Ventral Column Injury (SPECIFIC INJURIES)

Last updated: December 19, 2020

Fractures According to Mechanism

1. Mechanical Stability

Cervical Spine (C1-2)

- AO/ASIF Upper Cervical Classification System (2018)

Occipital Condylar Fractures

Antlanto-occipital Disassociation

Atlas Fractures

Posterior neural arch fracture (C1)

C1 burst fracture (Jefferson fracture)

Lateral mass fracture (C1)

Rotary Atlantoaxial Dislocation (s. Atlanto-axial Rotatory Fixation)

Griess’ syndrome

Occipito-Atlas (Denis) fractures

Type 1

Type 2

Type 2 with transverse ligament disruption

Type 3

Type 3A

Os Odontoideum

Hangman’s fracture (s. Traumatic Spondylolisthesis of C2)

Fractures of Axis Body

Combined C1-C2 fractures

Cervical Spine (Subaxial)

- Biomechanics

Classifications

Treatment Principles

Compression (wedge) fracture

Burst fracture of vertebral body

Teardrop fracture

Intrinsitic Extension Injury

Anterior Subluxation

Facet Subluxation / Perch / Dislocation

Radiology

Treatment

Facet Fracture

Lamina fracture

Fracture of Transverse Process

Clay Shoveler’s fracture

Whiplash injury (s. Cervical Spondylolisthesis Injury)

Thoracolumbar Spine

- Biomechanics

Radiological Evaluation

Compression (wedge) fracture

Percutaneous vertebral augmentation (PVA)

Burst fracture of vertebral body

Teardrop fracture

Facet Fracture

S. Chance ("seat belt") fracture

Lateral Flexion Fracture

"Sickle" fracture-dislocation, s. Torsional / Rotational injury, Holdsworth Sickle fracture

Facet Fracture-Dislocation

Fracture of Par S. Interspinaculars (Spondylolisthesis)

Fracture of Transverse Process

Pathologic Fractures

VCT – vertebral column trauma.

SCI – spinal cord injury.

N.B. MRI can directly image ligamentous damage (best sequences: STR > T2) – normal ligaments are dark, linear structures (on both T1 and T2); when acutely injured, they are outlined by bright edema or blood, making torn ends quite conspicuous.

The primary management of spine injuries consists of realignment (when necessary), decompression of the neural elements (when indicated), and stabilization.

- If the spine is in good alignment and no decompression is necessary, external immobilization may be all that is required to protect the neural elements while healing occurs:
  - this is particularly true when the major cause of the instability is bony injury.
  - primary ligamentous instability is much less likely to resolve after immobilization → early surgical stabilization.

FRACTURES ACCORDING TO MECHANISM

Any combination of forces may occur in any single case!

Flexion

1. Compression (wedge) fracture

2. Flexion teardrop fracture

3. Clay shoveler’s fracture

4. Anterior Subluxation

5. Transverse ligament disruption, Anterior atlantoaxial dislocation ± odontoid fracture

6. Atlanto-occipital dislocation

Flexion-Distraction

1. Distractive flexion fracture, s. Chance ("seat belt") fracture

2. Bilateral facet dislocation

Flexion with Lateral Component

1. Odontoid fracture with lateral displacement

2. Fracture of transverse process

3. Lateral flexion fracture

Flexion-Rotation

1. Unilateral facet dislocation

2. "Sickle" fracture-dislocation, s. Torsional injury

3. Rotatory atlantoaxial dislocation

- Failure of posterior and middle columns with varying degrees of anterior column insult – due to combination of:
  1) Rotation (→ disruption of posterior ligaments and articular facet)
2) Lateral flexion
3) Lateral-anteriorly directed force.
   • Uncommon in thoracic region due to limited range of rotation (at thoracic facet joints).

### Extension
1. Posterior neural arch fracture
2. Hangman's fracture (s. traumatic spondylolisthesis of C2)
3. Extension teardrop fracture
4. Distractive extension injury
5. Posterior atlantoaxial dislocation ± odontoid fracture
6. Whiplash injury (s. cervical sprain, hyperextension injury)
   • Must common in neck.
   • Must be stable as long as vertebral column is flexed.
   • If ligamentum flavum buckles into spinal cord → central cord syndrome.

### Vertical (axial) compression
1. Burst fracture of vertebral body
2. C1 fracture, incl. Jefferson fracture
3. Lateral mass fracture (C1)
4. Isolated fractures of articular pillar and vertebral body
   • Force is applied from either above (skull) or below (pelvis).
   • Fractures occur in cervical and thoracolumbar junction regions – they are capable of straightening at time of impact.

### Shearing (by horizontal force)
1. Translational fracture-dislocation
2. Lamina fracture

### MECHANICAL STABILITY

Cervical spine injuries in order of instability (most to least unstable):
1. Rupture of transverse ligament of atlas
2. Odontoid fracture
3. Flexion teardrop fracture (burst fracture with posterior ligamentous disruption)
4. Bilateral facet dislocation
5. Burst fracture without posterior ligamentous disruption
6. Hyperextension fracture dislocation
7. Hangman fracture
8. Extension teardrop (stable in flexion)
9. Jefferson fracture (burst fracture of ring of C1)
10. Unilateral facet dislocation
11. Posterior atlantoaxial dislocation ± odontoid fracture
12. Simple wedge compression fracture without posterior disruption
13. Axial fracture
14. Fracture of posterior arch of C1
15. Spinous process fracture (clay shoveler fracture)

### CERVICAL SPINE (C1-2)

Upper neck anatomy is specific - fractures are different from other parts of vertebral column! (> 85% cervical fractures occur below C3, except in infants and young children)

**Rule of thirds** - dens, spinal cord, and empty space each occupy approximately 1/3 of spinal canal at arch of atlas.

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**AOSPIE UPPER CERVICAL CLASSIFICATION SYSTEM (2018)**

Dr. Vaccaro explanation: https://www.youtube.com/watch?v=KyUYfz_JMh4

**Injury site vertically (bone and subjacent articulation):**
Type I - occipital and craniovertebral region
Type II - atlas and atlantoaxial joints
Type III - axis and C2-3 joints

**Injury type:**
A – Bone injury (clearly stable)
B – Ligamentous injury ± bone (potentially unstable – MRI is indicated)
C – Translations (clearly unstable)
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

A Type injuries
- Bony injury only without significant ligamentous, tension band, discal injury
- Most often stable injuries
- Non-operative, conservative management is most often appropriate

B Type injuries
- Tension band/ligamentous injury with or without bony injury
- May be unstable or stable depending on injury specifics
- No complete separation of anatomic integrity
- Management may be operative or non-operative depending on injury specifics

C Type injuries
- Any injury with significant translation in any directional plane and separation of anatomic integrity
- Unstable injuries
- Often requires operative management

Modifiers
M1: potential for instability
M2: high risk of nonunion
M3: high-risk patients' characteristics
M4: vascular injury or abnormality

M2: Injury with significant potential for instability
- I.e. Midsubstance injury to transverse ligament
- I.e. Displaced C1 unilateral lateral mass Tx
- I.e. >6.9 mm displacement of C1 lateral masses

M3: Patient specific factors affecting Tx
- Age, comorbidities, neuro status, smoking, other injuries, ankylosing spondylitis (AS)

M4: Vascular injury or abnormality affecting Tx

N0: Neurologically intact
N1: Transient neurologic deficit that has completely resolved by the time of clinical examination (usually within 24 h from the time of injury)
N2: Radiculopathy
N3: Incomplete spinal cord injury
N4: Complete spinal cord injury
N5: Lesexamimable patient
N6: Continued spinal cord compression

INJURIES

Occipital condyle injuries
- Type A–Isolated bony injury (condyle)
- Simple or comminuted
- I.e occipital condyle Type A injury

Occipital condyle injuries
- Type B–Non-displaced ligamentous injury (cranioceleval)
- Signs of ligamentary injury with or without condyle fracture without any signs of displacement between occiput and C-Spine
Occipital condyle injuries

- Type C
  - Any injury with displacement on spinal imaging
  - i.e. occipital cervical Type C injury

H INJURIES

C1 ring and C1-2 joint

- Type A – Isolated bony only (arch)
  - Anterior/Posterior/Combined arch fracture
  - Lateral Mass/Transverse process

C1 ring and C1-2 joint

- Type B – Ligamentous injury (Transverse Atlantoaxial Ligament)
  - TAL injury +/- bony injury, without acute signs of C1/C2 instability

C1 ring and C1-2 joint

- Type C – Atlantoaxial instability:
  Translation in any plane
  - Any injury with obvious C1/C2 Instability
  - C1/C2 translation, C1/C2 joint distraction or disruption, Jefferson + Capsule disruption etc.
C2 body and C2/3 joint

- Type A–Bone injury only without ligamentous, tension band, discal injury
- Type 1-3 Anderson D’Alonzo odontoid fractures; C2 body fractures (axial, sagittal or coronal): Benzel 1-3, Fujimura I-IV

C2 and C2/3 joint

- Type B–Tension band/ligamentous injury with or without bony injury
- E.g. Type IIa Hangmans fracture

C2 and C2/3 joint

- Type C–Any injury that leads to vertebral body translation in any directional plane
- E.g. Type II Hangmans fracture, unilateral or bilateral facet dislocation

OCCIPITAL CONDYLAR FRACTURES

See p. TrH5 >>

ATLANTOOCCIPITAL DISASSOCIATION

(unsafe)

- May be complete (dislocation) or incomplete (subluxation)
- Occurs predominantly in children; pediatric occipital condyles are small and almost horizontal & lack inherent stability.
- Usually but not invariably fatal due to respiratory arrest caused by injury to lower brain stem (complete disruption of all ligamentous relationships between occiput and atlas → brainstem stretching).
- Caused by severe hyperextension with distraction; non traumatic causes - Down's syndrome, RA.
- Along with joint capsules, tectorial membrane is torn.
- 48% patient have cranial nerve deficits at presentation; 20% are normal at presentation.

