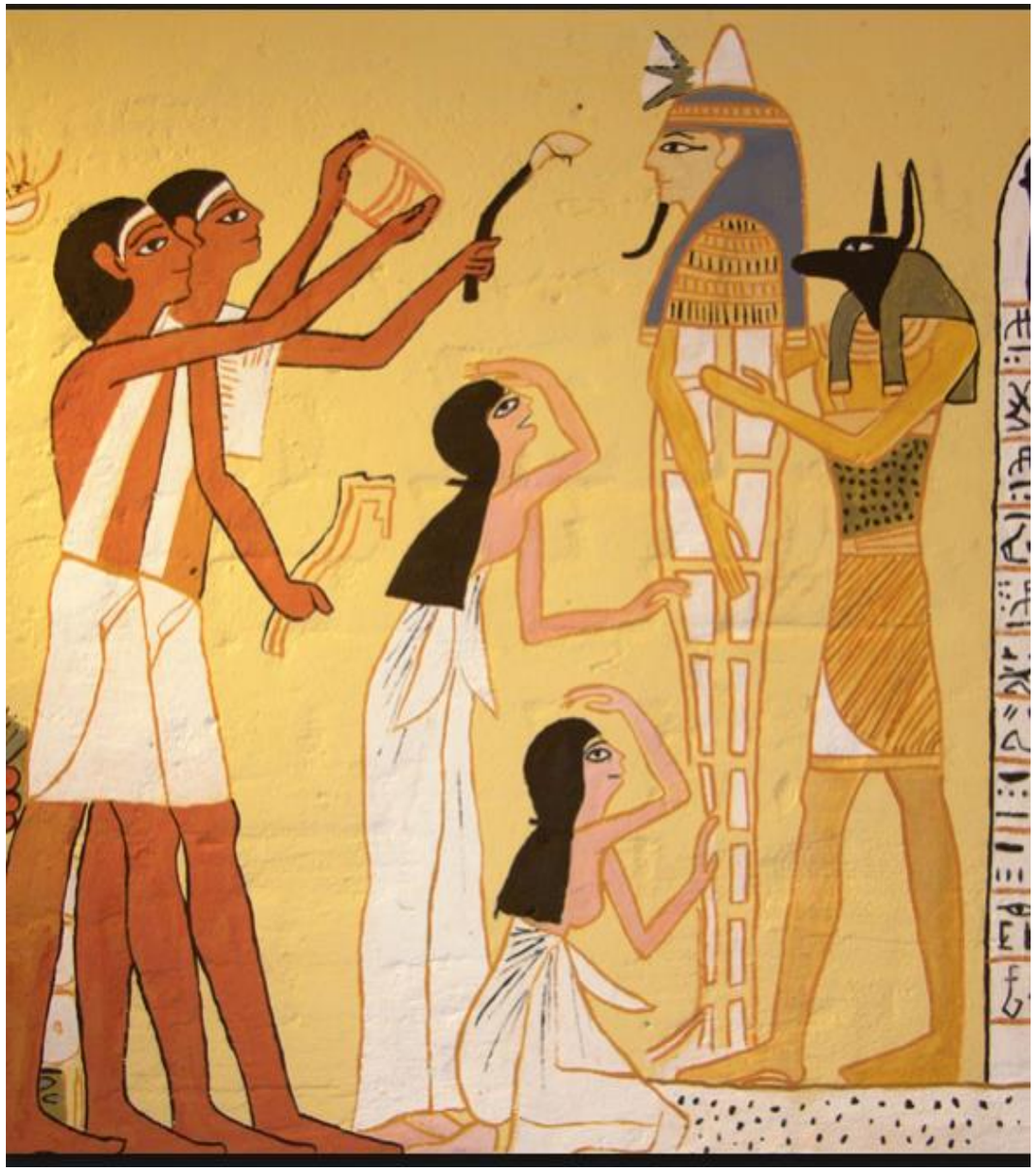
Spinal Trauma

Robert Veres

History of Spinal Injury Management



- Spinal cord injury is a mortal condition and has been recognised as such since antiquity.
- In about 2500 BC, in the Edwin Smith papyrus, Egyptian physician accurately described the clinical features of traumatic tetraplegia (quadriplegia) and revealed an awareness of the awful prognosis with the chilling advice: “an ailment not to be treated”.

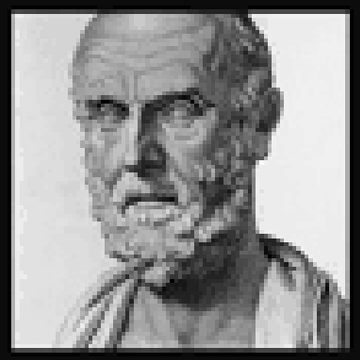
Edwin Smith papyrus

i.e. 3000-4000 – Egyipt: Description of the first spine cord injuries

No treatment

Assyrian sculpture
from 645-635 B.C.

First Perfect Representation of
Spinal Cord Injury



Look well to the spine for the cause of disease.

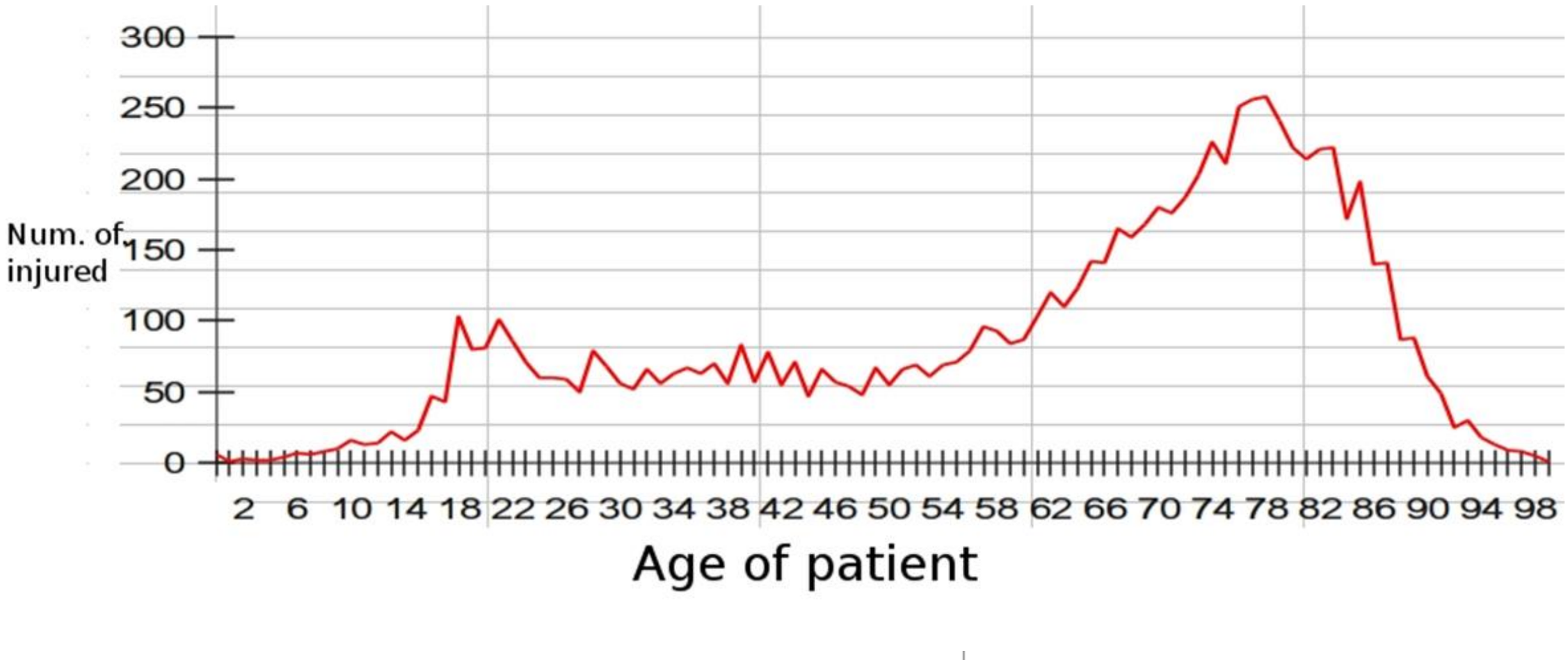
~ Hippocrates

Hippocrates Advocate traction for Spine injury treatement

Ibn Sina (Avicenna) 980-1030
The Canon of Medicine:
Spinal Cord injury no treatement

Epidemiology of Traumatic Spine Injury

Incidence of spinal cord trauma in developed countries:
11,5- 53,4 injured/ 1 million people



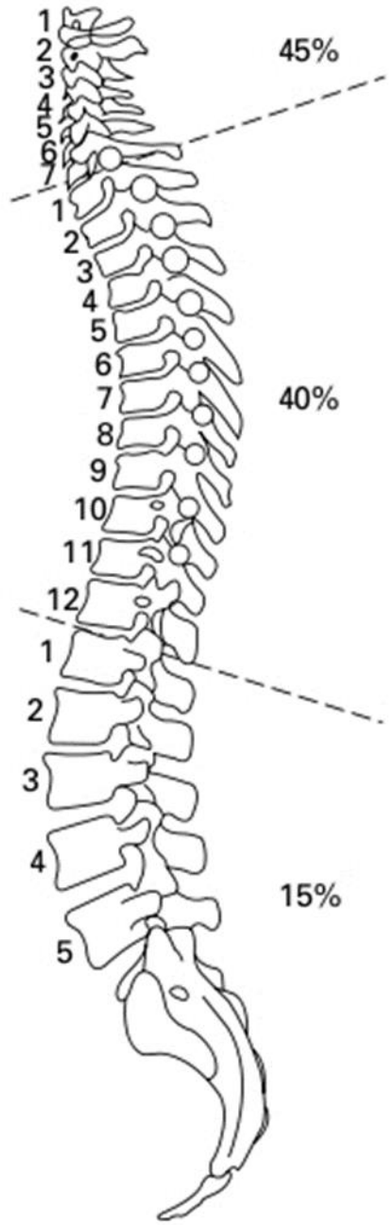
Causes and location of spinal cord injury*

