of Orthopaedic Med. 21(1). 1999

Management of CAD Injuries

- "The validity of the conclusions and recommendations of the Quebec Task Force regarding the natural course and epidemiology of whiplash injuries is questionable."
  - SPINE Vol. 23. No. 9, pp1043-1049

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Thank you
• Feb. 08