RADIOLoGY

Detection is difficult in cases of partial disruption or if reduction occurs after initial subluxation; plain XR has only 50% sensitivity.

A. Condyle-C1 interval (CC1) determined on CT has 100% sensitivity and 100% specificity in pediatric patients (Class I evidence); distance between occiput & atlas > 5 mm at any point in joint.

N.B. atlanto-occipital condyle distance should be < 5 mm regardless of age.

Lateral radiograph of pedestrian struck by car who sustained fatal atlantooccipital dislocation. Note marked widening of space between base of skull and atlas.
B. CNS/AANS recommended method (proposed by Harris et al., 1994) - most sensitive and reproducible radiographic parameter: on lateral XR - increased distance between clivus & dens – basion-axial-interval-basion dental interval (BAI-BDI):

C. Disruption of basilar line of Wackenheim (anterior / posterior subluxation);
Wackenheim's line – drawn down posterior surface of clivus and its inferior extension should barely touch posterior aspect of odontoid tip;
- this relationship does not change in flexion and extension
- if this line runs behind odontoid, posterior subluxation has occurred and vice versa;

**Opisthion** - the midpoint on the posterior margin of the foramen magnum.
**Basion** - the midpoint on the anterior margin of the foramen magnum.
D. Powers ratio > 1 (anterior subluxation)

\[
powers\text{ ratio} = \frac{BC}{OA}
\]

BC - distance from basion to midvertical portion of posterior laminar line of atlas;
OA - distance from opisthion to midvertical portion of posterior surface of anterior ring of atlas.

E. Prevertebral soft tissue swelling (70% patients)

TREATMENT
- avoid flexion of C-spine (can occur on standard adult trauma boards!) - ensure that mattress allows child's head to remain in anatomic position; head is immobilized w/ sandbags.
- cervical traction is absolutely contraindicated (→ stretching of brainstem and vertebral arteries!!! → 10% patients experience neurological deterioration).
- definitive treatment - occiput to C2 fusion.
- rigid immobilization in halo allows adjustment to obtain reduction, & maintains position during and after operation.

ATLAS FRACTURES

Landell type 1 (stable) – isolated fracture of anterior arch OR posterior arch, see below >>

Landell type 2 – burst fracture of C1 ring (Jefferson fracture), see below >>
- a) transverse ligament intact (stable)
- b) transverse ligament disrupted (unstable)

Landell type 3 (stable) – fracture through lateral mass of C1, see below >>

- rarely associated with neurological sequelae

Spinal Canal - Steele’s rule: 1/3 cord, 1/3 dens, 1/3 empty
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

GENERAL TREATMENT

No Class I or Class II medical evidence!

Intact transverse ligament → collar or halo (for Jefferson) for 8-12 weeks

Disrupted transverse atlantal ligament:
  a) Halo for 10-12 weeks
  b) C1-2 fusion

POSTERIOR NEURAL ARCH FRACTURE (C1)

(potentially unstable – because of location – but otherwise stable because anterior arch and transverse ligament remain intact; posterior C1 arch is routinely removed during Chiari decompression)

- Forced neck extension → compression of posterior neural arch of C1 between occiput and heavy spinous process of axis.

Vertebral artery injury:

RADIOLOGY

LATERAL VIEW - fracture line through posterior neural arch

ODONTOID VIEW - lateral masses of C1 and articular pillars of C2 fail to reveal any lateral displacement - differentiating from Jefferson fracture.

TREATMENT

C-collar (after differentiation from Jefferson fracture).

C1 BURST FRACTURE (JEFFERSON FRACTURE)

Classic JEFFERSON fracture (s. C1 burst fracture) – burst fracture of C1 ring in 4 places*± ± disruption of transverse ligament:

- Vertical compression force* (transmitted through occipital condyles to superior articular surfaces of lateral masses of atlas) drives lateral masses laterally.
- Extremely unstable if transverse ligament is disrupted.

* e.g. in diving accidents
± for at least in two sites - one anterior and one behind lateral masses

- Usually spinal cord is not damaged - canal of atlas is normally large (fracture fragments spread outward to further increase canal dimensions).
- Fractures in other parts of cervical spine are found in 50% patients!!

RADIOLOGY

X-ray - difficult to recognize if fragments are minimally displaced; H: CT LATERAL VIEW.
1) widening of atlantodental interval see below
2) prevertebral hemorrhage & retropharyngeal swelling.

ODONTOID view: margins of lateral masses (of C1) lie lateral to margins of articular pillars (of C2) – Spence’s rule. see below

CT is best for diagnosis.

Diagnosis of TRANSVERSE ATLANTAL LIGAMENT RUPTURE – 3 criteria:
1) MRI – most sensitive test (more sensitive than rule of Spence)
2) **Spence’s rule**: \( \geq 7 \) mm (sum of bilateral distances between dens and lateral mass) displacement of lateral masses in coronal CT view (or \( > 8 \) mm on plain XR open-mouth view to consider effects of radiographic magnification)
3) widening of atlantodental interval (ADI, s. predental space) in sagittal CT view (or lateral XR view): \( \geq 5 \) mm in adults (\( \geq 2.5 \) mm in females), \( \geq 4-5 \) mm in children.

Some experts say \( > 5 \) mm in adults.

N.B. if \( > 12 \) mm - rupture of all ligaments about dens.

Axial view of stable Jefferson fracture (transverse ligament intact):

Axial view of unstable Jefferson fracture (transverse ligament ruptured)

TREATMENT

A. *No transverse ligament injury* – long-term (10-12 weeks):
   a) C-collar
   b) halo (with mild cervical traction);

B. *Transverse ligament damage*:
   a) halo (12 weeks) – discomfort of prolonged immobilization + poor healing/union rate
   b) occ-C2 fusion – halo.
**LATERAL MASS FRACTURE (C1)**

A. Normal lateral cervical spine.
B. Axial CT - slightly displaced lateral mass fracture.

**TREATMENT**
- Comminuted fracture – collar, halo
- Transverse process fractures – collar

**ROTARY ATLANTOAXIAL DISLOCATION (S. ATLANTO-AXIAL ROTATORY FIXATION)**
- Unilateral facet dislocation at C1-C2 level (rotational injury usually without flexion).

**ETIOLOGY**
1) Trauma
2) Grisel’s syndrome – see below
3) Abnormal ligament laxity, e.g. Down syndrome, connective tissue diseases, osteogenesis imperfecta, neurofibromatosis type 1

**RADIOLOGY**
- Odontoid view - asymmetry between odontoid process and lateral masses of C1, unilaterally magnified lateral mass (wink sign).
- Three-position CT with C1-C2 motion analysis.
- > 5 mm of anterior displacement of arch of C1 indicates disruption of both facet capsules as well as transverse ligament (Fielding type III)

**TREATMENT**
- Subluxation is reduced in:
  a) Halter traction (if < 4 weeks duration)
  b) Tong/halo traction (if > 4 weeks duration)
- Specific forms of immobilization are recommended to ensure ligamentous healing:
  - Fielding Type I (transverse ligament intact and bilateral facet capsular injury) - soft collar
  - Fielding Type II (transverse ligament + unilateral facet capsular injury) - Philadelphia collar or SOMI brace
  - Fielding Type III (transverse ligament + bilateral facet capsular injury) - halo
- Following 6-8 weeks of immobilization, stability is assessed by flexion-extension XR; recurrence or residual instability → posterior atlantoaxial (C1-C2) arthrodesis.

**GRISEL’S SYNDROME**
- Unilateral or bilateral subluxation of atlantoaxial joint from inflammatory ligamentous laxity
- Etiology - inflammatory process in head and neck (e.g. upper respiratory tract infections, retropharyngeal abscess, tonsillectomy / adenotonsillectomy, otitis media)
- Causative organisms: Staphylococcus aureus, Group B streptococcus, oral flora.
- Anatomic studies have demonstrated existence of periodontoid vascular plexus that drains posterior superior pharyngeal region, no lymph nodes are present in this plexus, so septic exudates may be freely transferred from pharynx to C1-C2 articulation → synovial and vascular engorgements → mechanical and chemical damage to transverse and facet capsular ligaments.
- Rare cause of torticollis
- Usually occurs in infants / young children
- Neurological complications (occur in 15% of cases) range from radiculopathy to death from medullary compression.
- Treatment – manual reduction under sedation and collar; if recur - traction brace; residual subluxation after 8 weeks of treatment or neurological symptoms may require operative treatment (posterior atlantoaxial arthrodesis).
Vertebral column injury (specific injuries)

ODONTOID (DENS) FRACTURES

- 10% of cervical spine fractures.

Anderson and D’Alonzo (1974):
1974. Anderson LD, D’Alonzo RT.

Type I – oblique fractures through upper portion of dens.
Type II – fractures across dens base near junction with axis body.
Type III – dens fractures that extend into axis body.

Treatment

- all odontoid fractures are often effectively managed with external cervical immobilization, with understanding that failure of external immobilization is significantly higher for type 2 - type 2 has lowest rate of union (healing).
- management of odontoid fractures in elderly patients is associated with increased failure rates, and higher rates of morbidity and mortality irrespective of treatment offered.
- union is verified with CT (historical alternative – dynamic XR).