1. Road traffic accidents (motorcycle) **45%**

2. Domestic and industrial (workplace associated accidents) **34%**

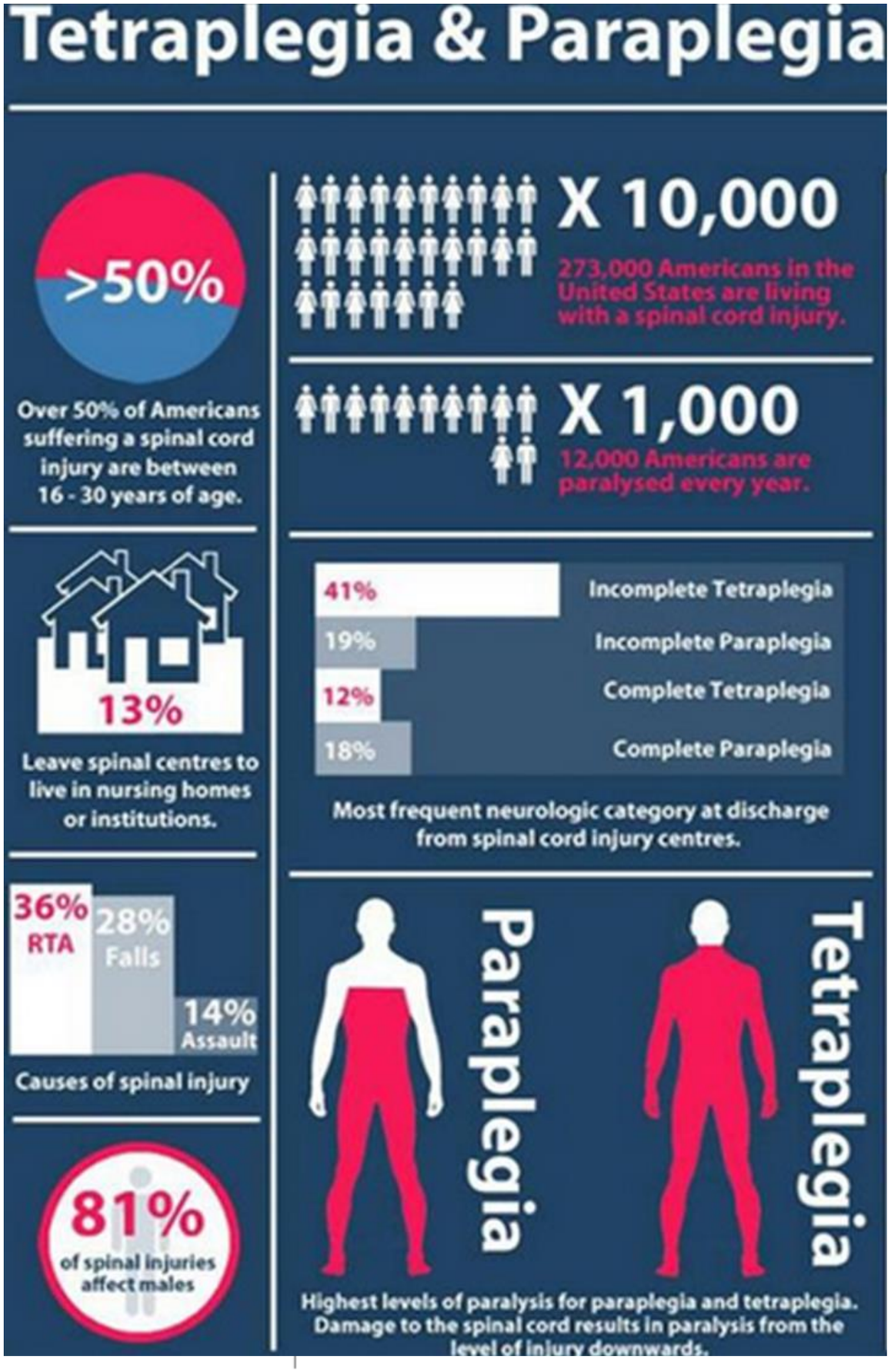
3. Injuries in sports **15%**

4. Self harm, criminal assault **6%**



*Duke of Cornwall Spinal Treatment Centre, 1997–99.

Epidemiology of Traumatic Spinal Cord Injury in USA



Military Actions

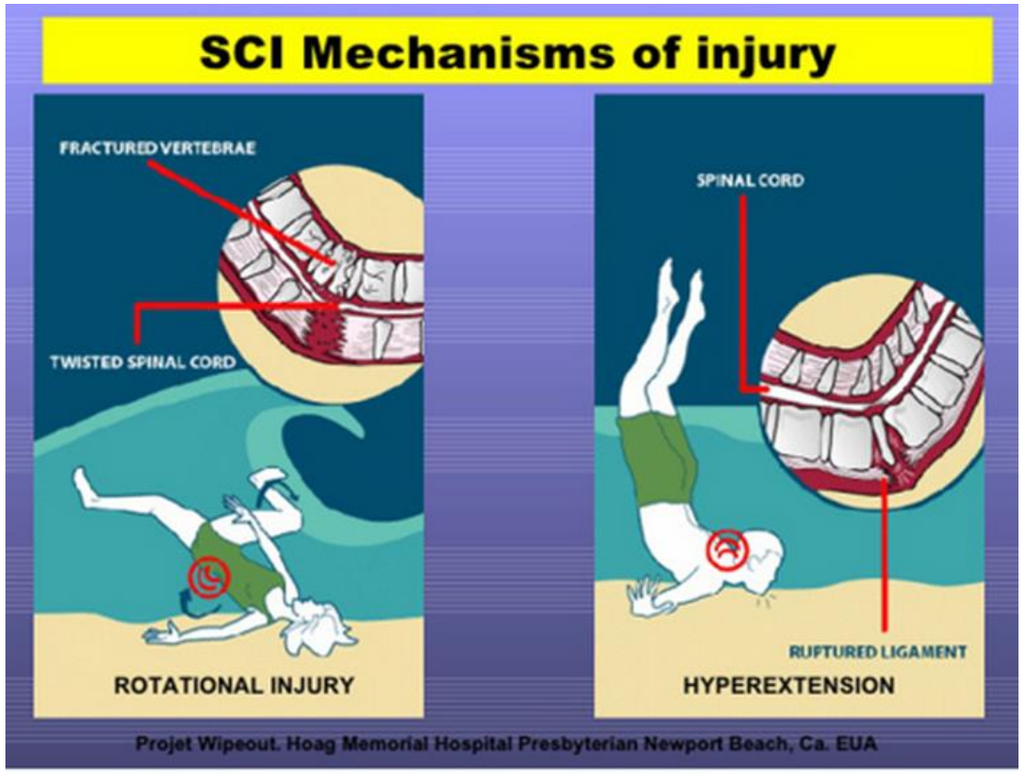
The Factors of the High Incidence of Spine Trauma

