

Chapter I

Spine

CERVICAL SPINE

Injuries to the Occiput-C1–C2 Complex

Anderson and Montisano Classification of Occipital Condyle Fractures

Type I: impaction of condyle

Type II: associated with basilar or skull fractures

Type III: condylar avulsion

Atlanto-Occipital Dislocation (Craniovertebral Dissociation)

Classification Based on Position of the Occiput in Relation to C1

Type I: Occipital condyles anterior to the atlas; most common

Type II: Condyles longitudinally result of pure distraction

Type III: Occipital condyles posterior to the atlas

Atlas Fractures

Levine and Edwards Classification

1. Burst Fracture (Jefferson Fracture). Axial load injury resulting in four fractures: two in the posterior arch and two in the anterior arch.
2. Posterior arch fractures. Hyperextension injury that is associated with odontoid and axis fractures.
3. Comminuted fractures. Axial load and lateral bending injury associated with high nonunion rate and poor clinical result.
4. Anterior arch fractures. Hyperextension injury.
5. Lateral mass fractures. Axial Load and lateral bending injury.
6. Transverse process fracture. Avulsion injury.
7. Inferior tubercle fracture. Avulsion of the longus colli muscle.

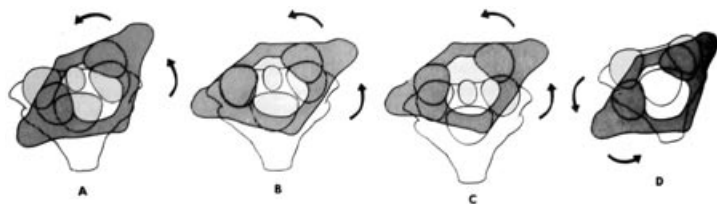


FIGURE 1.1. Fielding classification of atlantoaxial rotatory subluxation and dislocation. (Reproduced with permission and copyright © of the Journal of Bone and Joint Surgery, Inc. Fielding WJ, Hawkins RJ; Atlanto-axial rotatory fixation (Fixed rotatory subluxation of the atlanto-axial joint). *J Bone Joint Surg* 1977;59-A:37-44.)

Atlantoaxial Rotatory Subluxation and Dislocation

Fielding Classification (Figure 1.1)

- Type I: Simple rotatory displacement without anterior shift. Odontoid acts as a pivot point; transverse ligament intact.
- Type II: Rotatory displacement with anterior displacement of 3.5 mm. Opposite facet acts as a pivot; transverse ligament insufficient.
- Type III: Rotatory displacement with anterior displacement of more than 5 mm. Both joints anteriorly subluxed. Transverse and alar ligaments incompetent.
- Type IV: Rare; both joints posteriorly subluxed.
- Type V: (Levine and Edwards) frank dislocation; extremely rare.

Fractures of the Odontoid Process (Dens)

Anderson and D'Alonzo Classification (Figure 1.2)

- Type I: Oblique avulsion fracture of the apex (5%).
- Type II: Fracture at the junction of the body and the neck; high nonunion rate (60%).
- Type III: Fracture extends into the body of C2 and may involve the lateral facets (30%).

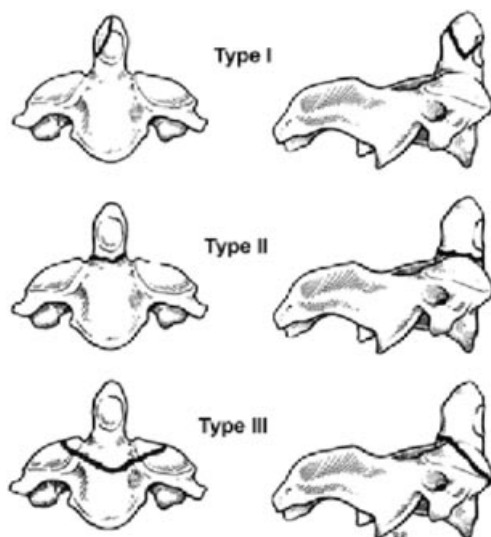


FIGURE 1.2. Anderson and D'Alonzo classification of fractures of the odontoid process (Dens). (Reproduced with permission and copyright © of The Journal of Bone and Joint Surgery, Inc. Anderson LD, d'Alonzo RT. Fractures of the Odontoid process of the axis. *J Bone Joint Surg Am* 1974;56A:1663–1674.)