Indications for surgical fusion:
1. Type 2 fracture in patient > 50 yrs
2. Type 2 or 3 fracture with dens displacement ≥ 5 mm post attempted reduction (or inability to maintain alignment* with external immobilization); some experts say even > 2 mm *e.g. > 5° angulation between supine and upright films
3. Dens comminution (type 2A fracture)
4. Transverse ligament disruption
5. Atlanto-occipital dislocation

TYPE 1 (stable) - fracture across tip of dens.
- treated with cervical collar (successful in 100% cases).
- may be associated with life-threatening atlanto-occipital dislocation (1H fusion).

TYPE 2 (most unstable type!) - fracture at base of dens, most common type;
- odontoid process develops embryologically as body of atlas; during development, body becomes separated from ring of atlas and fuses to body of axis - cartilaginous material at site of fusion is present until maturity is reached - separation at base of odontoid may occur with relatively slight injury to head during childhood (resulting bony segment is os odontoideum).

Embryologically – fracture line corresponds to fetal intervertebral disc!

TREATMENT
- unfavorable healing potential:
  1) considerably less trabecular bone at the base of the odontoid
  2) the destructive forces from the apical ligament
  3) dens is surrounded by synovial cavities, resulting in diminished periosteal blood supply
- patients rarely seen initially with significant neurological deficits, but risk of posterior displacement - managed with halo vest for 3-6 months – flexion-extension XR to confirm stability, inability to maintain dens displacement < 5 mm is indication for surgery.
• limited vascular supply, small area of cancellous bone - high prevalence of nonunion (43-47% for collar, 16-35% for halo or surgery) and ischemic necrosis of odontoid, risk groups - elderly patient*, delay of treatment, failed reduction or secondary loss of reduction. H: operative fixation.

*NB: consider surgical fusion for type II odontoid fractures in patients > 50 yrs! (age > 50 yrs increases nonunion risk 21-fold when treated in halo), reported union rates in elderly patients treated with halo vary between 20% and 100% in literature; plus, elderly mortality rates as high as 26-42% with use of halo have been reported.

Implications of nonunion - type II dens fractures in elderly > 65 yrs treated in C-collar (3 months)


- 125 patients
- 29% demonstrated osseous-union, 71% had nonunion (of which 40% had radiological instability but none of these complained of pain or neurological symptoms).
- no patient developed myelopathy.
- no statistically significant differences in pain, disability, or quality of life.
- 42% mortality rate (union: 33%; nonunion: 46%; median time to death was 30 mo); median length of survival was 77 mo for osseous-union vs 50 mo for nonunion but no significant effect of osseous-union status (P = .22) on Cox proportional hazards modelling.

*the cause of the nonunion (eg. frailty, comorbidity) may be the cause of the reduced survival length rather than the nonunion itself.

Conclusion: management with a semi-rigid collar in older people with type II odontoid fracture is safe and associated with low levels of pain and disability without statistically significant differences (incl. length of survival) between those demonstrating osseous-union or stable or unstable nonunions – C1-2 fusion may not be necessary for patients who fail to achieve union through conservative management (e.g. only 25% of UK surgeons advocating surgical management in older patients with nonunion)

A. C1-2 fusion via posterior approach: see technical details at p. Op210 >> a) C1 and C2 screws; if C2 posterior elements are fractured – add C3 (same with C1 – add occipital); b) quick alternative - wiring between C1 lamina and C2 spinous process + iliac grafts or methylmethacrylate (between decorticated spinous processes); (historical - frustration with Halifax clamps – poor results) c) transarticular C1-2 screws - no longer popular alternative

There studies showing that for odontoid fractures with intact transverse ligament, C1-2 temporary fixation (without fusion) has same odontoid healing rates but better functional outcomes than C1-2 fusion


B. Odontoid Screw: via anterolateral approach (preserves rotation motion!); high fusion rates (87-100%)* if performed during first 6 weeks after fracture – odontoid screw works best if placed early!

*fusion rates in elderly may be as low as 60% (same as with halo) - age is important factor but not all studies agree with that (plus, fibrous union with radiographic stability may be a suitable outcome in elderly patients)

Contraindications: comminuted odontoid fracture, Grana type IIC fracture, transverse ligament rupture, nondisplaced fractures, nonunion persisting > 3 months, osteoporosis, barrel chest, short neck, severe thoracic kyphosis

Grauer treatment-oriented subclassification of type 2 dens fractures

Type IIA - horizontal fracture pattern and < 1 mm of displacement → external immobilization
Type IIB - oblique fracture extending from the anterosuperior to the posteroinferior portion of the dens → anterior screw fixation
Type IIC - oblique fracture beginning anteroinferiorly and extending posteroinferiorly and associated with significant anterior comminution → posterior C1-2 fusion

**TYPE 2 WITH TRANSVERSE LIGAMENT DISRUPTION**

(unsafe because of transverse ligament disruption)

a) transverse or alar ligament ruptures are uncommon unless there are predisposing factors (rheumatoid arthritis, posterior pharyngitis, ankylosing spondylitis, etc).
b) transverse ligament rupture (with intact odontoid) can cause immediate death from respiratory failure (cord compression between odontoid and posterior arch of C1).

Radiology

i. preodontal (ADI) space ↑ see above >>
ii. disrupted posterior cervical line
iii. retropharyngeal swelling.

T2-MRI - traumatic transverse ligament injury (arrow):

Flexion and extension dynamic CT - craniovertebral junction instability (atlanto-dens interval > 3 mm) caused by traumatic transverse ligament injury (arrow):

**Treatment**

- traction (with neck in extension) → C1-C2 fusion (as for type 2 odontoid fracture); odontoid screw is contraindicated in transverse ligament disruptions!

Fixation with posteriorly placed plate held in place with sublaminar and occipital wires:

- on occasion, reduction is impossible and odontoid must be removed by drilling (through transoral or anterolateral approach) → fusion.
**TYPE 3**

- fracture extending into body of C2.

  - treatment
    a) collar (fails in 35-50% cases).
    b) halo vest (fails in 1-16% cases)

**TYPE 3A**

- horizontal osseous fracture through body of C2 extending into C1-2 facet joints:

  - associated with circumferential (atlantoaxial ligament, tectorial membrane, interspinous and capsular joints) ligament avulsion - highly unstable!!!
  - described by Jea et al.

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**OS ODONTOIDEUM**

**Definition** - ossicle with smooth circumferential cortical margins representing odontoid process that has no osseous continuity with body of C2.

**Etiology** - remains debated in the literature with evidence for both acquired and congenital causes.

**Clinical features:**
1) occipital-cervical pain
2) myelopathy - transient (commonly after trauma), static, or progressive.
3) vertebralbasilar ischemia
   - sudden spinal cord injury in association with os odontoideum after minor trauma have been reported.

**Evaluation** - flexion-extension lateral XR.
   - most often, there is anterior instability, with os odontoideum translating forward in relation to body of C2.
   - at times, one will see either no discernible instability or “posterior instability” with os odontoideum moving posteriorly into spinal canal during neck extension.
   - degree of C1-C2 instability on XR does not correlate with presence of myelopathy; sagittal diameter of spinal canal at C1-C2 level < 13 mm does correlate with myelopathy detected on clinical examination.

**Classification** - 2 anatomic types:
- Orthotopic - ossicle that moves with anterior arch of C1.
- Dystopic - ossicle that is functionally fused to basion; dystopic os odontoideum may sublux anterior to arch.

**Management** - indications for surgery:
1) neurological symptoms → C1-2 fusion
2) irreducible DORSAL* cervicomedullary compression → occipital-cervical fusion ± C1 laminectomy
3) associated occipital-atlantal instability → occipital-cervical fusion ± C1 laminectomy
   - vs. irreducible VENTRAL cervicomedullary compression → ventral decompression.

N.B. odontoid screw fixation has no role!

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**HANGMAN’S fracture** (S. TRAUMATIC SPONDYLOLYSIS of C2)

(unsual - but cord damage is rare because AP diameter of neural canal is greatest at C2 level and because bilateral pedicular fractures permit spinal canal to decompress itself with forward displacement of C2 body)

- abrupt deceleration (e.g. hanging with knot in submental position, striking chin on steering wheel in head-on automobile crash) → cervicocranium (skull, atlas, and axis functioning as unit) is thrown into extreme hyperextension → bilateral pedicle fractures of axis (→ broken subjacent disc bond → forward subluxation of C2 on C3) → cervical spine / spinal cord damage happens in only those hangings that involve fall from distance greater than body height.
RADIOLOGY
1) Fracture lines extending through pedicles of C2 (i.e. anterior to inferior articular facets).
2) Disrupted posterior cervical line (base of C2 spinous process lies > 2 mm behind posterior cervical line).
3) Prevertebral swelling (may cause respiratory obstruction).

CLASSIFICATION AND TREATMENT
Effendi classification:
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

**Type I (stable):** isolated hairline (< 1 mm) fracture of axis ring with minimal displacement of C2 body associated with axial loading and hyperextension → 6 weeks C-collars.

**Type II (unstable):** fractures of axis ring with displacement (> 1 mm) of anterior fragment with disruption of disk space below axis associated with hyperextension and rebound flexion → 12 weeks of halo → if instability on dynamic XR then add C2-3 fusion.

**Type III (unstable):** fractures of axis ring with displacement of axis body in flexed forward position (angulation), in conjunction with C2-3 facet dislocation associated with primary flexion and rebound extension → open reduction and C2-3 fusion → halo for 12 weeks.

