Ventral Column Injury (SPECIFIC INJURIES)

FRACTURES ACCORDING TO MECHANISM

1. Mechanical Stability

2. Cervical Spine (C1-2)

3. Occipital Convoluted Fractures

4. Atlantoaxial Disassociation

5. Atlas Fractures

6. Posterior neural arch fracture (C1)

7. C2 burst fracture (Jefferson fracture)

8. Lateral mass fracture (C1)...

9. Rotatory atlantoaxial dislocation (S. atlanto-axial rotatory fixation)

10. Grisel’s syndrome

11. Ospocénd (Dens) fractures

12. Type 1

13. Type 2

14. Type 2 with transverse ligament disruption

15. Type 3

16. Type 3A

17. On odontoid process

18. Hangman’s fracture (S. traumatic spondylolysis of C2)

19. Fractures of Axis Body

20. Comminuted C1-C2 fractures

21. Cervical Spine (subaxial)

22. Biomechanics

23. Classifications

24. Treatment Principles

25. Compression (wedge) fracture

26. Burst fracture of vertebral body

27. Teardrop fracture

28. Distraction-extension injury

29. Anterior Subluxation

30. Facet subluxation / perch / dislocation

31. Radiology

32. Treatment

33. Facet fracture

34. Laminar fracture

35. Fracture of transverse process

36. Clay shoveler’s fracture

37. Whiplash injury (S. cervical spinal hyperextension injury)

38. Thoracolumbar Spine

39. Compression (wedge) fracture

40. Burst fracture of vertebral body

41. Distraction flexion fracture, S. Chance (“seat belt”) fracture

42. Lateral flexion fracture

43. “Slight” fracture-dislocation, S. torsional injury

44. Facet fracture-dislocation

45. Fracture of pars interarticularis arcus (Spondylolysis)

46. Fracture of transverse process

47. Pathologic Fractures

48. VCT – ventral column trauma.

49. SCI – spinal cord injury.

50. 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.

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. Atlantoaxial 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. “Slicé” fracture-dislocation, s. torsional injury

3. Rotary atlantoaxial dislocation

• failure of posterior and anterior columns with varying degrees of anterior column insult – due to combination of:

1) rotation (→ disruption of posterior ligaments and articular facet)

2) lateral flexion

• a posterior-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 spondylolysis of C2)

3. Extension teardrop fracture

4. Distractive extension injury

5. Posterior atlantoaxial dislocation + odontoid fracture

6. Whiplash injury (s. cervical spinal hyperextension injury)

• most common in neck

• most are stable as long as vertebral column is flexed.
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

TrS9 (2)

- ligamentum flavum buckles into spinal cord → central cord syndrome.
- prevertebral (retropharyngeal) swelling may be the only sign (hypertension injuries may reduce spontaneously or when spine is placed in neutral position by paramedical personnel).

**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
    - if 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. Bilateral facet dislocation
12. Simple wedge compression fracture without posterior disruption
13. Bilateral facet dislocation
14. Fracture of posterior arch of C1
15. Unilateral facet dislocation

**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.

- **Occipital condylar fractures**
  - See p. TrH5 >>

- **Atlantooccipital disassociation**
  - (unstable)
  - 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)

- 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
  - atlanto-occipital condyle distance should be < 5 mm regardless of age!

Upper neck radiographs 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;
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

this relationship does not change in flexion and extension
if this line runs behind odontoid, posterior subluxation has occurred and vice versa;

D. Powers ratio > 1 (anterior subluxation)

Powers ratio = 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.
ATLASE 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 sequela

Spinal Canal - Steele’s rule: 1/3 cord, 1/3 dens, 1/3 empty

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)
- 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.
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

- **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** or 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 diagnosis.

Diagnosis of **TRANSVERSE ATLANTAL LIGAMENT RUPTURE** – 3 criteria:

1) **MRI** – most sensitive test (more sensitive than rule of Spence)
2) **Spence’s rule:** ≥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) > 3 mm in adults (> 2.5 mm in females), >4-5 mm in children.

N.B. if > 12 mm - rupture of all ligaments about dens. Some experts say > 5 mm in adults.

**Fracture through posterior arch:**

**Odontoid process**

**Lateral mass (laterally displaced):**

**Odontoid process**

**Articular pillar**

**Articular pillar**

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) fusion (fixation between occiput and laminae of axis; outer table of occiput is removed and bony struts are affixed to remaining occipital bone and decorticated C2 laminae; bony struts are supported by wires or metallic plates) → halo.