TRAUMATIC SPONDYLOLISTHESIS OF AXIS (HANGMAN'S FRACTURE)

Levine and Edwards (Figure 1.3)

- Type I: Minimally displaced with no angulation; translation <3 mm; stable.
- Type II: Significant angulation at C2–C3; translation >3 mm; unstable; C2–C3 disc disrupted. Subclassified into flexion, extension, and listhetic types.
- Type IIA: Avulsion of entire C2–C3 intervertebral disc in flexion, leaving the anterior longitudinal ligament intact. Results in severe angulation. No translation; unstable due to flexion-distraction injury.
- Type III: Rare; results from initial anterior facet dislocation of C2 on C3 followed by extension injury fracturing the neural arch. Results in severe angulation and translation with unilateral or bilateral facet dislocation of C2–C3; unstable.

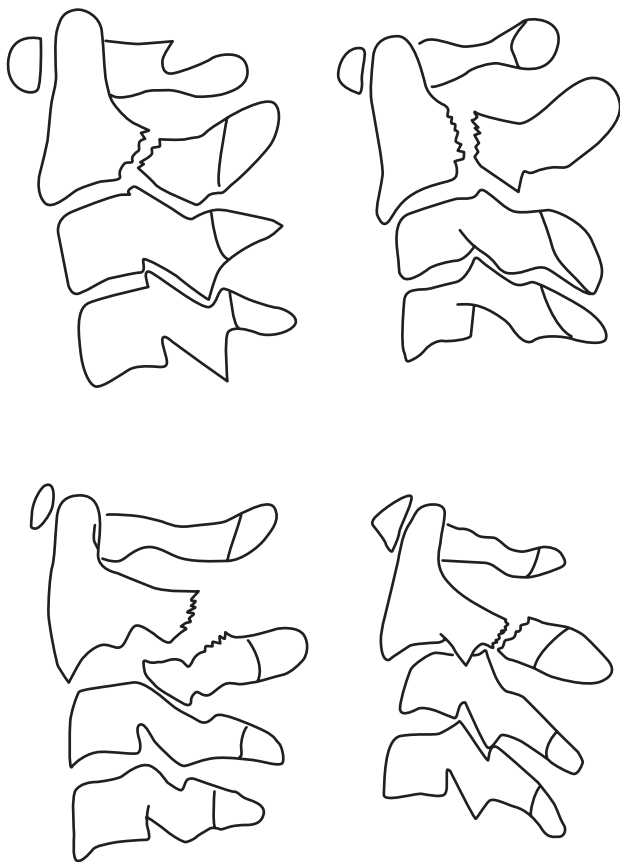


FIGURE 1.3. Levine and Edwards classification of Traumatic Spondylolisthesis of axis: Type I (top left), Type II (top right), Type IIA (bottom left), Type III (bottom right). (Reproduced with permission and copyright © of The Journal of Bone and Joint Surgery, Inc. Levine AM, Edwards CC. The management of traumatic spondylolisthesis of the axis. *J Bone Joint Surg Am* 1985;67A:217–226.)

INJURIES TO C3–C7

Allen Classification

1. Compressive flexion (shear mechanism resulting in “teardrop” fractures)

Stage I: Blunting of anterior body; posterior element intact.

Stage II: “Beaking” of the anterior body; loss of anterior vertebral height.

- Stage III: Fracture line passing from anterior body through the inferior subchondral plate.
- Stage IV: Inferoposterior margin displaced <3 mm into the spinal canal.
- Stage V: Teardrop fracture; inferoposterior margin >3 mm into the spinal canal; posterior ligaments and the posterior longitudinal ligament have failed.
2. Vertical compression (burst fractures)
 - Stage I: Fracture through superior or inferior endplate with no displacement.
 - Stage II: Fracture through both endplates with minimal displacement.
 - Stage III: Burst fracture; displacement of fragments peripherally and into the neural canal.
 3. Distractive flexion (dislocations)
 - Stage I: Failure of the posterior ligaments, divergence of spinous processes, and facet subluxation.
 - Stage II: Unilateral facet dislocation; displacement is always $<50\%$.
 - Stage III: Bilateral facet dislocation; displacement $>50\%$.
 - Stage IV: Bilateral facet dislocation with 100% translation.
 4. Compressive extension
 - Stage I: Unilateral vertebral arch fracture.
 - Stage II: Bilaminar fracture without other tissue failure.
 - Stage III: Bilateral vertebral arch fracture with fracture of the articular processes, pedicles, and lamina without vertebral body displacement.
 - Stage IV: Bilateral vertebral arch fracture with full vertebral body displacement anteriorly; ligamentous failure at the posterosuperior and anteroinferior margins.
 5. Distractive extension
 - Stage I: Failure of anterior ligamentous complex or transverse fracture of the body; widening of the disc space and no posterior displacement.
 - Stage II: Failure of posterior ligament complex with displacement of the vertebral body into the canal.
 6. Lateral flexion
 - Stage I: Asymmetric unilateral compression fracture of the vertebral body plus a vertebral arch fracture on the ipsilateral side without displacement.
 - Stage II: Displacement of the arch on the anteroposterior view or failure of the ligaments on the contralateral side with articular process separation.