**Francis classification** - grades of increasing severity of displacement and angulation of C2 on C3:
- **Grade I:** fractures with 0-3.5 mm displacement and/or C2-3 angulation < 11°
- **Grade II:** fractures with displacement < 3.5 mm and angulation > 11°
- **Grade III:** fractures with displacement > 3.5 mm but less than half of C3 vertebral width and angulation < 11°
- **Grade IV:** fractures with displacement > 3.5 mm but less than half of C3 vertebral width with angulation > 11°
- **Grade V:** fractures with complete C2-3 disk disruption.

**Levine and Edwards classification** (modification of Effendi classification with added flexion-distraction as a mechanism of injury (type IIA)):
- **Type 1 (stable) - hyperextension and axial loading → C2/3 disc remains intact (stable) - no change in stability; insignificant displacement (< 3 mm horizontal displacement) or angulation.**
  - Treatment: rigid cervical collar / occipital-mandibular brace for 4-12 weeks

- **Type 2 - initial hyperextension and axial loading followed by hyperflexion → C2/3 disc and PLL are disrupted with vertical fracture line (unstable): significant horizontal translation (> 3 mm) and angulation (> 11°)**
  - Treatment: < 5 mm displacement → reduction with traction + halo for 6-12 weeks. > 5 mm displacement → consider surgery or prolonged traction. Usually heal despite displacement (autofuse C2 on C3).

- **Type 2A - results from flexion-distraction → horizontal fracture line: no translation but severe angulation (> 11°)**
  - Treatment: reduction with hyperextension + halo immobilization for 6-12 weeks. Avoid traction! (type 2A fractures experience increased displacement in traction but are reduced with gentle extension and compression in halo vest)

- **Type 3 (grossly unstable) - results from flexion-compression → Type I fracture with unilateral or bilateral C2-3 facet dislocation.**
  - Treatment: surgery - reduction of facet dislocation followed by stabilization required.
    - N.B. C2-3 disc disruption (C2 translation > 3 mm over C3) requires surgery
      - a) C2-3 ACDF – 100% fusion at 6 months, helps to remove herniated disc fragments but risk of dysphagia (dissect neck tissues well and avoid too much traction).
      - b) C1-3 PCF – helps to achieve facet reduction directly but risk of vertebral artery injury.

  - Union occurs within ≈ 3 months, with spontaneous anterior interbody fusion.
Resume - indications for surgery (anterior or posterior C2-3 fusion):

a) severe angulation (Francis grade II and IV, Effendi type II)
b) severe (> 5 mm) translation
c) C2-3 disc disruption (C2 translation > 3 mm over C3) (Francis grade V, Effendi type III)
d) facet dislocations
e) failure of external immobilization - inability to achieve or maintain fracture alignment.

FRACTURES OF AXIS BODY

Comminuted fracture – evaluate for vertebral artery injury.

Fractures of the ring of the axis are typically associated with low rates of neurological injury as displacement of most fracture patterns results in spinal canal expansion;

- fractures involving the posterior cortex of C2, when accompanied by translation, can result in canal compression causing neurological dysfunction.

TREATMENT

- external immobilization.

- indications for surgery:
  1) severe ligamentous disruption
  2) inability to achieve or maintain fracture alignment with external immobilization.

COMBINED C1-C2 FRACTURES

- increased incidence of neurological deficit compared with either isolated C1 or isolated C2 fractures.
- management decisions must be based on characteristics of axis fracture.
- historically, as proposed by Levine and Edwards, combination fractures of C1 and C2 have been managed sequentially, allowing 1 fracture to heal (usually atlas) before attempting definitive management of axis injury.
- rigid external immobilization is typically recommended as initial management for majority of patients.
- modern approach:
  - atlas fractures in combination with type II or III odontoid fractures with atlantoaxial interval > 5 mm → early surgical management
  - atlas fractures in combination with Hangman fracture with C2-C3 angulation > 11° → surgical stabilization and fusion

- surgical options:
  - posterior C1-2 internal fixation and fusion
  - combined anterior odontoid and C1-2 transarticular screw fixation with fusion.

CERVICAL SPINE (SUBAXIAL)

Specificities for ANKYLOSING SPONDYLITIS
- see p. Op210 >>

BIOMECHANICS

Lateral cervical spine - anatomical location of main discoligamentous structures contributing to physiological stability of a single motion segment:
CLASSIFICATIONS

SLIC (Subaxial Injury Classification) and CSISS (Cervical Spine Injury Severity Score) classifications are recommended (Level I).

SLIC (Subaxial Injury Classification) by Vaccaro and Colleagues


MORPHOLOGY

<table>
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<tr>
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<tr>
<td>Distraction (facet perch, hyperextension)</td>
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</tr>
<tr>
<td>Rotation/translation (facet dislocation, unstable teardrop or advanced stage flexion compression injury)</td>
<td>4</td>
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</table>

DISC-LIGAMENTOUS COMPLEX (DLC)

Intact | 0 |
| Indeterminate (isolated interspinous widening, MRI signal change only) | 1 |
| Disrupted (widening of disc space, facet perch or dislocation) | 2 |

NEUROLOGICAL STATUS

| Intact | 0 |
| Root injury | 1 |
| Complete cord injury | 2 |
| Incomplete cord injury | 3 |
| Continuous cord compression in setting of neurological deficit (NeuroModifier) | 1 |

SLIC scores:

1-3 → non-surgical management
2-5 → surgical fixation.

TREATMENT PRINCIPLES

- Decompression / restoration of spinal canal is the goal.
- Internal fixation or external immobilization is recommended (to allow for early mobilization and rehabilitation): Failure rates:
  - Internal fixation - 9%
  - External immobilization only (traction or orthosis) - 30%; risk factors: vertebral compression ≥ 40%, kyphosis ≥ 15%, vertebral subluxation ≥ 20%

- Either anterior or posterior fixation and fusion is acceptable in patients not requiring particular surgical approach for decompression of spinal cord; complication rates:
  - Anterior fusion - 9%
  - Posterior fusion - 37%

- Prolonged bed rest in traction is recommended if more contemporary treatment options are not available.

COMPRESSION (WEDGE) FRACTURE

- (mechanically stable - intact posterior column)
  - During flexion, longitudinal pull is exerted on strong posterior ligaments (tolerate longitudinal pull very well - usually remain intact) → most of force is expended on vertebral body anteriorly → simple wedge fracture.

- Fragment of posterior vertebral body may be displaced into spinal canal.

RADIOLGIC

1) anterior border of vertebral body - decreased height (> 3 mm than posterior border) and increased concavity.
2) increased density of vertebral body resulting from bony impaction.
3) slight separation of spinous processes (exaggerated in flexion films)
4) prevertebral soft-tissue swelling

Reconstructed sagittal CT - compression of anterior element and failure of middle element (displacement of superior posterior lip of vertebral body into spinal canal)

TREATMENT
a) wedge fractures (not associated with neurologic impairment / additional radiographic abnormalities) can be managed on OUTPATIENT basis with orthosis (soft or hard cervical collar).
b) bone / disk impingement on spinal canal → decompression via anterior approach (corpectomy);

c) injury to posterior ligaments can be fixed with Halifax clamps and fusion:

BURST FRACTURE OF VERTEBRAL BODY
see THORACOLUMBAR >>

TEARDROP FRACTURE
Teardrop fracture is marker of potential for high instability (may be stable or highly unstable)

Two trauma mechanisms:
A. Flexion (+ vertical compression) force fractures (bursts!*) vertebral body - wedge-shaped fragment (resembles teardrop) of anteroinferior portion of vertebral body is displaced anteriorly (indicates anterior longitudinal ligament disruption), at same time posterior ligamentous disruption happens (→ posterior column fracture – rest of vertebral body may be posteriorly dislocated) - disruption of all 3 columns → frequent neurologic damage.

B. Forced abrupt extension (e.g. diving accidents) → dense anterior longitudinal ligament pulls anteroinferior corner of vertebral body away from remainder of vertebra → classic innocent-appearing triangular-shaped fracture (true avulsion); no subluxation!!! (vs. flexion teardrop fracture) but anterior ligament may be disrupted (stable in flexion; highly unstable in extension) • often occurs in lower cervical vertebrae (C5-C7).
Diagnostic work up – flexion-extension XR to document stability

Management
a) no ligamentous damage – cervical collar for 3-4 months
b) ligamentous damage – surgical fusion

DISTRACTIVE EXTENSION INJURY

• rarely demonstrates significant damage by X-ray:

ANTERIOR SUBLUXATION
(Stable in extension but potentially unstable in flexion)

• posterior ligamentous rupture without bony fracture
• Injury begins posteriorly in nuchal ligament and proceeds anterior to involve other ligaments to varying extent.
• anterior longitudinal ligament (anterior column) remains intact – rare neurologic sequelae.

N.B. significant displacement can occur with flexion → very rare cases of neurologic deficit!

RADIOLOGY

1. LATERAL RADIOGRAPH (neck in neutral position) - subtle findings (often missed if flexion / extension views are not obtained):
   - widening of interspinous space
   - gaping of intervertebral space posteriorly.

2. OBLIQUE VIEWS - widening or abnormal alignment of facets.

3. LATERAL RADIOGRAPH (flexion / extension views - risk of causing neurologic injury!! → perform only if above views cannot confirm subluxation) - disrupted anterior and posterior contour lines.

4. MRI can visualize ligaments
A. Lateral cervical X-ray - prevertebral soft tissue swelling and slight C2 subluxation over C3 (arrow).

B. Sagittal T2 MRI demonstrates ligamentous disruption (double arrows) with blood tracking along both ligaments and prevertebral soft tissues (arrowheads):

C4-C5 fracture subluxation (MRI) - 50% anterolisthesis of C4 on C5; fracture of posterior C4 vertebral body; interruption of normally black anterior longitudinal ligament at C4-C5 disc space; bright signal in spinal cord is combination of edema and hemorrhage.