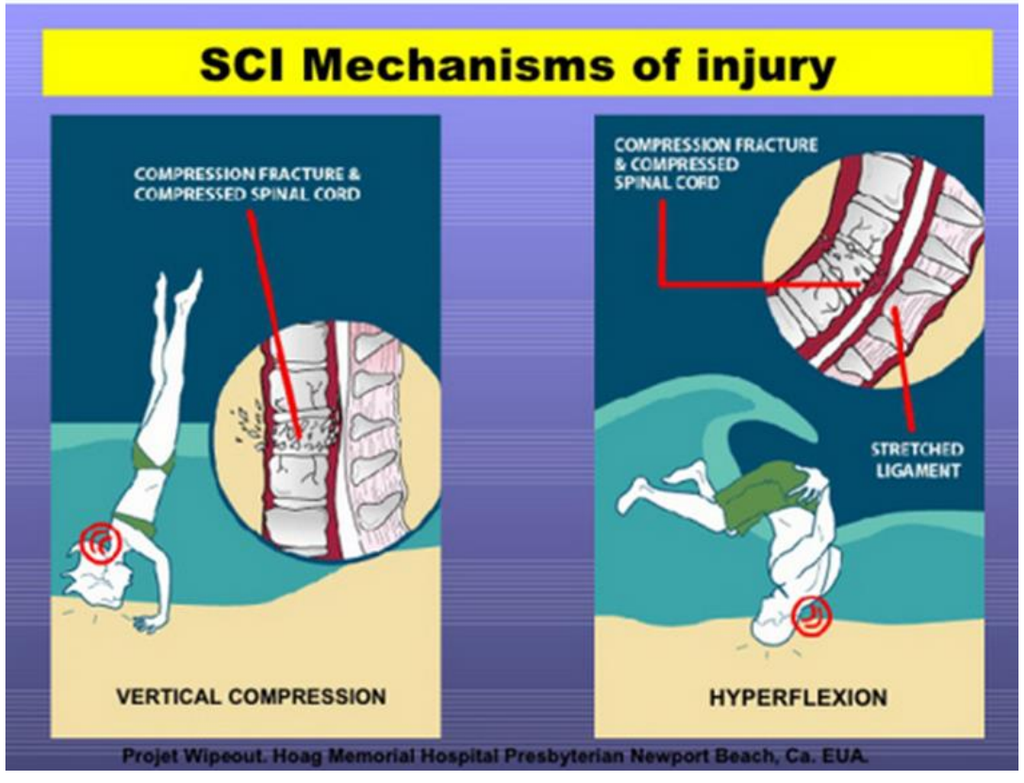
Severe Road Trafic Accdent

Prehospital Care in Spinal Injury Patient Prevention

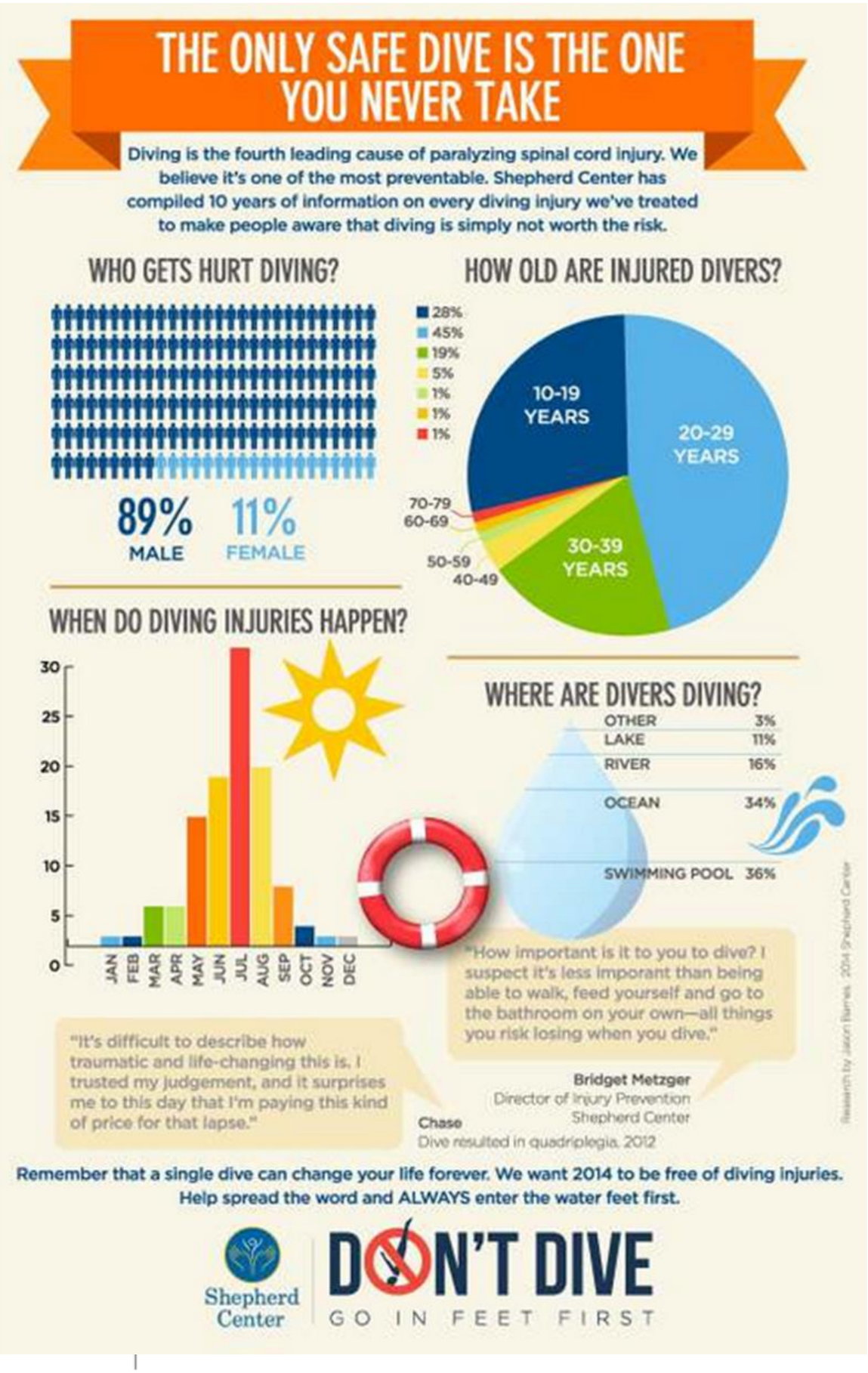
Primary Prevention

Think First program

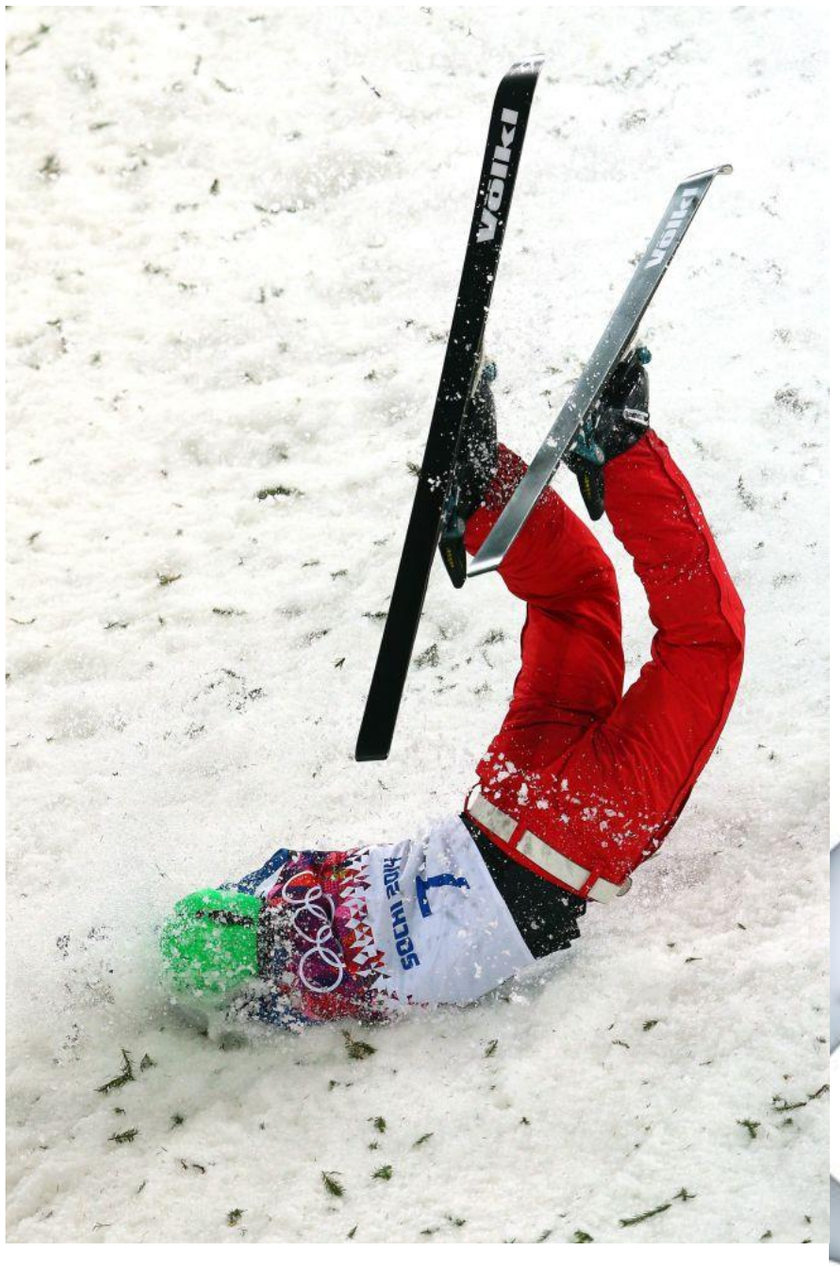




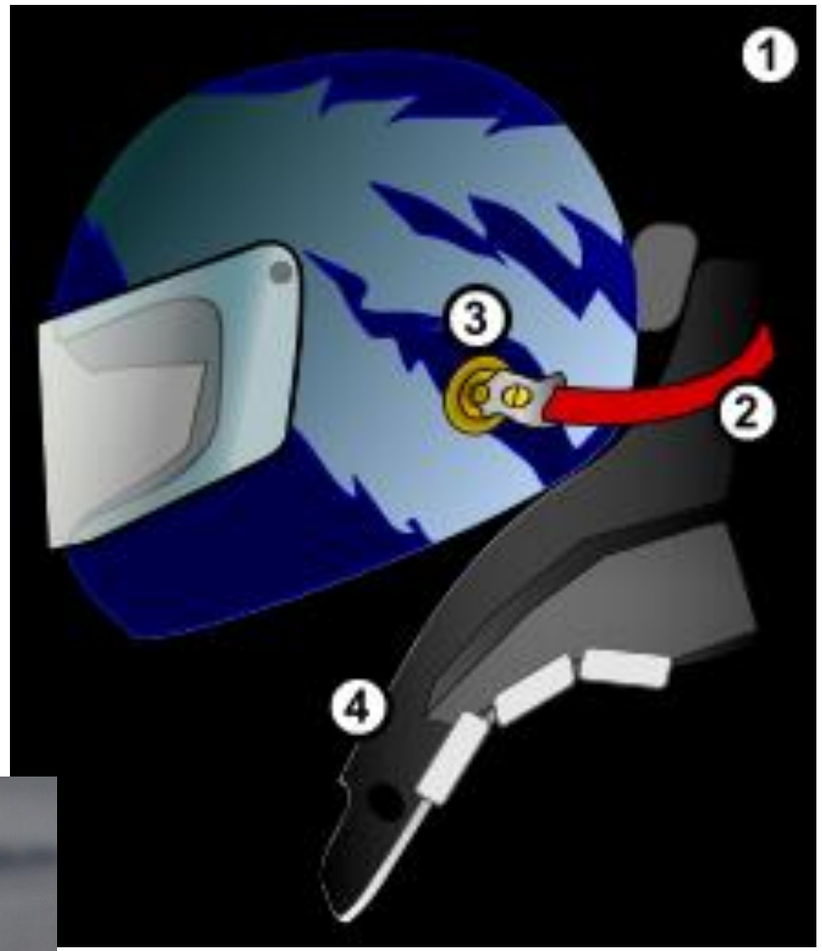
Dive Injury
Feet First program



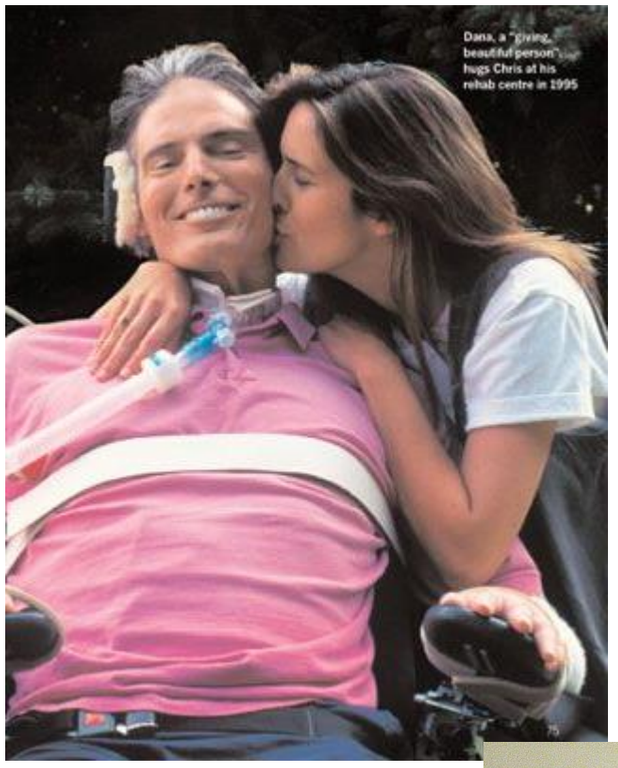
Avoid the accident