**LATERAL MASS FRACTURE (C1)**

A. Normal lateral cervical spine.

B. Axial CT - slightly displaced lateral mass fracture:

   - specific type of unilateral facet dislocation at C1-C2 level (rotational injury usually without flexion).

**TREATMENT**

Comminuted fracture – collar, halo
Transverse process fractures – collar

**ROTARY ATLANTOAXIAL DISLOCATION (S. ATLANTO-AXIAL ROTATORY FIXATION)**

(unsable - because of location - despite fact that facets may be locked)
- specific type of unilateral facet dislocation at C1-C2 level (rotational injury usually without flexion).

**ETIOLOGY**

1) trauma
2) Grisel 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).

N.B. considerable care during interpretation of odontoid views - if skull is shown obliquely (asymmetrical basilar skull structures, esp. jugular foramina), there is false-positive asymmetry between odontoid process and lateral masses of C1. H: 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)
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

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 (C1-2) arthrodesis.

GRISEL's syndrome
- unilateral or bilateral subluxation of atlanto-axial 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 periodontoi 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 recurs - traction brace; residual subluxation after 8 weeks of treatment or neurological symptoms may require operative treatment (posterior atlantoaxial arthrodesis).

ODONTOID (DENS) FRACTURES

- Type I - oblique fractures through upper portion of dens.
- Type II - fractures across dens base near junction with axis body.
- Type IIA (Hadley, 1988) - comminuted dens base fracture with free fracture fragments
- Type III - dens fractures that extend into axis body.

Treatment

Type I
- No AOD
- Collar
- Surgery

Type II
- AOD
- Odontoid Fractures
- Type I
- Type II
- Type III
- ???
- MRI
- TL intact
- TL disrupted
- Ante and poste fusion

Type III
- MIR
- Posterior Fusion
- TL intact
- TL disrupted
- Fells
- Simple fix
- Ante post fus

ADD – atlanto-occipital dislocation
TL – transverse ligament

- 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.

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
3. Dense comminution (type 2A fracture)
4. Transverse ligament disruption
5. Atlanto-occipital dislocation

*Denotes > 5° angulation between supine and upright films

TYPE 1

(stable) - fracture across tip of dens.
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES) TrS9

- treated with cervical collar (successful in 100% cases).
- may be associated with life-threatening atlanto-occipital dislocation (H. fusion).

- 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**
- 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) and ischemic necrosis of odontoid; risk groups - elderly patient*, delay of treatment, failed reduction or secondary loss of reduction; H: operative fixation:
  - *N.B. consider surgical fusion for type II odontoid fractures in patients > 50 yrs! (age > 50 yrs increases nonunion risk 21-22 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)
  - a) **C1-2 FUSION via posterior approach** - using transarticular screws, iliac grafts or methylmethacrylate (between decorticated spinous processes) + wiring between C1 lamina and C2 spinous process (or fixation with Halifax clamps):
    - posterior fusion has 87% success rate
  - b) **ODONTOID SCREW via anterolateral approach** (preserves rotation motion! - wire pin inserted under fluoroscopy is replaced by lag screws (1 or 2 screws have same success); 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)

- contraindicated if transverse ligament is disrupted.
- look at apical ligament before surgery (if calcified*, aseptic necrosis will happen and odontoid screw will not work).
- *distal dens blood supply is coming through apical ligament.
- difficult if patient has prominent chest (hard to achieve angle).

**TYPE 2 WITH TRANSVERSE LIGAMENT DISRUPTION**
(unstable because of transverse ligament disruption)
- a) transverse or atlas 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**
1. **Predental (ADI) space** ↑ see above >>
2. disrupted posterior cervical line
3. retropharyngeal swelling.

**T2-MRI** - traumatic type E38 transverse ligament injury (arrow).
Flexion and extension dynamic CT - craniocervical junction instability (atlanto-dens interval > 3 mm) caused by traumatic type E8 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) halo vest (fails in 1-16% cases)
  b) collar (fails in 35-50% cases).

**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) vertebrobasilar 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 – osicle that moves with anterior arch of C1.
Dystopic – osicle 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!

HANGMAN’S fracture (S. TRAUMATIC SPONDYLOLYSIS of C2)
(unsuitable – 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) → cervicotranium (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.

Potential dislocation:

Hangman’s

Coccyx x 200

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:

Type I (stable): isolated hairline fracture of axis ring with minimal displacement of C2 body associated with axial loading and hyperextension.

Type II (unstable): fractures of axis ring with displacement of anterior fragment with disruption of disk space below axis associated with hyperextension and rebound flexion.

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.