**FACET SUBLUXATION / PERCH / DISLOCATION**

**UNILATERAL** (stable):
- Rotation about one of facet joints (acts as fulcrum) + simultaneous flexion → contralateral facet joint dislocates with superior facet riding forward and over tip of inferior facet and coming to rest within intervertebral foramen (mechanically locked in place - stable injury even though posterior ligament complex is disrupted).
- Neurologic deficits are rare.

**BILATERAL** (always unstable)
- Extreme form of anterior subluxation: flexion (± axial distraction) causes soft-tissue disruption to continue anteriorly to involve annulus fibrosus and anterior longitudinal ligament; forward movement of spine causes inferior articulating facets to pass upward and over superior facets of lower vertebra (anterior displacement of spine above level of injury).
- High incidence of spinal cord injury!!!

High level of suspicion for vertebral artery injury (esp. in bilateral jumped facets) – consider vascular imaging (CTA or MRA)?

**RADIOLOGY**

**UNILATERAL**
- Plain films
  - AP view - disrupted line bisecting spinous processes, asymmetry of uncovertebral joints.
  - Lateral view
    1) dislocated superior articulating facet forms “bow tie” deformity with nondislocated superior articulating facet.
2) upper vertebral body is anteriorly subluxed / anterolisthesis (≤ 25% of AP diameter of vertebral body; vs. ≥ 50% in bilateral facet dislocations).

Oblique view:
1) superior articulating facet projects within neural foramen.
2) expected tiling of laminae is disrupted.
3) widening of apophyseal joint (may be strongest differentiation from torticollis!).

CT – "empty facet" sign.

PERCHED FACET

BILATERAL

LATERAL view - vertebral body subluxed anteriorly with displacement greater than ½ of AP diameter of lower vertebral body; lower vertebral body may be compressed.

AP view - widening of intervertebral disc space at joint of Luschka.
### TREATMENT
- keep in C-collar until reduction attempts.
- reduction is safest in cooperative examinee patient – therefore is best with skeletal traction.
- reduction under anesthesia is less safe (at least use monitoring).
- **jumped facets**
  - intact patient → MRI → closed reduction* → ACDF
  - SCL, cooperative patient → closed reduction* → MRI → ACDF

N.B. it is too easy to oversize ACDF graft due to facet injury – be cautious! Also chances of CSF leak (use dural sealant and HBO up postop)

*if unsuccessful, proceed with open reduction via posterior approach (drill off facet) → PFC; some experts recommend 360 fusion for bilateral jumped facets

### CLOSED REDUCTION WITH SKELETAL TRACTION
- prior to attempted reduction ensure that diagnosis is correct;
- pure vertical distraction injuries (at first glance can resemble facet dislocation) - should not be managed traction since this would be expected to only worsen the injury.
- alert and cooperative patient → immediate reduction w/o MRI;
- N.B. some experts recommend MRI before reduction or operative intervention is attempted - significant number of bilateral facet dislocations are accompanied by disk herniation* - catastrophic compression of spinal cord may occur if injured disk retroperuses during cervical traction! (monitor reposition clinically)

*in this case, consider ACDF followed by posterior fusion;
- patient must be admitted to ICU with one to one nursing care to monitor his neurologic status preferably when patient is awake and alert.

N.B. prior to traction / operative manipulation on obtunded patient, ensure (e.g. with MRI) that no concomitant disc rupture has occurred (present in 30-50% patients with fracture dislocation).

If yes → perform diskectomy first! (otherwise, increased neurological deficits can result during manipulations).

N.B. preduction MRI is not necessary if patient is awake and can be examined during reduction and traction application.

Fragment posteriorly – careful with closed reduction (might be OK in awake cooperative patient but avoid manipulative reduction, just let weight do its job), does not do posterior approach but proceed with ACDF with discectomy, then traction.

#### Methods of traction
a) **TONGS** (Gardner-Wells tongs, Crutchfield tongs) – 2 screws into outer table of skull: see p. TrS5

b) **HALO** fixation – 4-6 screws; very rigid external immobilization; may be used for cervical traction in recumbent position or attached to body jacker lined with sheepskin (patient may be ambulatory in halo cast or vest). see p. TrS5

c) **sterilized FISH HOOKS** applied to posterior zygamas - for patients with severe skull injuries.

#### Traction Force
- (needed amount is variable) - weight is added incrementally, X-rays being made before each addition

begin with: 10 lbs is added for occiput; additional 5 lbs for each vertebra to level of injury (but begin with < 20 lbs)

re-evaluation: after placement of weight, check lateral X-ray & full neuro exam; if reduction does not occur, weight is then added in 5 lb increments, in approximate half hour intervals, being certain to repeat lateral X-ray and neuro exam after each weight increase.

max amount of traction weight that can be applied safely is unknown (up to one third of body weight may be required; reports include up to 60-75 lbs) up to 20 lbs can be applied to C1 & C2; up to 50 lbs can be applied in lower cervical region (C3-C7)

- weights aid in spinal realignment:

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<th>Rule of thumb</th>
<th>5 pounds (2.25 kg) for each cervical level is required for reduction</th>
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<td>(e.g. to reduce C3 dislocation – start with 25 pounds; if insufficient, additional weight increments are applied every 20-30 minutes until reduction is attained).</td>
<td>– weight is increased by 5-pound increments.</td>
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<tr>
<td>– in routine clinical practice (especially for injuries such as bilateral facet dislocations) results in excess of 50 pounds may be necessary to achieve reduction.</td>
<td>– maximal weight that can be safely applied to Gardner-Wells tongs is 80-90 pounds (36-40 kg) or 2/3 of body weight.</td>
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<td>– head of bed elevated enough to counter weight of traction.</td>
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<td>*e.g. RotoRest</td>
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#### During traction
- when traction is applied, patient is continually monitored (radiographically and clinically) for traction success - overdistraction may cause cranial nerve deficits or neurological worsening
- muscle relaxants (e.g. scheduled diazepam) – reduce spasm, which may inhibit reduction efforts.

If reduction is achieved → traction weight is reduced to 20 lbs (9.1 kg) or less to maintain alignment (redilution is performed with moderate cervical extension)

- some experts may apply halo; others would go to ACDF (esp. with bilateral facet dislocation – all ligaments and disc are disrupted – will not heal without arthrodesis).

If reduction does not occur, closed reduction attempts are discontinued when:

a) > 1 cm of distraction occurs at site of injury
b) maximum amount of weight is applied
c) neurological status deteriorates
d) unsuccessful reduction by 3-6 hrs after trauma with neurological deficit present

→ proceed to MRI → open reduction in OR
• if reduction is not achieved, bony or soft tissue interposition should be suspected.

**OPEN REDUCTION**

First try to reduce manually. After patient is under general anesthesia and complete paralysis (remove C-collar and apply Hoffer traction* in preparation for ACDF):

*may have halo crown ready in OR in case will need more manipulation

• under live fluoroscopy: apply axial traction and gentle neck flexion (lever action allows superior facet to go over the top of inferior facet) — maintain traction and extend neck by gradually minimizing axial traction (superior facet lands behind inferior facet) — proceed to surgery (ACDF).

**Surgical open reduction options:**

a) posterior approach is gold standard for straightforward open reduction of facet dislocations; some experts would use pedicle screws to gain more strength.

b) **ACDF** to reduce dislocation and open foramen (going from posterior cannot place pedicle screw because of fracture; would need screws level above and level below); some experts think it is equally acceptable alternative to posterior approach.

- some experts recommend **360° fusion** for bilateral facet dislocations (alternative — after ACDF, flex neck and do XR — if spinous process space widens, add PCF, if not — keep in C-collar)

### FACET FRACTURE

a) unilateral — may cause subluxation up to 25%

b) bilateral — may cause subluxation up to 50%

**TREATMENT**

- if subluxation or nerve root dysfunction → **C-collar** with XR in collar and then follow up in 2 weeks — if subluxation or nerve root dysfunction (that happens quite often) → one-level **ACDF**

**Cervical subaxial nondisplaced unilateral facet fractures**


Facet fractures were classified:

- type A1 fractures: superior facet fracture of caudal vertebra
- type A2: inferior facet fracture of rostral vertebra
- type A3: floating lateral mass (fracture of pedicle and vertical laminar fracture).

• all patients were given a trial of hard cervical collar.

• mean follow-up was 2.7 ± 0.4 mo.

• **outcomes**: nonoperative management was successful in 82.9% patients (others developed instability requiring surgery); no significant association was found between the type of facet fracture and outcome (Fisher's exact test, P = 0.18).

**LAMINA FRACTURE**

c) evidence of nerve root dysfunction → surgical decompression.

**FRACTURE OF TRANSVERSE PROCESS**

(stable)

F. if above C7, need CTA to check for VA injury

**CLAY SHOVELER’S FRACTURE**

(mechanically stable)

- oblique fracture of spinous process base in one of lower cervical vertebrae

G. commonly occurred in clay miners (Australia during 1930s) — when miner lifted heavy shovelful of clay, abrupt flexion of his head, in opposition to stabilizing force of strong supraspinous ligament, resulted in spinous process avulsion.

H. **modern etiology**

a. direct trauma to spinous process.

b. forced neck flexion (e.g. sudden deceleration in motor vehicle crashes, direct trauma to occiput).
- as for cervical sprain - soft orthosis for comfort (2-3 months).