Diminished the injuries

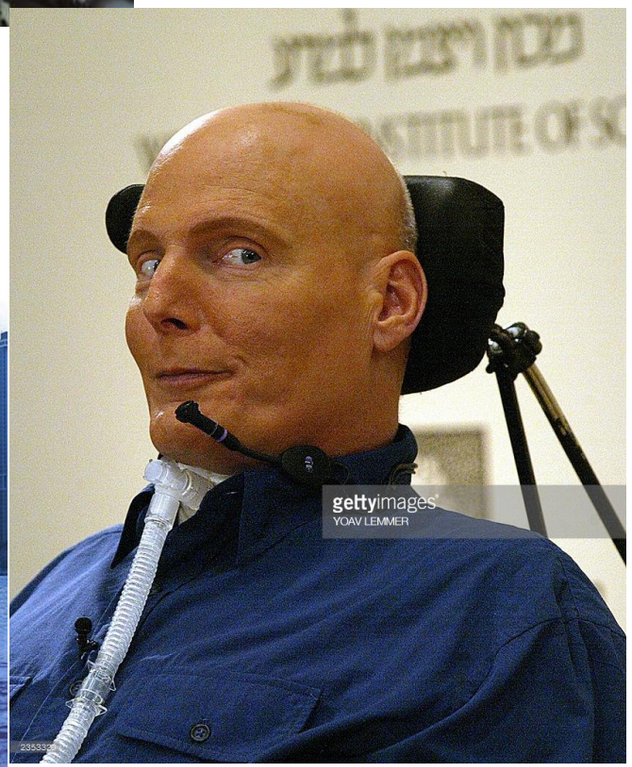


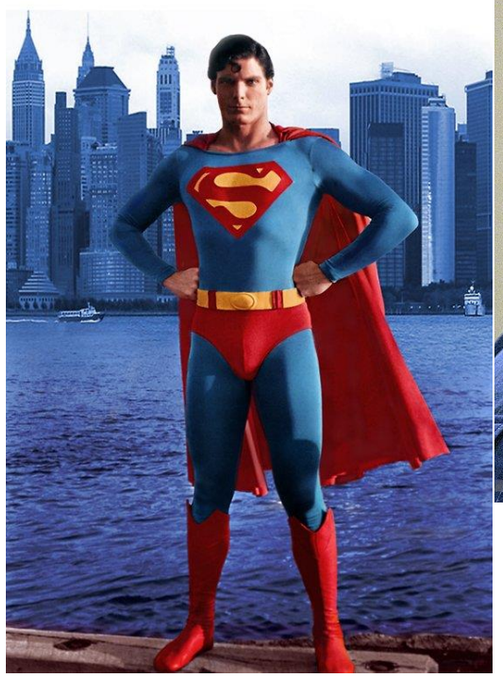
ThinkFirst
program



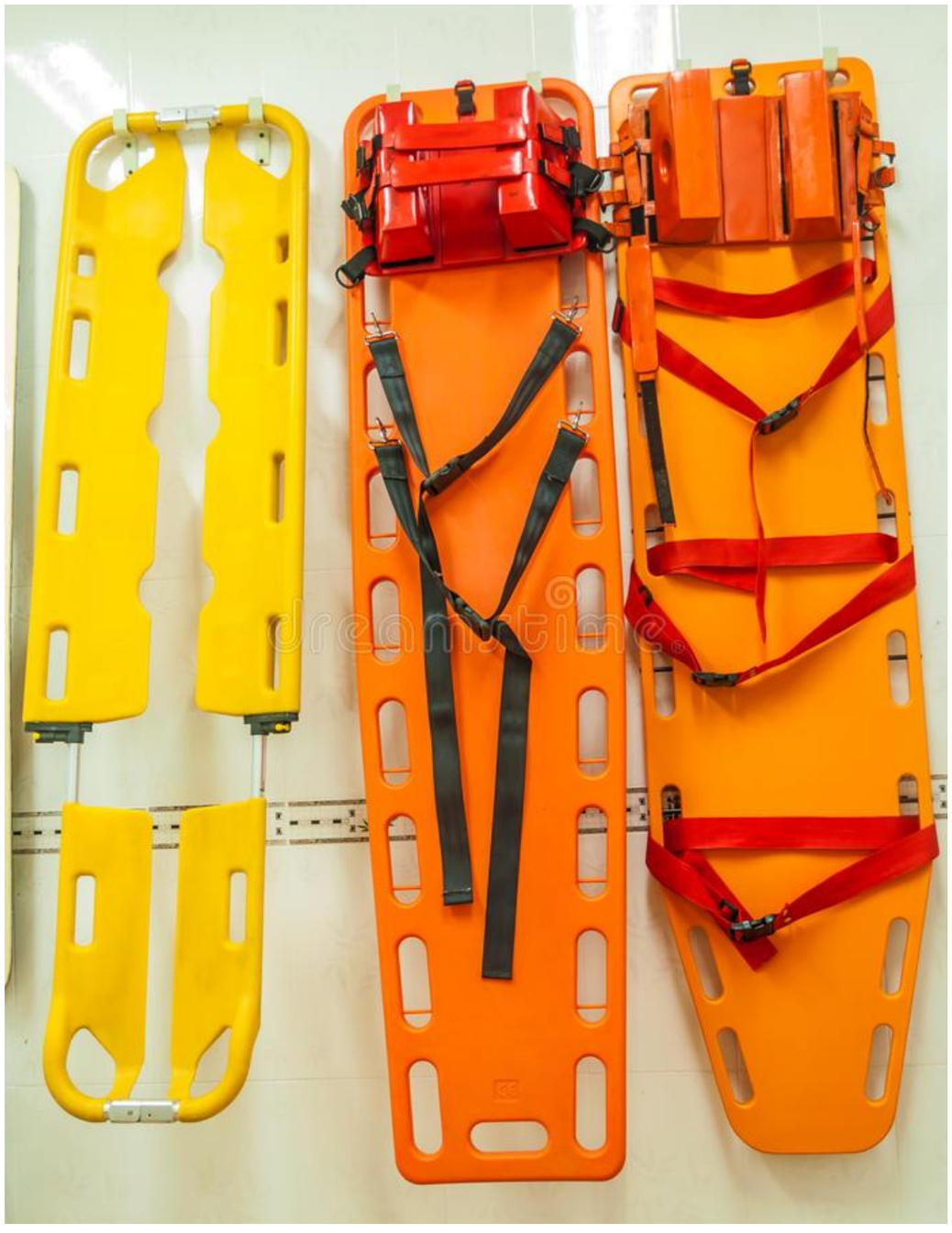
Passive protections







Safety First



Every injured patient should be considered and treated as a spine injured

If any suspect of spine injury the whole spine should be considered instable untill the opposite has proven.