**ORTHOPAEDIC TRAUMA ASSOCIATION (OTA)
CLASSIFICATION OF CERVICAL SPINE INJURIES**

- Type A: Compression injuries of the body (compressive forces)
- Type A1: Impaction fractures
 - Type A2: Split fractures
 - Type A3: Burst fractures
- Type B: Distraction injuries of the anterior and posterior elements (tensile forces)
- Type B2: Posterior disruption predominantly osseous (flexion-distraction injury)
 - Type B3: Anterior disruption through the disk (hyper-extension-shear injury)
- Type C: Multidirectional injuries with translation affecting the anterior and posterior elements (axial torque causing rotation injuries)
- Type C1: Rotational wedge, split, and burst fractures
 - Type C2: Flexion subluxation with rotation
 - Type C3: Rotational shear injuries (Holdsworth slice rotation fracture)

THORACOLUMBAR SPINE FRACTURES**McAfee Classification**

Classification is based on the failure mode of the middle osteo-oligamentous complex (posterior longitudinal ligament, posterior half of the vertebral body, and posterior annulus fibrosus): The six injury patterns are the following:

1. Wedge-compression fracture
2. Stable burst fracture
3. Unstable burst fracture
4. Chance fracture
5. Flexion-distraction injury
6. Translational injuries

Denis Classification

The three-column model according to Denis (Figure 1.4):

Anterior Column:

- Anterior longitudinal ligament
- Anterior half of vertebral body
- Anterior portion of annulus fibrosis

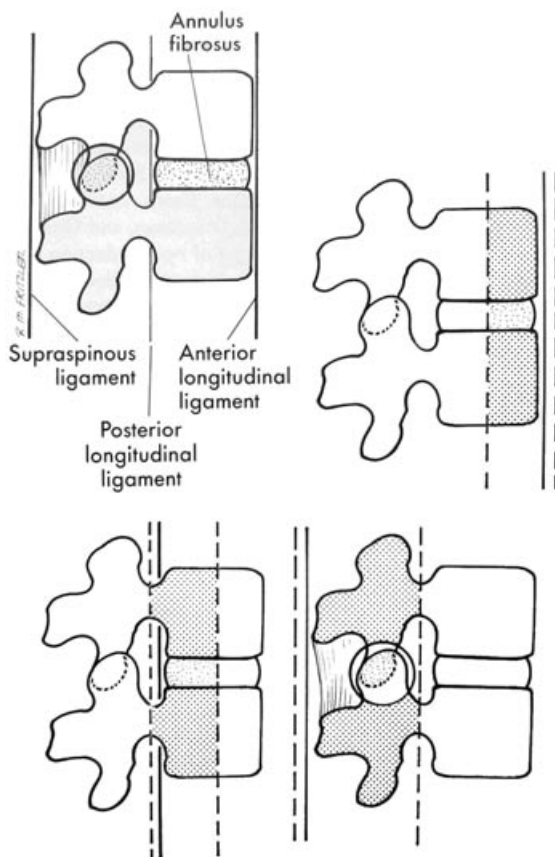


FIGURE 1.4. Denis' concept of three-column model.

Middle column:

- Posterior longitudinal ligament
- Posterior half of vertebral body
- Posterior aspect of annulus fibrosis

Posterior column:

- Neural arch
- Ligamentum flavum
- Facet capsule
- Interspinous ligament

TABLE 1.1. Pattern of failure.