WHIPLASH INJURY (S. CERVICAL SPRAIN, HYPEREXTENSION INJURY)

- cervical myofascial injury
  - mechanism - different sequences and combinations of flexion, extension, and lateral motion
    - Most common* mechanism - hyperextension followed by flexion (motor vehicle is hit from behind by another vehicle, i.e. rear-end collisions).
    - *cause 85% whiplash injuries
  - women* > men.
  - narrower neck with less muscle mass supporting head
    - N.B. cases with fractures, disk herniations, head injuries are excluded; hyperextension may cause central cord syndrome due to spinal cord damage.

Clinically:
1. Persistent neck pain without objective findings.
   - onset within 24 hours (in 93% cases).
   - can persist for months (in minority of patients – for years).
   - risk factors for more severe symptoms - unprepared car occupant, rotated or inclined head position at moment of impact.
   - psychosocial factors, negative affectivity, and personality traits are not predictive of symptom duration.
   - despite common belief that pending litigation is responsible for persistent symptoms, symptom duration.
2. Possible concomitant symptoms:
   - 80% patients complain of headaches (muscle contraction type ± greater occipital neuralgia; third occipital neuralgia*).
     - *i.e. pain referred from C2-3 facet joint innervated by 3rd occipital nerve muscle.
   - neck stiffness in one or more directions of motion.
   - localized areas of muscle tenderness (trigger points) in posterior musculature may develop.
   - dizziness is common complaint (dysfunction of vestibular system / cervical proprioceptive system / brain stem / cervical sympathetic nerves).
   - paresthesias of upper extremities.
   - cognitive impairment is controversial topic (attention deficits present in 18% patients 2 years after injury).
   - intercostal pain (20%), low back pain (35%).

- rare sequelae - cervical dystonia or torticollis.

Diagnosis - cervical spine MRI (if abnormalities are present, possibility that they are pre-existent should be considered*). Diagnoses - psychological problems, malingerers.

TREATMENT

Instruct patient that complete resolution of symptoms may require 6-12 weeks!
1) ice → heat
2) NSAIDS, muscle relaxants.
3) try to avoid soft cervical collars (esp. after first 2-3 weeks) → gentle stretching & early mobilization, range-of-motion exercises, physical therapy, trigger point injections, TENS
4) if pain persists > 12 weeks, patient has cervical disc degenerative disease.

THORACOLUMBAR SPINE

CLASSIFICATION

Classification system should:
1) enhance communication among clinicians with varying degrees of experience
2) reliably guide treatment
3) predict the outcome of various treatment options

Historical Denis classification (3-column concept) provided level III evidence and became a popular scheme in North America. However, the system does not clearly identify injuries, which may or may not require operative intervention:
- clinicians thought that if ≥ 2 columns were involved then the patient needed surgical intervention. However, McAfee quickly determined, there were burst fractures which were stable and could be treated nonoperatively.

CNS Evidence-Based Guidelines for Thoracolumbar Spine Trauma (2019)

Insufficient evidence to recommend a universal classification system or severity score that will readily guide treatment of all injury types and thereby affect outcomes.

Grade B Recommendation - a classification that uses readily available clinical data (e.g. CT with or without MRI) should be used to improve characterization of injuries and communication among treating physicians:
1. Thoracolumbar Injury Classification and Severity Scale (TLICS) - cannot yet be adopted to predict management in all populations (there is still wide variation in treatment recommendations) >>
2. AO Spine-Thoracolumbar Spine Injury Classification System >>

Thoracolumbar injury classification & severity score (TLICS) – 3 components:

- T: Thoracic
- L: Lumbar
- C: Column
- S: Stability
- I: Injury
- C: Classification

TLICS
-1: Normal
-2: Minor
-3: Major
-4: Severe
-5: Catastrophic
Injuries with ≤ 3 points = non operative
Injuries with 4 points = nonop vs op
Injuries with ≥ 5 points = surgery

Fundamental issues of TLIC:

1) evaluation of the PLC requires MRI which may not be available in all centers around the globe and may be quite subjective
2) operative management is likely to vary based on the country, resources, and perceived clinical condition of the patient.

AO Spine Thoracolumbar Spine Injury Classification System (AO- Arbeitsgemeinschaft fur Osteosynthesefragen, 1994)

- it is derivative of Magerl’s Comprehensive Classification: type A-axial compression, type B-distraction of anterior and/or posterior elements, and type C-axial torque leading to anterior and posterior element disruption with rotation
  - many observers believe that identification beyond the three basic types (A, B, or C) is confusing, and the AO system does not specifically include the degree of neurological injury.
  - inclusive of all injury patterns observed at the thoracolumbar junction, it did not help guide treatment.

Type A injuries - compression injuries with injury of the anterior elements and preservation of the posterior ligamentous complex: A0 fractures represent transverse or spinous process fractures; A1 are wedge compression fractures of 1 endplate without involvement of the posterior wall of the vertebral body; A2 are split or pincer fractures with involvement of both endplates; A3 are incomplete burst fractures which involve the posterior wall of the vertebral body but only 1 endplate; and A4 fractures are complete bursts, which involve both endplates and the posterior wall.

Type B injuries - failure of the posterior or anterior tension band in distraction: B1 injuries are transverse monosegmental failure of the posterior tension band; B2 are bony and/or ligamentous failure of the posterior tension band in conjunction with an A fracture of the vertebral body; B3 injuries are hyperextension injuries through the disc space or bone as commonly seen in ankylosing spondylitis. There is some confusion because the first iteration of Magerl’s Comprehensive Classification did these injuries under type C. However, for the purposes of this guideline, the authors will include them as type B as this is the classification which has been investigated for internal and external reliability.

Type C injuries suffer disruption of all elements with displacement or dislocation of the cranial spinal elements relative to the caudal elements. There are no subtypes any longer for this injury pattern. In addition to the morphological classification, there is also a neurological grading component (N0 = intact, N1 = transient symptoms, N2 = radiculopathy; N3 = incomplete or cauda injury, and N4 = complete) and case-specific modifiers.

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<th>Types</th>
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  - many observers believe that identification beyond the three basic types (A, B, or C) is confusing, and the AO system does not specifically include the degree of neurological injury.
  - inclusive of all injury patterns observed at the thoracolumbar junction, it did not help guide treatment.

Type A injuries - compression injuries with injury of the anterior elements and preservation of the posterior ligamentous complex: A0 fractures represent transverse or spinous process fractures; A1 are wedge compression fractures of 1 endplate without involvement of the posterior wall of the vertebral body; A2 are split or pincer fractures with involvement of both endplates; A3 are incomplete burst fractures which involve the posterior wall of the vertebral body but only 1 endplate; and A4 fractures are complete bursts, which involve both endplates and the posterior wall.

Type B injuries - failure of the posterior or anterior tension band in distraction: B1 injuries are transverse monosegmental failure of the posterior tension band; B2 are bony and/or ligamentous failure of the posterior tension band in conjunction with an A fracture of the vertebral body; B3 injuries are hyperextension injuries through the disc space or bone as commonly seen in ankylosing spondylitis. There is some confusion because the first iteration of Magerl’s Comprehensive Classification did these injuries under type C. However, for the purposes of this guideline, the authors will include them as type B as this is the classification which has been investigated for internal and external reliability.

Type C injuries suffer disruption of all elements with displacement or dislocation of the cranial spinal elements relative to the caudal elements. There are no subtypes any longer for this injury pattern. In addition to the morphological classification, there is also a neurological grading component (N0 = intact, N1 = transient symptoms, N2 = radiculopathy; N3 = incomplete or cauda injury, and N4 = complete) and case-specific modifiers.
**VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)**

**Compression (Wedge) Fracture**

**Etiopathophysiology**
- Results from compression-anterior flexion mechanism (middle column remains intact and acts as hinge) → **Anterior Wedge Fractures** (most common type of thoracolumbar fractures!)
- N.B. traumatic compression fracture in young patient - suspect possible flexion-distraction (Chance) fracture!
- Often as **Pathologic Fractures** (esp. elderly white women).

**Clinical Features**

**Radiology**

- **Anterior column failure** (stable) - wedging of anterior component of vertebral bodies (loss of anterior vertebral body height is < 50%), soft tissue swelling, anterior superior cortical impaction, buckling of anterior cortex of vertebral body, trabecular compaction, endplate fractures, disk-space narrowing.

- **Anterior column failure & posterior column ligamentous failure** (possibility of being unstable) - anterior wedging (loss of vertebral body height > 50%*) + increased interspinous distance.

- Failure of all 3 columns (unstable!!!) - anterior wedging + varying degrees of posterior vertebral body disruption.

* > 50% loss of vertebral body height in wedge fracture → **CT** to rule out middle column and burst fractures (up to 25% fractures diagnosed initially as wedge fractures are actually burst fractures)

- **Denis classification system:**
  1. Type A - involvement of both endplates
  2. Type B - involvement of superior endplate
  3. Type D - buckling of anterior cortex with both endplates intact.

- Compression fractures can be devastating for 2 reasons:
  1. Bony pain (from fracture itself) sometimes does not resolve.
  2. Fracture can alter mechanics of posture → increased kyphosis (sometimes to point that patient cannot stand upright → hip flexor contractures [due to iliopsoas shortening], secondary pain in hips, sacroiliac joints, spinal joints).

**Treatment**

Best **Managed in Hospital**:

1. Patients have marked discomfort, often requiring parenteral narcotics.
2. Associated intraabdominal injuries should be considered.
3. Often associated with prolonged ileus (secondary to hemorrhage of sympathetic ganglia), requiring continuous nasogastric suction.

- For malignant causes – emergent radiotherapy, steroids.
- For infectious causes – antibiotics.

Analgesia (avoid NSAIDs) and muscle relaxants

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**CNS Evidence-Based Guidelines for Thoracolumbar Spine Trauma (2019)**

Grade B Recommendation: MRI has been shown to influence the management of up to 24% of patients - providers may use MRI to assess posterior ligamentous complex integrity, when determining the need for surgery.