Secondary Injury preventions

Prehospital Care in Spinal Injury Patient Field Care

Field Care

Rapid trauma assessment and immediate treatment of life-threatening injuries
More detailed trauma assessment and stabilization of non life-threatening injuries

Casualty Evacuation Care

Continual casualty assessment

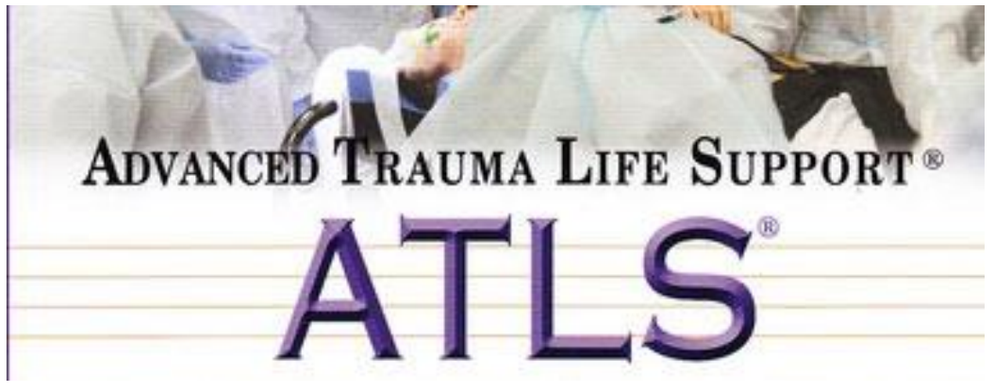
Scene Assessment

Determine safety of scene
Determine mechanism of injury
Determine number of casualties
Request additional help if necessary

Communicate verbally with casualty
Helps establish immediate status of airway, breathing, circulation, and mental status

Airway
Breathing
Circulation
Disability (Neurologic status)
Exposure

Primary Assessment:
ABCDE



When life-threatening injuries are encountered during the primary assessment, stop and perform the necessary life-saving procedure before proceeding

Failure to do so may result in an otherwise preventable death

IMPORTANT!

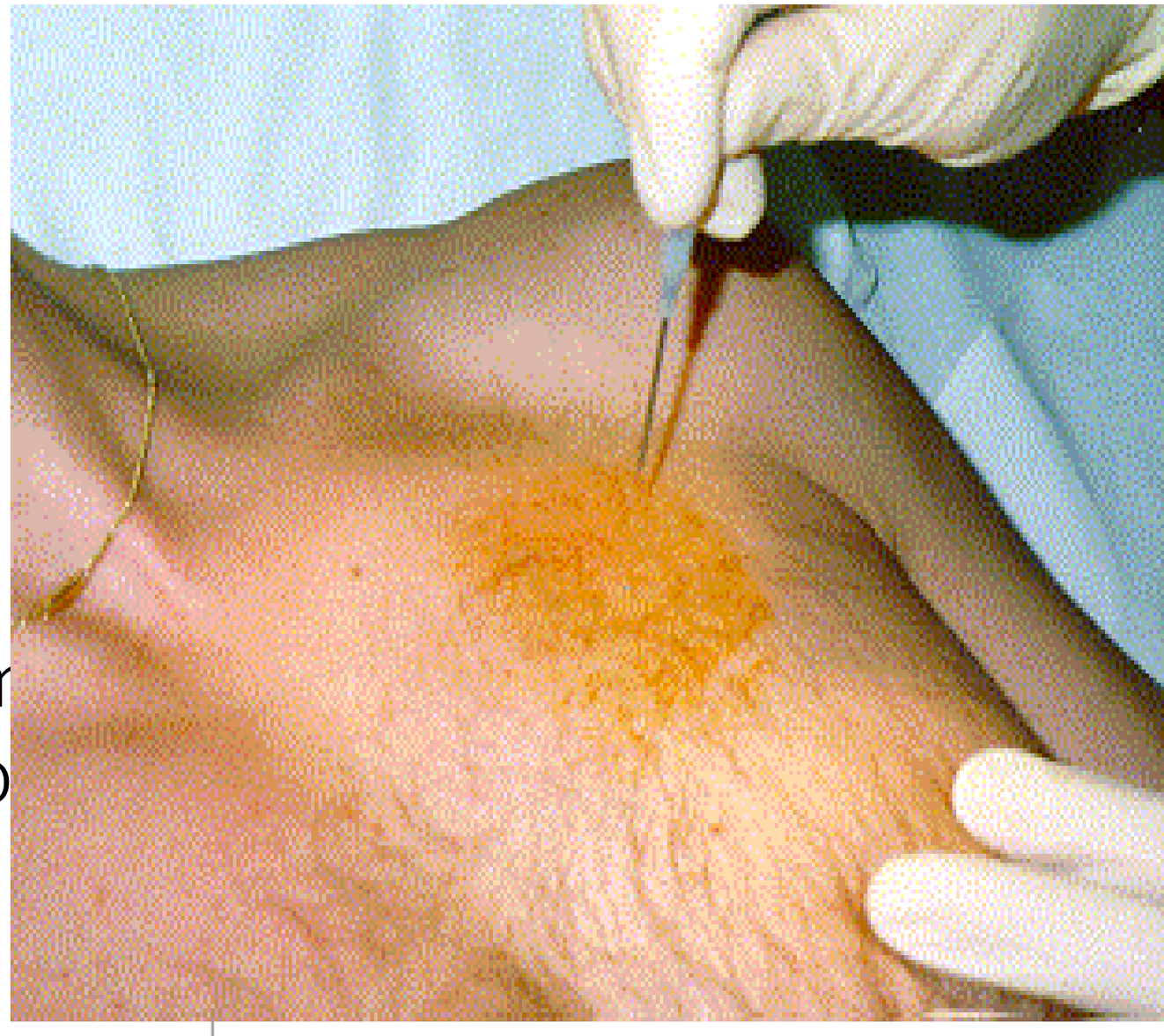
Airway

Attention to manual stabilization of cervical spine if appropriate
Airway obstructions are often noisy (but not always)
Suspect airway problems
- Unconscious
- Head, face, neck, chest injuries

Open, clear, and maintain the airway

Breathing

Look,
Listen, and Feel



If chest injury and severe difficulty breathing, perform needle chest decompressio to relieve tension pneumothorax

Circulation

Look for severe external bleeding

STOP THE BLEEDING!

- Direct pressure
- Pressure points
- Tourniquet

Assess for internal bleeding

- Check pulses
- Observe for shock

Initiate IV fluids

Disability (Neurologic Status)

Level of consciousness using AVPU scale

- Alert: Converses spontaneously and appropriately
- Verbal: Responds to verbal stimuli
- Painful: Responds to painful stimuli
- Unresponsive: Unresponsive to any stimuli

Pupil size

- Pupils should be equal and constrict vigorously to light stimulus

Motor function

- Strength should be normal and equal in all extremities

Exposure

Remove clothing to expose area of injury
Do not delay resuscitation to expose injuries
Keep casualty covered after exposure to avoid hypothermia due to blood loss

Casevac

Prepare to Evacuate

Diagnosing and excluding spinal injury

A polytraumatised patient should be treated as having spine injuries until excluded:

- Conscious,
- No sensory of motor deficit,
- CT scan of cervical spine - negative

<u>Maintenance of mean arterial pressure and oxygenation</u> are important for both polytraumatised and isolated spine injured patients

Initial Hospital Evaluation of Spinal Trauma Patient

Detailled History:

Circumstances of accident

Mechanism of injury

Clinical evaluation:

Primary Trauma assesment

Secondary Trauma assesment

Neurological evaluations

ASIA Classificatio

Radiological evaluations

Examinations Evaluations

Continue ATLS - life threatening lesions
Sign of SI/SCI: physical and neurological exam

local sign: pain,steps,
pressure sensitivity, deformity

neurological sign:focal
neurol.deficit

warning: altered mental status,
intoxication
distracting painful injury

Examinations
Evaluations

Head
Neck
    Apply cervical collar
    if unconscious
Chest
Abdomen
Pelvis
Extremities
Back
    Log roll casualty
    to stabilize spine

Secondary Trauma Assessment: Head to Toe

Perform more detailed exam of body areas

Deformities
Contusions
Abrasions
Penetrating injuries
Burns
Tenderness
Lacerations
Swelling

Secondary Trauma Assessment

1. Determine sensory score
2. Determine motor score
3. Determine single neurological level (lowest segment where sensory and motor function is still normal on both sides
4. Determine if injury is complete or incomplete (If there is no anal contraction or anal sensation the injury is complete, otherwise injury is incomplete)
5. Detemine ASIA Imapirment Scale (AIS)

ASIA Imparment Scale:
AIS A if injury is complete
AIS B motor injury is complete
AIS C at least half of the key muscles below single level are grade 3 or better
AIS D less than grade C
AIS E Normal

Steps in ASIA Classification

American Spinal Injury Association (ASIA) Classification System

Sensory evaluation:

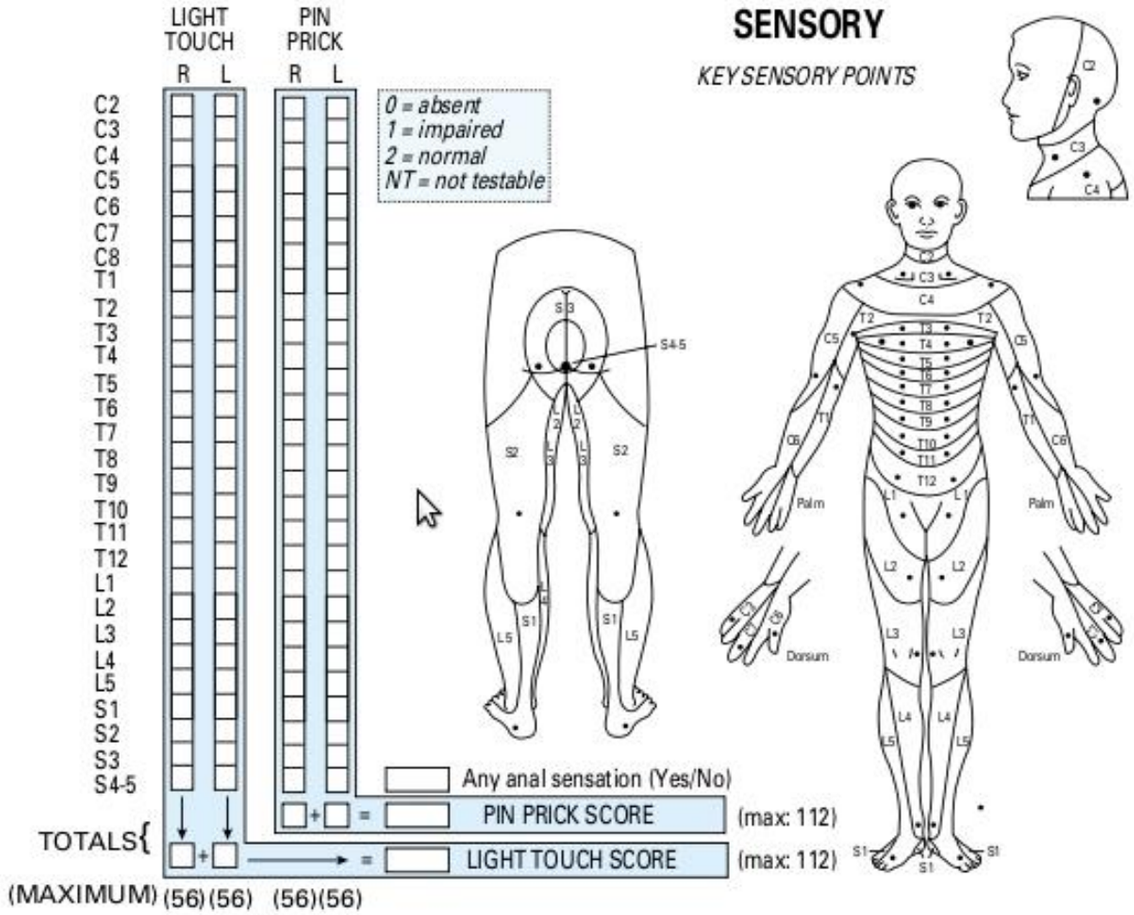
- 0- Absent Sensation
- 1- Sensation present, but abnormal
- 2- Intact sensation

Sensory system is divided into 28 dermatomes: 7 cervical, 12 thoracal, 5 lumbar, 4 sacral

Left and right side are graded individually

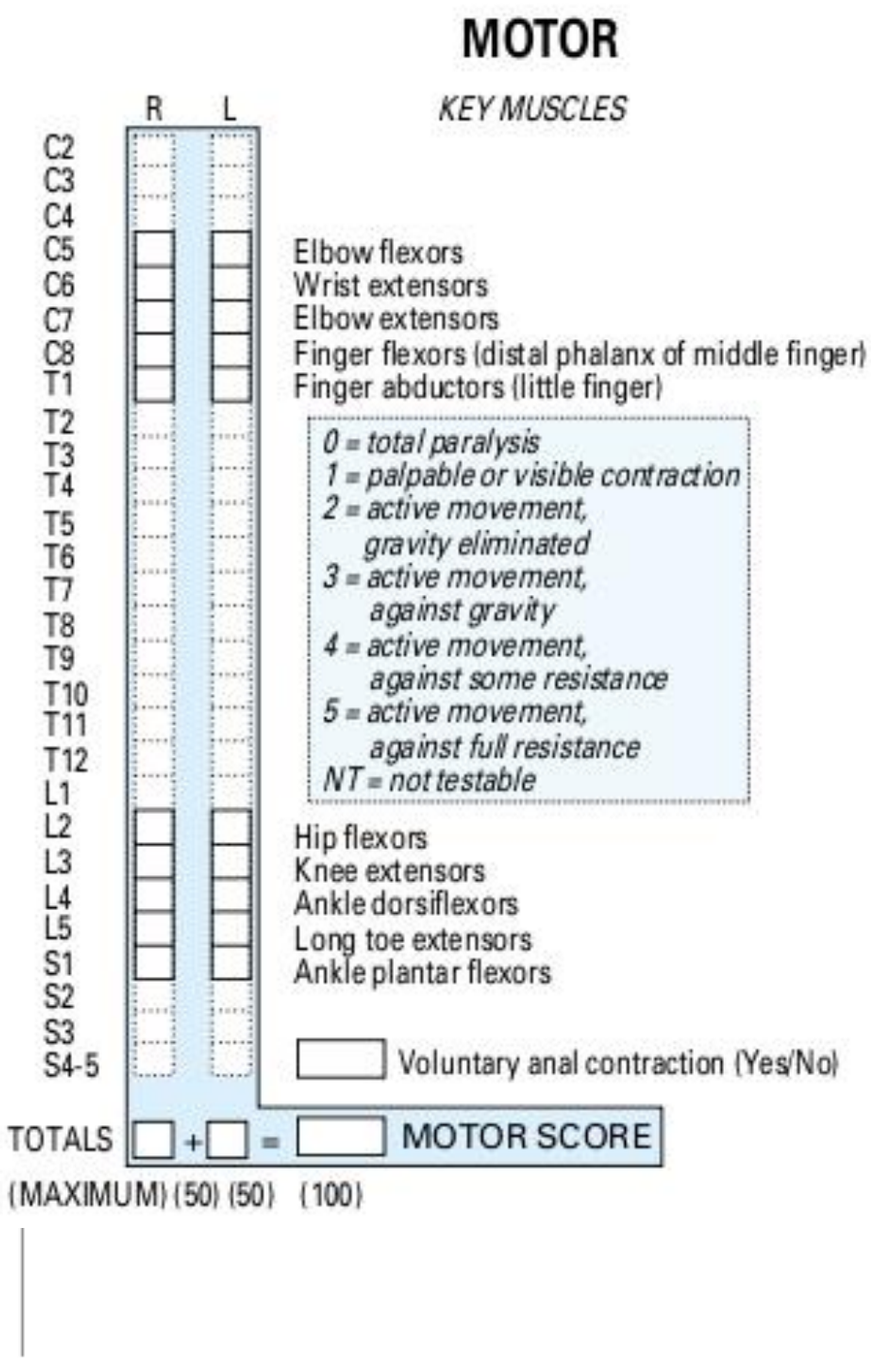
Light touch (dorsal column) and pin prick (spinothalamic system) are graded individually