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-C3 angulation < 11°
- Grade II: fractures with displacement > 3.5 mm and angulation > 11° but less than half of C3 vertebral width and angulation < 11°
- Grade III: fractures with displacement > 3.5 mm but less than half of C3 vertebral width with angulation > 11°
- Grade IV: fractures with complete C2-C3 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 anatomy; 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) C3-5 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:

a) severe angulation (Francis grade II and IV, Effendi type I)
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.

FRACURES OF AXIS BODY

Comminuted fracture – evaluate for vertebral artery injury.

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)
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

SLIC (SUBAXIAL INJURY CLASSIFICATION)

by Vaccaro and Colleagues


MORPHOLOGY

No abnormality 0
Compression 1
Extraction (facet perch; hypertension) 2
Rotation/translation (facet dislocation, unstable tearout or advanced stage flexion compression injury) 3

DISRUPTION/ELEMENTS COMPLEX (DLEC)

Intact 0
Rotator (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 = 1

CT evidence of facet joint disruption:
articulare apposition < 50% diastasis > 2 mm through facet joint

1-3 → non-surgical management
≥ 5 → surgical fixation.
4 → either non-operative or operative approach.

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:
  - intertid 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%
  - advantages:
    - anterior approach - safe and straightforward patient positioning (no need to turn patient prone with potential of unstable injury), dissection along defined tissue planes with little if any iatrogenic muscle injury.
    - posterior approach - superior biomechanics, straightforward reduction of facet dislocations.
- 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.

RADILOGIC

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);
  - Flexion compression fracture of C5 fixed by corpectomy and fusion maintained with Caspar plate:
  - c) injury to posterior ligaments can be fixed with **Halifax clamps** and fusion:

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**BURST FRACTURE OF VERTEBRAL BODY**

**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
- In order of evaluation:
  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):
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.

 B1. Facet subluxation
 B2. Facet perch
 B3. Facet dislocation or Locked Facet

bilateral (always unstable)
- extreme form of anterior subluxation: flexion (± axial distraction) causes soft tissue disruption to continue anteriorly to involve annulus fibrosis 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!!!

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 (< ¼ of AP diameter of vertebral body; vs. bilateral facet dislocation).
  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.
**Vertebral Column Injury (Specific Injuries)**

**Perched Facet**

- **Perched Facet**: 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 examinable patient – therefore is best with skeletal traction.
- Reduction under anesthesia is less safe (at least use monitoring).

**Closed Reduction with Skeletal Traction**

- Prior to attempted reduction ensure that diagnosis is correct.
- Pure cervical 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/ 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 disc retropulses during cervical traction1 (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 discectomy first! (otherwise, increased neurological deficits can result during manipulations).

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

**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 dislocation in recumbent position or attached to body jacket lined with sheepskin (patient may be ambulatory in halo cast or vest); see p. TrS5

c) sterilized FISH HOOKS applied to posterior zygomas – for patients with severe skull injuries.

**Traction Force**

**Surgical open reduction options**

- First try to reduce manually
- 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:
  - **Rule of thumb**: 5 pounds (2.25 kg) for each cervical level is required for reduction
  - **(e.g. to reduce C6 dislocation – that with 25 pounds; if insufficient, additional weight increments are applied every 20-30 minutes until reduction is attained).**
  - weight is increased by 5-pound increments.
  - in routine clinical practice especially for injuries such as bilateral facet dislocations weights in excess of 50 pounds may be necessary to achieve reduction.
  - maximal weight that can be safely applied to Gardner-Wells tongs is 80-90 pounds (36-40 kg) or 2/3 of body weight.

- **head of bed elevated enough to counter weight of traction.**

**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 (redistraction is prevented with moderate cervical extension)

**OPEN REDUCTION**

First try to reduce manually after patient is under general anesthesia and complete paralysis (remove C-collar and apply Holter 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:**

- **ACDF** to reduce dislocation and open foramens (going from posterior cannot place pedicle screw because of fracture; would need screws level above and level below)
- **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).

**TREATMENT**

- if not 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.

**LAMINA FRACTURE**

- **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**
TREATMENT
- as for cervical sprain - soft orthosis for comfort (2-3 months).

WHIPLASH INJURY (S. CERVICAL SPRAIN, HYPEREXTENSION INJURY)
- cervical myofascial injury

d) 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

e) = 1 million cases per year in USA.

f) women > men. *narrower neck with less muscle mass supporting head

g) pathologies - muscle tears, rupture of ligaments, retropharyngeal hematoma, nerve root damage, cervical sympathetic chain injury, hematoma of facet joints.

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, most patients are not cured by verdict.