Type	Column		
	Anterior	Middle	Posterior
1. Compression	Compression	none	none/distraction
2. Burst	Compression	Compression	None/Splaying of pedicles
3. Flexion-Distraction	None/Distraction	Distraction	distraction
4. Flexion-Dislocation	Compression/Rotation/shear	Compression/Rotation/shear	Compression Rotation/shear

Based on the three-column model, fractures are classified according to the mechanism of injury and the resulting fracture pattern into one of the following categories (see Table 1.1):

1. Compression
2. Burst
3. Flexion-Distraction
4. Fracture-Dislocation

1. *Compression Fractures*

Four subtypes described on the basis of endplate involvement are as follows:

Type A: Fracture of both endplates

Type B: Fractures of the superior endplate

Type C: Fractures of the inferior endplate

Type D: Both endplates intact

2. *Burst Fractures (Figure 1.5)*

Type A: Fractures of both endplates

Type B: Fracture of the superior endplate

Type C: Fracture of the inferior endplate

Type D: Burst rotation

Type E: Burst lateral flexion

3. *Flexion-Distraction Injuries (Chance Fractures, Seat Belt-Type Injuries)*

Type A: One-level bony injury

Type B: One-level ligamentous

Type C: Two-level injury through bony middle column

Type D: Two-level injury through ligamentous middle column

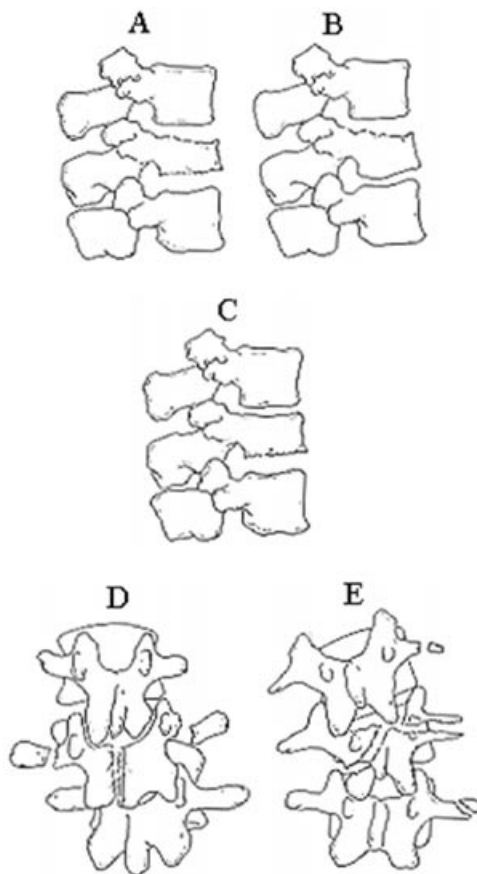


FIGURE 1.5. Burst thoracolumbar spine fractures.

4. Fracture Dislocations

Type A: Flexion-rotation. Posterior and middle column fail in tension and rotation; anterior column fails in compression and rotation; 75% have neurological deficits, 52% of these are complete lesions.

Type B: Shear. Shear failure of all three columns, most commonly in the postero-anterior direction; all cases with complete neurological deficits.

Type C: Flexion-distraction. Tension failure of posterior and middle columns, with anterior tear of annulus fibrosus and stripping of the anterior longitudinal ligament; 75% with neurological deficits (all incomplete).

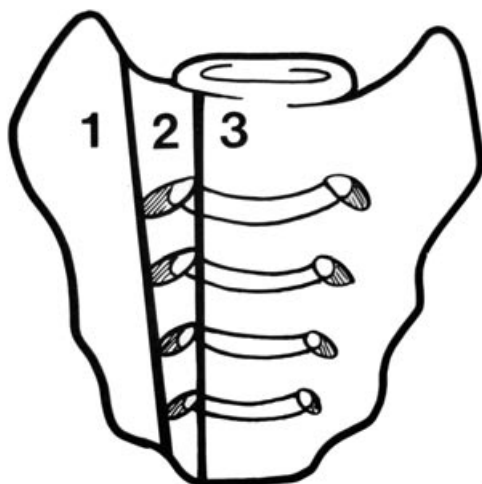


FIGURE 1.6. Denis classification of sacral fractures.

SACRAL FRACTURES (Figure 1.6)

Denis Classification

Zone 1: the region of the ala

Zone 2: the region of the sacral foramina

Zone 3: the region of central sacral canal