224 points for a patient with no sensory deficit



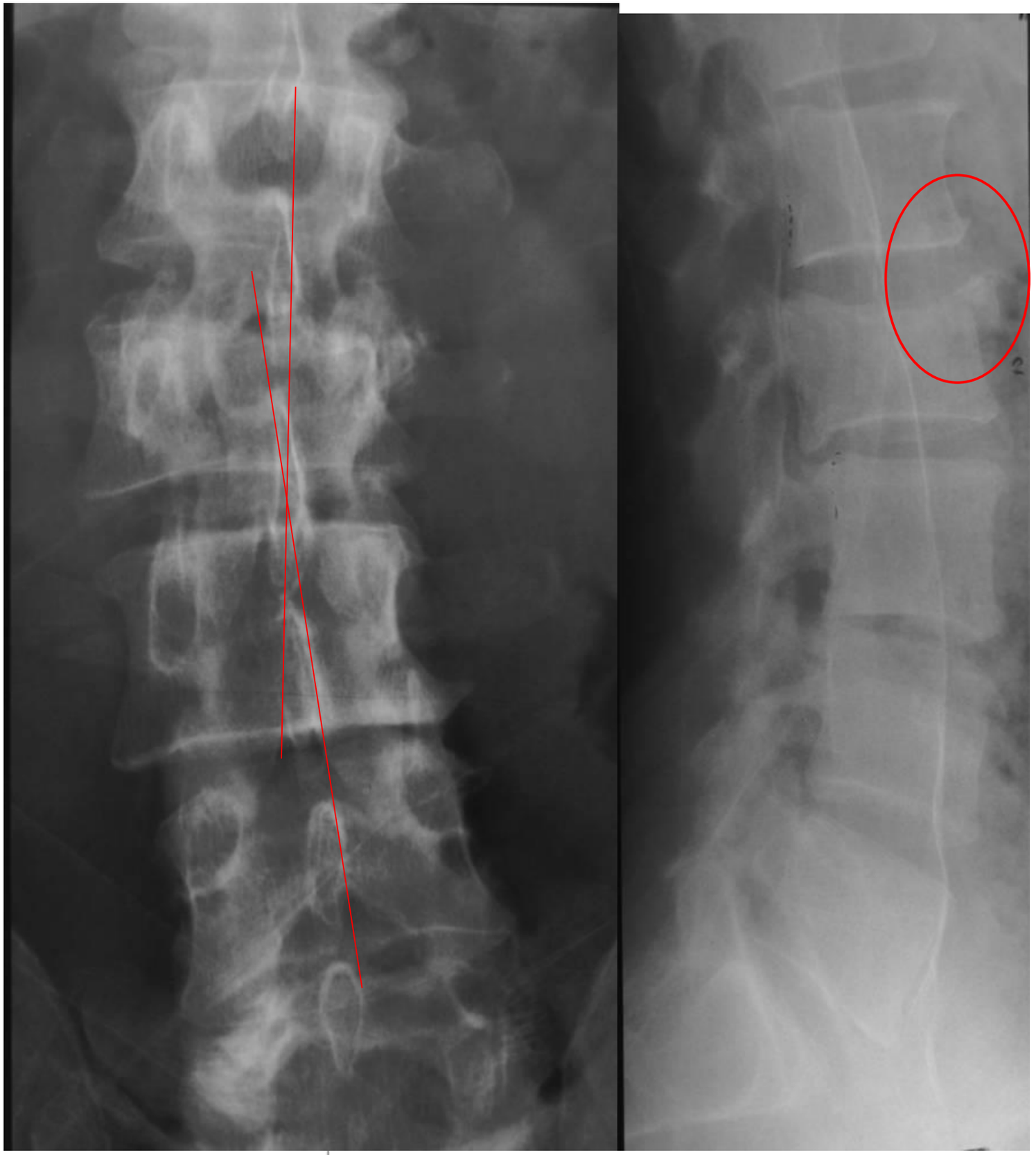
American Spinal Injury Association (ASIA) Classification System

Motor evaluation:
0- Total paralysis
1- Visible muscle contraction
2- Full range of movement with gravity eliminated
3- Full range of movement against gravity
4- Full range of movement against gravity with partail resistance
5- Full motor activity
Each limb is divided into 5 muscle groups, each receiving 1-5 point, totaling max. points per limb
100 point maximum for no motor deficit