Insufficient evidence that radiographic findings can be used as predictors of clinical outcomes.

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**Radiological Evaluation**

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**Anterior wedging > 50% or multiple contiguous anterior wedge compression fractures = CHRONIC INSTABILITY** (progressive angulation may occur with time!!!).

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VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

If pain is not improving with bracing over 2-12 weeks ➔ kyphoplasty or vertebroplasty

Bracing (for 8-12 weeks) to prevent progressive angulation:
- custom made TLSO (body cast)
- “off-the-shelf” adjustable TLSO
- no bracing
- extension brace is best – prevents kyphosing.
- young people heal very well but many refuse brace (H: percutaneous stabilization).
- bracing is more prone to fail in obese patients.
- bracing is more prone to fail at high stress areas (e.g. thoracolumbar junction) – follow up with new X-ray in 2 weeks (the older is fracture, the more difficult is to reduce it once kyphosis happened)
- bracing is more prone to fail in obese patients.
- bedrest is not benign - bone density declines approximately 2% per week, muscle strength declines 1–3% per day or 10-15% per week

Early rehabilitation - become ambulatory as soon as comfortable (increased incidence of thromboembolic events)
- restrictions for 8 weeks: forward bending, hip flexion < 90°, lifting/carrying ≤ 5 kg.
- first 4 weeks simply walking ➔ isometric spine stabilization exercises for 4 weeks ➔ isotonic exercises.

Radiographic monitoring (some fractures can worsen over ensuing months - might require surgical stabilization)
  - Serial radiographs for 1 year - progressive kyphosis can occur

INDICATIONS FOR SURGICAL STABILIZATION:
- inability to wear external brace or external brace failure
- kyphosis > 30° - indicates instability
- major anterior column comminution with height loss > 50% - indicates instability
- significant posterior element disruption - indicates instability
- neurological deficits - add decompression to fusion

PERCUTANEOUS VERTEBRAL AUGMENTATION (PVA)

INDICATION:
- symptomatic osteoporotic and neoplastic fractures (also see p. Onc56 >>
  *RTTs of PVA showed statistically significant improvement in pain and function, particularly ambulation

Fracture age requirement – look for STIR signal (vertebral body edema) on MRI* (absence of STIR signal means fracture has healed, thus, fracture age limit is probably near 6 months).
  *if MRI is contraindicated, may do nuclear study to show ongoing metabolism

CONTRAINDICATIONS
1) split fracture
2) complete burst fracture with posterior wall compromise – now it is only a relative contraindication – modern devices* able to contain cement
3) pedicle fracture
4) high-energy trauma
5) asymptomatic
6) spinal cord compression or canal compromise requiring decompression

*KIVA – PEEK coil with holes on the inside – contains cement:
Vertebral Column Injury (Specific Injuries)

Details, Types:

- mostly outpatient procedure.
- under MAC or general anesthesia.
- cement – viscous (different degrees of viscosity) polymethylmethacrylate
- fluoroscopy guidance.
- percutaneous trocar or large needle is introduced into fractured body through pedicle, and cement is injected.

Vertebroplasty – high-pressure injection of cement polymer into fractured vertebral body → better vertebral body resistance to upright loads → decreased pain.

- complications:
  1) cement spread to neural structures
  2) adjacent-level vertebral body fractures (risk increased > 4 times).

Kyphoplasty - similar to vertebroplasty, except balloon is used to expand volume of fractured segment → cement polymer is delivered under low-pressure* into closed balloon (less likely extrusion of cement into spinal canal!).

- complications:
  1) canal compromise contraindicates kyphoplasty (and sometimes vertebroplasty).
  2) ideal for cancer pain (pathologic fractures due to metastases!! – indicator – STIR signal on MRI.

SpineJack (Stryker) - mechanical kyphoplasty with height restoration; FDA approved for osteoporotic (non-oncologic) compression fractures

EVLove Trial

- first large prospective on-label as-treated clinical trial designed to include patients commonly seen in clinical practice.
- 354 patients with 1 to 3 painful vertebral compression fractures (VCFs) from T5 to L5 due to osteoporosis or cancer.
- study demonstrates that kyphoplasty is a safe, effective, and durable procedure for treating patients with painful VCF due to osteoporosis or cancer.

Percutaneous vertebroplasty (PVP) and kyphoplasty (PKP) have widely gained acceptance as a line of treatment in symptomatic osteoporotic vertebral fractures and osteolytic primary or secondary lesions in the spinal column.
The introduction of vertebroplasty by Galibert et al. in 1984 and kyphoplasty by Garfin et al. in 1997 of vertebroplasty and this technique is fast, safe and minimally invasive. Vertebroplasty consists of injecting polymermethylethacrylate (PMMA) into the vertebral body through a transpedicular or extrapedicular approach. The technique is used for the treatment of acute or chronic pain associated with vertebral compression fractures. Kyphoplasty is a similar procedure that involves the injection of PMMA into the vertebral body to restore vertebral height and stability. However, kyphoplasty is generally reserved for cases where vertebroplasty is inadequate or contraindicated.

In general, kyphoplasty is considered a safe and effective treatment for vertebral compression fractures. Various studies have reported high satisfaction rates among patients undergoing kyphoplasty, with reductions in pain and improved quality of life. However, like vertebroplasty, kyphoplasty also has potential complications, such as cement leakage or extravasation, which can lead to neurological complications or mechanical failure.

The use of PMMA as the principal component in vertebroplasty and kyphoplasty has been widely adopted due to its excellent radiopacity, mechanical properties, and ability to bond to bone. However, PMMA has some limitations, such as the need for additional antibiotics to mitigate the risk of infection and the potential for delayed cement polymerization.

An alternative to PMMA is hydroxyapatite cement, which is a biocompatible and osteoconductive material. It is derived from natural bone and has a porous structure that promotes bone growth and integration. Hydroxyapatite cement has been shown to be effective in the treatment of vertebral compression fractures, with reductions in pain and improved vertebral height.

Other options for vertebral augmentation include polymethylmethacrylate (PMMA), a synthetic cement that is commonly used in orthopedic surgery. PMMA is easy to use, has high mechanical strength, and is radiopaque, making it ideal for fluoroscopic guidance. However, PMMA has some limitations, such as the need for additional antibiotics to mitigate the risk of infection and the potential for delayed cement polymerization.

There are several approaches to vertebroplasty and kyphoplasty, including percutaneous, transpedicular, and extrapedicular approaches. The choice of approach depends on the individual patient’s characteristics, the location of the fracture, and the presence of other pathologies.

Vertebroplasty and kyphoplasty are generally well-tolerated by patients, with a high level of satisfaction and improvement in pain scores. However, some patients may experience transient complications, such as cement leakage or extravasation, which can lead to neurological complications or mechanical failure.

In conclusion, vertebroplasty and kyphoplasty are effective and safe treatment options for vertebroplasty and kyphoplasty, they are associated with excellent outcomes, and are widely used in clinical practice. However, further research is needed to determine the optimal treatment parameters and to evaluate the long-term efficacy of these procedures.
Burr et al. reported in their series of 38 consecutive patients with 70 osteoporotic vertebral fractures treated with PVP initial pain relief of 95%. After 18 mo, pain relief was 94%. However, this group also treated eight patients with 13 vertebrae with neoplasms with the primary goal of spinal stabilization and not pain relief. Substantial pain reduction was reached only in 50% and mechanical stability in 88%.

PKP has been found superior to conservative management and at least equal to PVP regarding pain reduction in a meta-analysis by Taylor et al. Pain reduction by PKP also is superior in younger vertebral fractures than in older vertebral fractures.

Cement in Osteolytic Lesions

The primary aim of cement augmentation in primary and secondary osteolytic vertebral lesions is palliative pain relief, and various studies have reported a consistent and sustained reduction of preprocedural pain independent of the type of underlying malignancy. Controversially discussed issues when comparing PVP and PKP use in osteolytic lesions are the optimal filling volume of cement, safety regarding extravasation, and pain reduction. For fear of intraspinal cement escape, some authors consider a posterior wall defect to be a contraindication for cement application; however, others claim good results when done carefully. Other authors have combined radiofrequency ablation with vertebroplasty and report similar pain relief and complication rates when compared to PVP or PKP. The concept relies on tumor dissolution rather than displacement, theoretically reducing the incidence of cement extravasation. Gia et al. reported good pain relief in 94% of their 31 patients with metastatic spinal tumors and malignant vertebral compression fractures treated with interventional tumor removal followed by percutaneous vertebroplasty. They reported a good to excellent analgesic effect in 92% at 6 mo and that the occurrence of complications was not related to the nature of the lesion. Nevertheless, a filling failure occurred in five vertebrae, all being osteoblastic.

A new interesting approach is the incorporation of 13.7% holmium and 8.9% samarium phosphates by weight with calcium phosphate bioceramics, thus marking the advent of radiovertebroplasty. After neutron activation, the Ho-166 and Sm-153 bioactive powder emitted 14.5 and 32.5 MBq/mg, respectively. However, its in vivo applicability and efficiency have yet to be proven.

BURST FRACTURE OF VERTEBRAL BODY

- vertebral body and plate(s) fracture → nucleus pulposus is forced into vertebral body → body is shattered outward from within (burst fractures)
- failure of the anterior and middle columns by axial loading → circumferential expansion of entire involved vertebra.
- fracture of the posterior vertebral body wall leads to retropulsion.
- retroplused bone splinters and disc material may impinge on ventral surface of spinal cord (with dural laceration) → anterior cord syndrome → immediate decompressive surgery (via anterior approach)!
- attempted weight bearing without surgical fixation → severe neurologic injury can be expected.