2. Possible concomitant symptoms:
   - 80% patients complain of headaches (muscle contraction type ± greater occipital neuralgia, third occipital neuralgia*).
   - *pain referred from C3 facet joint innervated by 3rd occipital nerve
   - 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).
   - interscapular pain (20%), low back pain (35%).

h) rare sequelae - cervical dystonia or torticollis.

Diagnosis – cervical spine MRI (if abnormalities are present, possibility that they are pre-existent should be considered!).

Differential – psychological problems, malingering.

TREATMENT
Instruct patient that complete resolution of symptoms may require 2-12 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


TABLE 1: The TLICS system*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>injury morphology</td>
<td>1</td>
</tr>
<tr>
<td>burst</td>
<td>+1</td>
</tr>
<tr>
<td>translation/rotation</td>
<td>2</td>
</tr>
<tr>
<td>distraction</td>
<td>3</td>
</tr>
<tr>
<td>neurological status</td>
<td>4</td>
</tr>
<tr>
<td>nerve injury</td>
<td>5</td>
</tr>
<tr>
<td>cont, cord-modulated</td>
<td>6</td>
</tr>
<tr>
<td>incomplete</td>
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</tr>
<tr>
<td>complete</td>
<td>8</td>
</tr>
<tr>
<td>PLC integrity</td>
<td>9</td>
</tr>
<tr>
<td>intact</td>
<td>10</td>
</tr>
<tr>
<td>indurated†</td>
<td>1</td>
</tr>
</tbody>
</table>

* As reported by Vaccaro et al.†

1. For patients with suggested ligamentous injury on STIR imaging or T2 weighted MRI.

Injuries with ≤ 3 points = non-operative
Injuries with 4 points = nonop vs op
Injuries with ≥ 5 points = surgery

COMPRESSION (WEDGE) FRACTURE

EPITHIOPATHOPHYSIOLOGY

i) 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!

j) often as PATHOLOGIC FRACTURES (esp. elderly white women). see PATHOLOGIC FRACTURES >>

CLINICAL FEATURES

ANTERIOR WEDGE FRACTURES (most common type of thoracolumbar fractures!)

PATHOLOGIC FRACTURES

COMPRESSION (WEDGE) FRACTURE

ANGULAR DEFORMITY

RADIOLOGY

anterior column failure (stable) - wedging of anterior component of vertebral bodies (loss of anterior vertebral body height < 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. see FLEXION-DISTRACTION FRACTURE >>

> 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)

failure of all 3 columns (unstable!!!) - anterior wedging + varying degrees of posterior vertebral body disruption. see FLEXION-DISTRACTION FRACTURE >>, BURST FRACTURE >>

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

8-14% are asymmetric - caused by compression-lateral flexion (stable LATERAL WEDGE FRACTURES).

Denis classification system:

type A - involvement of both endplates
type B - involvement of superior endplate
type C - involvement of inferior endplate
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 → increase in kyphosis (sometimes to point that patient cannot stand upright → hip flexor contractures [due to iliospouas 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 intrathoracic / abdominal injuries should be considered.

3) often associated with prolonged ileus (secondary to hemorhage of sympathetic ganglia), requiring continuous nasogastric suction.

for malignant causes – emergent radiotherapy, steroids

for infectious causes – antibiotics
**Analgesia** (avoid NSAIDs) and muscle relaxants

N.B. bony and neuropathic pains are treated differently!

- if pain is not improving with bracing over 2-12 weeks → **kyphoplasty** or **vertebroplasty**

**Bracing** (for 8-12 weeks) to prevent progressive angulation:

a) custom made TLSO (body cast)

b) "off-the-shelf" adjustable TLSO

c) 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 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.

**Early rehabilitation** - become ambulatory as soon as possible (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 → isometric 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**

a) instability to wear external brace or external brace failure

b) kyphosis > 30° - indicates instability

c) major anterior column comminution with height loss > 50% - indicates instability

N.B. vertebral body comminution is risk factor per se that bracing will fail as bone fragments will keep “floating”

d) significant posterior element disruption - indicates instability

e) neurological deficits - add recompensation to follow

- percutaneous screws (“internal brace”) may suffice if no need to decompress and enough fractured bone contact to heal (esp. young people) – see p. Op/220

- postoperative TLSO bracing (10-12 weeks).

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

- anesthesia - local or general.

- fluoroscopy guidance

- percutaneous trocar or large needle is introduced into fractured body through pedicle, and cement is injected.

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

N.B. according to study by Kallmes and colleagues, vertebroplasty for compression fracture

- not associated with improvements in pain or function vs placebo!