MCACF classified burst fractures:

stable burst fractures - posterior column is intact.
unstable burst fractures - posterior column has sustained significant insult (dural tears are frequent - portions of cauda equina can herniate through dural defect - if not repaired → scarring and chronic pain).

RADILOGIC

LATERAL view - comminuted vertebral body, loss of vertebral height (> 50%), retropulsion of bone fragments (canal narrowing > 30%), kyphotic angulation (> 20%).
AP view - characteristic vertical fracture of vertebral body (-helps differentiate from simple wedge fracture and flexion tear drop fracture); widened interpedicular distance (indicates instability).
Always perform CT / MRI to document amount of bone retropulsion.

Burst fracture of T12 - anterior deformation, comminution, retropulsion of bone fragments into spinal canal.
**TREATMENT**

- TL burst fractures in neurologically intact patients are considered to be inherently stable, and responsive to nonsurgical management.
- Burst fractures with significant vertebral collapse, angulation, canal compromise, or associated neurologic deficit are considered to be unstable and necessitate surgical intervention.

**Stable / neurologically intact:** see also conservative treatment under compression fractures

A. Bed rest on firm mattress (6-12 weeks) – in third world countries

B. TLSO brace (custom made molded polypropylene body jacket or “off-the-shelf” adjustable brace)
   - Required to be worn at all times except while lying on back.
   - Because years ago, burst fractures were traditionally operated on, many clinicians no longer offer anterior to the majority of their patients.
   - In 5 years, patients who received surgery either (either posterior or anterior approach), had higher complication rates but there was little difference in outcomes.
   - In 15 years later, there was no statistical difference in kyphosis or pain scores but 30% operated patients showed significant segmental degeneration immediately caudal to their fusion, plus, disability (Osseous Disability Index, Roland and Morris Disability Questionnaire) showed statistically significant advantage for nonoperative group (more patients in nonoperative group were working while 4 times as many operated patients were using narcotics).

- **Grade B Recommendation** for follow-up care
  - Bracing may use for fragment tamping back into place, may do discectomy above the fracture to create the room and clinical [with or without an external brace produces no bracing] and short term stabilization is provided by interbody arthrodesis using bone graft.

C. No bracing
   - Brace is worn for 8-12 weeks when out of bed. External bracing may provide needed patient assurance to promote early mobilization and participation in physical therapy.
   - Patients treated without brace are encouraged to return to normal activities at 8 weeks.
   - Pain continues to improve for first 6 months.

CNS Evidence-Based Guidelines for Thoracolumbar Spine Trauma (2019)

**Grade B Recommendation** - external bracing in the nonoperative treatment of neurologically intact patients with TL burst fractures

- **Level 1-2 evidence** (Bailey et al. at 2014, Shami et al. 2014 - studies did not include burst fractures of the upper and midthoracic and lower lumbar spine) - nonoperative management with or without an external brace produces equivalent improvement in outcomes (radiological and clinical [pain and disability]) - decision to use an external brace is at the discretion of the treating physician.
- Bracing is not associated with increased adverse events compared to no bracing.
- No brace leads to shorter duration of stay.

Unstable, canal implantation: see indications for surgery under compression fractures

- **surgery via anterior** or **posterior approach**
- **STABILIZATION** with restoration of normal vertebral body height (long-term stabilization is provided by interbody arthrodesis using bone graft).
- **posterior approach** (laminectionomy) increases instability and is ineffective to relieve anterior impairment
- **DECOMPRESSION** is not always needed; should not be attempted until adequate **STABILIZATION** (halo-vest) or **posterior stabilization** has been performed

DECOMPRESSION:

- full laminectomy
- if at the cord level, remove pedicle, drill the cavity behind the fragment, and push the retroplased fragment back into cavity – ligamentectomy
- for fragment tampling back into place, may do discectomy above the fracture to create the room for it.
- may use US to check if ventral decompression is complete.

STABILIZATION:

a) traditional open approach → fusion with pedicle screws
b) percutaneous approach → stabilization with pedicle screws (it is not fusion!!!), hardware needs to come out later

N.B. do not use polyaxial screws for trauma (one of AO principles?)

N.B. include at least 2 levels above and 2 levels below fracture; short segment fusions (1 above, 1 below) are rarely acceptable!
Burst fractures in neurologically intact patient

Conflicting evidence to recommend for or against the use of surgical intervention to improve clinical outcomes - discretion of the treating provider.

- main emphasis – integrity of posterior ligamentous complex (PLC)

Nonburst fractures

- Insufficient evidence to recommend for or against the use of surgical intervention - discretion of the treating physician.

DISTRACTIVE FLEXION FRACTURE, S. CHANCE ("SEAT BELT") FRACTURE

- Failure of single and posterior column (injury to ligamentous components, bony components, or both) with varrying degrees of anterior column collapse.

- George Quentin Chance, a Manchester-based British physician, an eminent radiologist of his time who described the eponymous fracture in 1948.

- Often due to lap belts in motor vehicle accidents - individual is subjected to sudden deceleration and torso is flexed forward over restraining belt.

- Only about 15% of Chance fractures lead to neurological deficits

- Up to 50% of patients with Chance fractures will have associated intra-abdominal injuries.

SUBTYPES (dependent on axis of flexion):

CLASSIC CHANCE SUBTYPE (although 2 columns disrupted, but classically stable!!) - axis of flexion anterior to anterior longitudinal ligament:

1) horizontal fracture through posterior and middle column bony elements (spinous process, pedicles, transverse processes)

2) disruption of supraspinous ligament (increase in interspinous distance)


*all 3 columns are involved

- Diagnosis of posterior element failure requires CT.

- If pars interarticularis is disrupted (in either type of fracture), then instability is increased → significant subluxation → neurologic sequelae.

18 year-old female with lap belt caused fracture dislocation at L4-L5 with spinal cord transection.
LATERAL FLEXION FRACTURE

Lateral flexion injury at L1-2 junction - acute scoliosis in frontal view; compression of anterior elements with posterior displacement of middle element in lateral view; fracture of lateral part of vertebral body and pedicle in CT.

“SLICE” FRACTURE-DISLOCATION, S. TORSIONAL/ROTATIONAL INJURY, HOLDSWORTH SLICE FRACTURE

( unstable)
- occurs in (thoraco)lumbar region (articular processes are large, curved, and nearly vertical – unilateral facet dislocation cannot occur) - one or both articular processes fracture → upper vertebra swings anteriorly on lower:

- An unstable fracture dislocation of the thoraco-lumbar junction of the spine.
- The injury comprises a fracture through a vertebral body, rupture of the posterior spinal ligaments and fractures of the facet joints.
Sir Frank Wild Holdsworth (1904-1969), a renowned British orthopedic surgeon who laid a solid foundation for rehabilitation of spinal injuries under the aegis of the Miners’ Welfare Commission, described in detail the management of thoraco-lumbar junctional rotational fracture.

**Facet Fracture-Dislocation**
- direct blow → displacing vertebra off adjacent one with fracture and dislocation of articular processes and rupture of ligaments & disk.
- frequent severe injury to neural elements.
- imaging represents recoiled position of some greater displacement at time of injury.

Treatment - reduction and fusion
N.B. percutaneous internal stabilization is contraindicated as ligamentous complex and disc are disrupted!
- open reduction of locked facets – bilateral Smith-Peterson osteotomies to remove medial facets (reduction happens spontaneously) → posterolateral fusion.
- may place ropivacaine infusion pump for postop pain management.

FRACTURE OF PARS INTERARTICULARIS (SPONDYLOLYSIS)
- see p. Spin17 >>

**Fracture of Transverse Process**
(stable)
- associated with severe injury to paravertebral muscles (e.g. psoas with retroperitoneal hemorrhage)
- correlation exists between L1 transverse process fracture and same-side renal injury.

**Pathologic Fractures**
- caused by trivial injury predisposed by disorders with considerable loss of bone substance:
  1. osteoporosis (vertebral fracture increases risk of death 9 times!)
  2. chronic steroid use
  3. vertebral malignancies (metastases, multiple myeloma)
  4. vertebral osteomyelitis (incl. tuberculous).
  5. hyperparathyroidism
  6. prolonged immobilization
- most often - thoraco-lumbar compression (wedge) fractures. see above >>
  - N.B. compression fracture → seek for treatable risk factors!
- most common fractures of thoracolumbar spine! (most frequently T12-L1 level).
- stable in thoracic spine - thoracic cage provides support.
- compression fractures above mid-thoracic region are suggestive of malignancy.

CLINICAL FEATURES
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)  

- many remain undiagnosed - present with progressive painless kyphosis or scoliosis.
- others present with back pain* and tenderness.
- may result in compression of cord or cauda equina.

*axial, nonradiating, aching, stabbing, may be disabling

N.B. presence of kyphosis (esp. > 15°) decreases risk of SCI!

DIAGNOSIS

- occult compression fractures may be detected with Tc⁹⁹m-hydroxyethylidiphosphonate bone scans.

Benign compression fractures - plate-like increased T2 signal beneath fracture, with sparing of remaining vertebral body and pedicles.

Metastatic disease - frequently globular, involving more than half of vertebral marrow and often extending into pedicles.

AP and lateral views of L₁ osteoporotic wedge compression fracture:

TREATMENT

- as COMPRESSION FRACTURE see above >>

- kyphoplasty is ideal for pain due to pathologic fractures due to metastases!!!

BIBLIOGRAPHY for ch. “Spinal Trauma” → follow this LINK >>