- significant neurological deficits – add recompensation to follow

- bone fragments will keep “floating”

- anterior column comminution, loss of vertebral height (> 50%), kyphosis > 30°, kyphotic angulation (> 20%) – indicate DECOMPRESSION

**Burst Fracture of Vertebral Body**

- vertebral body end plate(s) fracture → nucleus pulposus is forced into vertebral body → body is shattered outward from within (burst fracture).

- circumferential expansion of entire involved vertebra.

- retropulsed bone splinters and disc material may impinge on ventral surface of spinal cord (with circumferential expansion of entire involved vertebra. (helps differentiate from simple wedge fracture and flexion teardrop fracture); increased incidence of neural impingement → immediate decompressive surgery (via anterior approach)!)

- attempted weight bearing without surgical fixation → severe neurologic injury can be expected.

**McAfee** 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 = scaring and chronic pain).

**Radiology**

**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 teardrop fracture); widened interpedicular distance (indicates instability).

Always perform CT / MRI to document amount of bone retropulsion.
VERTEBRAL COLUMN INJURY (SPECIFIC INJURIES)

Burst fracture of T12: anterior deformation, comminution, retropulsion of bone fragments into spinal canal:

**TREATMENT:**

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-shell” adjustable brace)

— required to be worn at all times except when lying flat in bed

Kirkham Wood, MD (chief of orthopedic spine service at Massachusetts General Hospital and associate professor of orthopedic surgery at Harvard Medical School) — surgical vs. nonsurgical treatment for neurologically intact and stable burst fractures of the thoracolumbar junction:

- years ago, burst fractures were traditionally operated on; now most clinicians no longer offer surgery to the majority of their patients.
- at 4 years, patients who received surgery (either posterior or anterior arthrodesis), had higher complication rates but there was little difference in outcomes.
- at 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 ( Oswestry 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).

Sonali R. Gnanenthiran "Nonoperative versus Operative Treatment for Thoracolumbar Burst Fractures Without Neurologic Deficit: A Meta-analysis"

- Level II Evidence: operative management of thoracolumbar burst fractures without neurologic deficit may improve residual kyphosis, but does not appear to improve pain or function at an average of 4 years after injury and is associated with higher complication rates and costs

C. No bracing


AO-A3 burst fractures T11-L3, skeletally mature, age > 60 years, kyphotic deformity < 35°, no neurologic deficit: TLSO is equivalent to no bracing at 3 months postinjury (health-related quality of life outcomes, satisfaction, and length of stay).

Unstable, canal impingement: see indications for surgery under compression fractures >>

→ surgery via anterior* or posterior approach: DECOMPRESSION** + STABILIZATION with restoration of normal vertebral body height (long-term stabilization is provided by interbody arthrodesis using bone graft).

**DECOMPRESSION is not always needed; should not be attempted until adequate EXTERNAL 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 retropulsed fragment back into cavity — ligamentotaxy.
- 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!)
DISTRACTIVE FLEXION FRACTURE, S. CHANCE ("SEAT BELT") FRACTURE

- failure of POSTERIOR column (injury to ligamentous components, bony components, or both).
  - often due to lap belts in motor vehicle accidents - individual is subjected to sudden deceleration and torso is flexed forward over restraining belt.

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)

FLEXION-DISTRACTION SUBTYPE (unstable*) - axis of flexion posterior to anterior longitudinal ligament: Classic Chance fracture + anterior wedge fracture.

*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 L4-5 with spinal cord transection.

LATERAL FLEXION FRACTURE

N.B. include at least 2 levels above and 2 levels below fracture; short segment fusions (1 above, 1 below) are rarely acceptable!
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 INJURY**
(unstable)
- occurs in 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:

**FACET FRACTURE-DISLOCATION**
- direct blow → displacing vertebra off adjacent one with fracture and dislocation of articular processes and rupture of ligaments & disk.
  - failure of all three columns - grossly unstable (although stability may be maintained by rib cage).
  - 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. Spine17 >>

**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!)
   - 50% of all osteoporotic fractures are vertebral (lumbar, 1/3 are thoracolumbar, and 1/3 are thoracic).

2) chronic steroid use

3) vertebral malignancies (metastases, multiple myeloma)

4) vertebral *osteomyelitis* (incl. tuberculous).

5) hyperparathyroidism

6) prolonged immobilization

- most often - *thoracolumbar 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 midthoracic region are suggestive of malignancy.

**CLINICAL FEATURES**

- 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 Tc-99m-hydroxydimethylpyrimidine bone scans.

  differentiation MALIGNANT vs. BENIGN fractures (not always possible by imaging): 

  - 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 >>