Radiology of Spinal Trauma Patient

AP and
Lateral

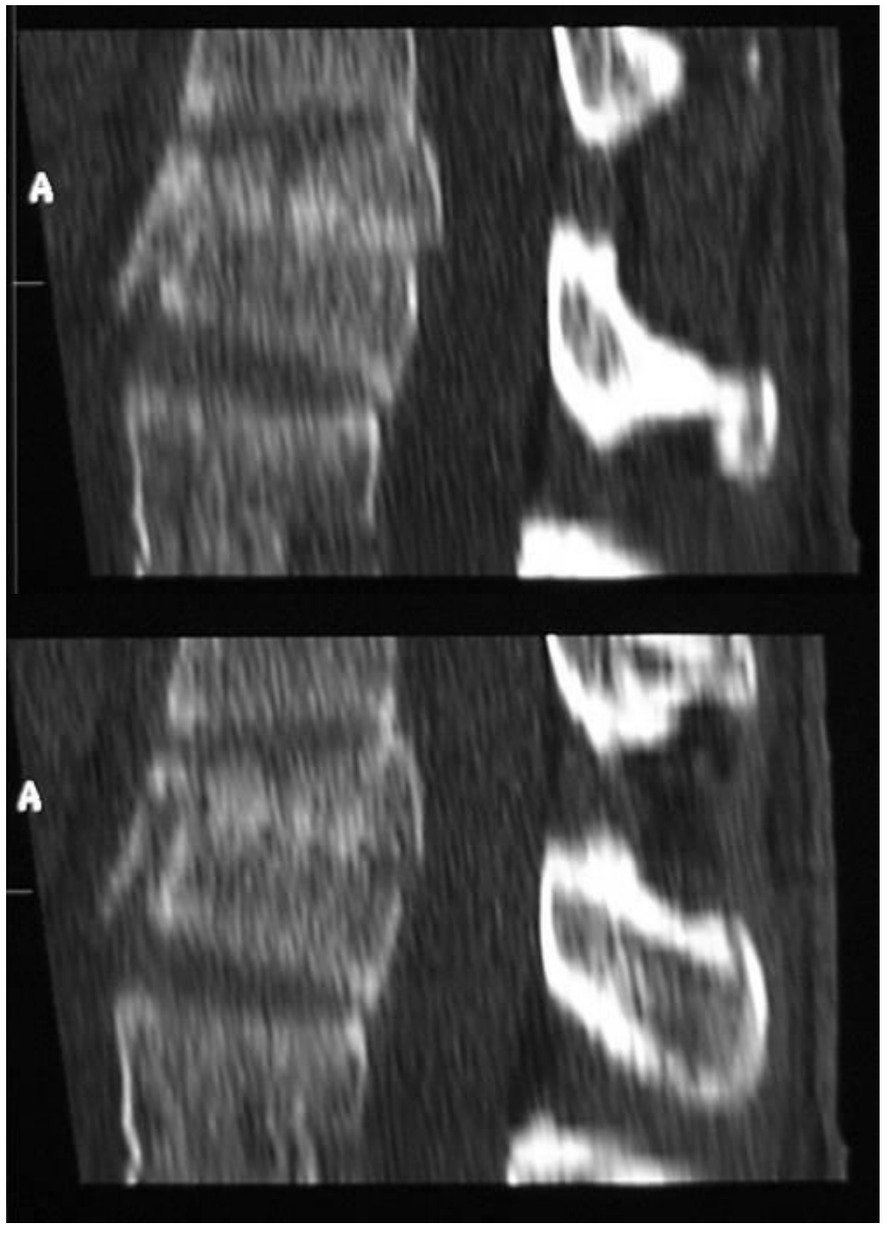


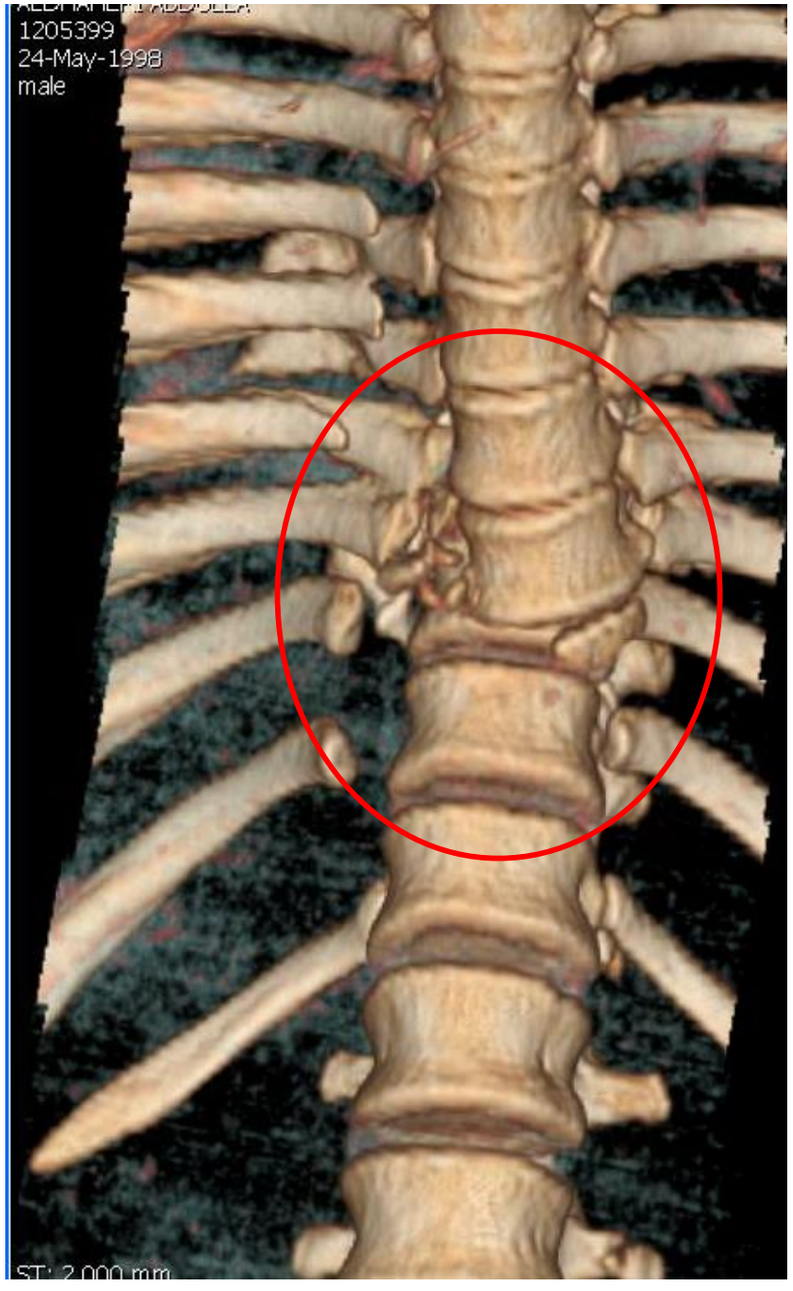
Analog x-ray

AP and Lateral

Analog x-ray

CT for evaluation of bony structures





3D CT for evaluation of bony structures

MRI for evaluation of soft tissues

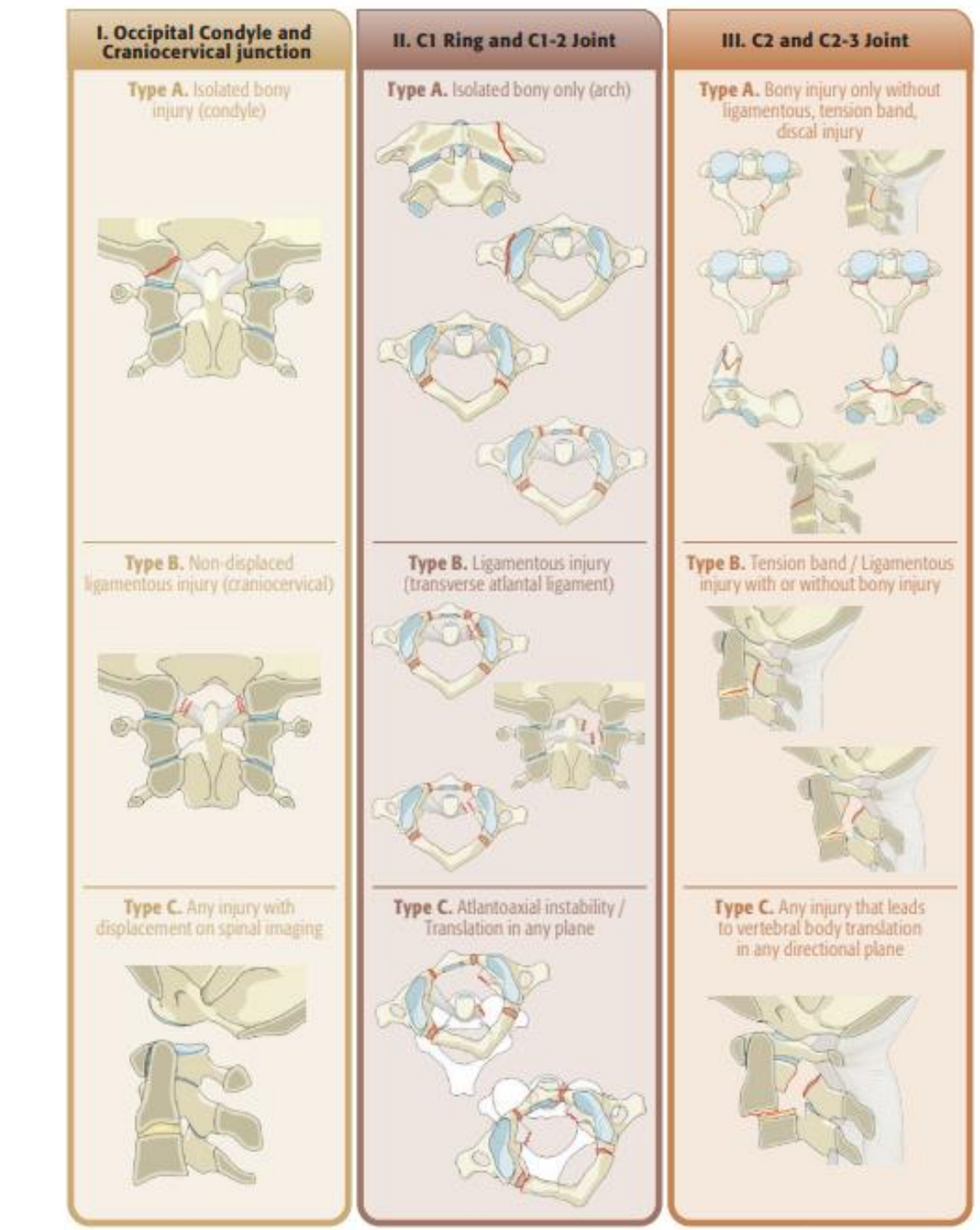
Ligamentous injury

MRI for evaluation of soft tissues

Spinal Cord Injury

Classifications and Scoring of Spinal Injuries

Upper Cervical Spine 1



Upper Cervical Spine 2

AOSPINE

AOSpine Upper Cervical Classification System

Upper Cervical Spine Fractures Overview

I. Occipital condyle and occipital cervical joint complex injuries

II. C1 ring and C1-2 joint complex injuries

III. C2 and C2-3 joint complex injuries

Type A.
Bony injury only
- Without significant ligamentous, tension band, discal injury
- Stable injuries

Type B.
Tension band/ligamentous injury
- With or without bony injury
- No complete separation of anatomic integrity
- Stable or unstable depending on injury specifics

Type C.
Translation injury
- Any injury with significant translation in any directional plane and separation of anatomic integrity
- Unstable injuries

Neurology

Type	Neurological
N0	Neurologically intact
N1	Transient neurologic deficit
N2	Radiculopathy
N3	Incomplete Spinal cord injury
N4	Complete spinal cord injury
NX	Unexaminable patient
+	Continued spinal cord compression

Modifiers

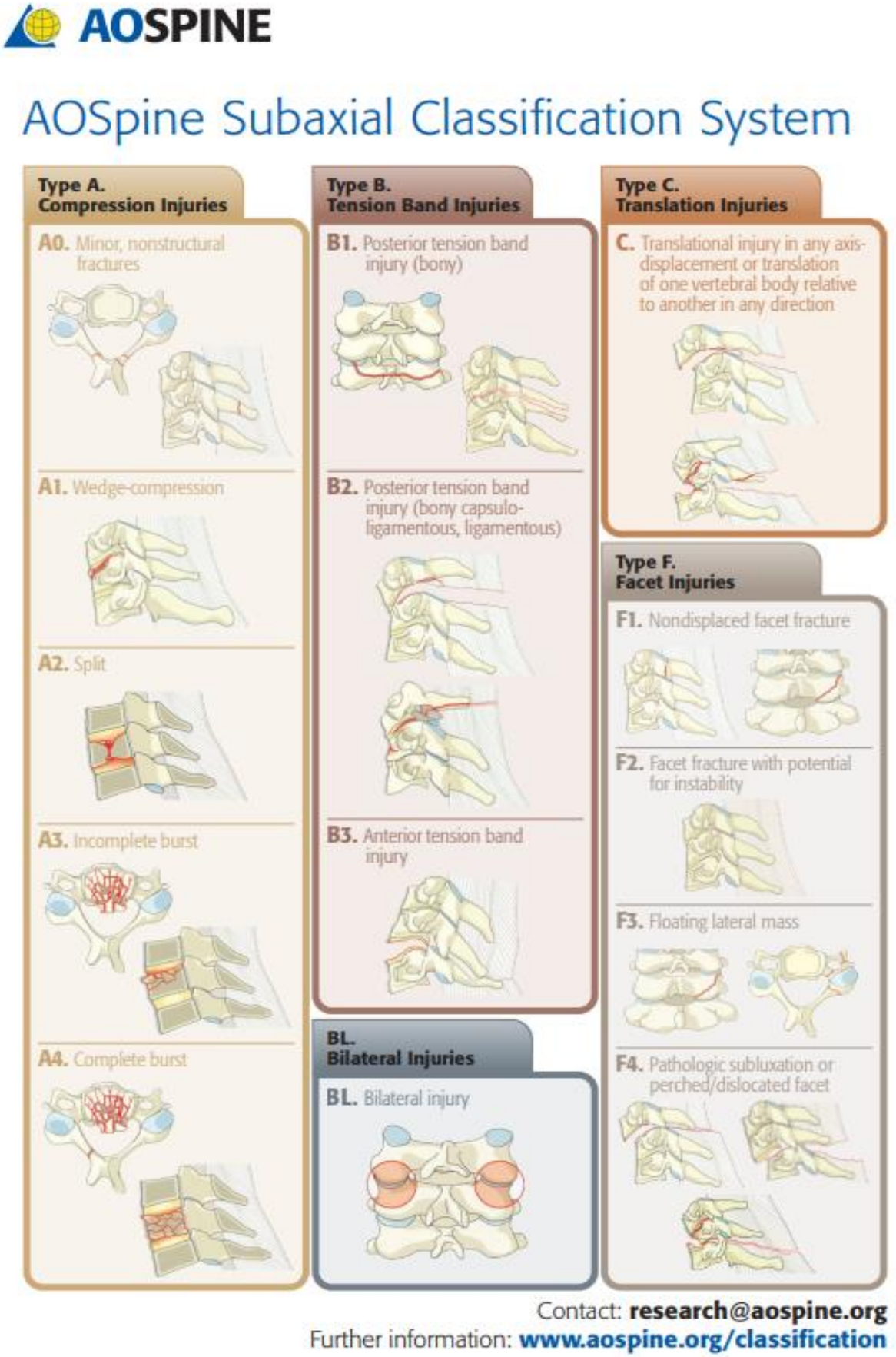
Type	Description
M1	Injuries at High Risk of Non-Union with Nonoperative Tx
M2	Injury with significant potential for instability
M3	Patient Specific Factors Affecting Tx
M4	Vascular Injury or Abnormality Affecting Tx

Classification nomenclature

Atlanto-occipital dissociation with a complete spinal cord injury.

Primary injury → **OC Type C, N4** ← Neurologic status and modifiers

Subaxial Cervical Spine 1

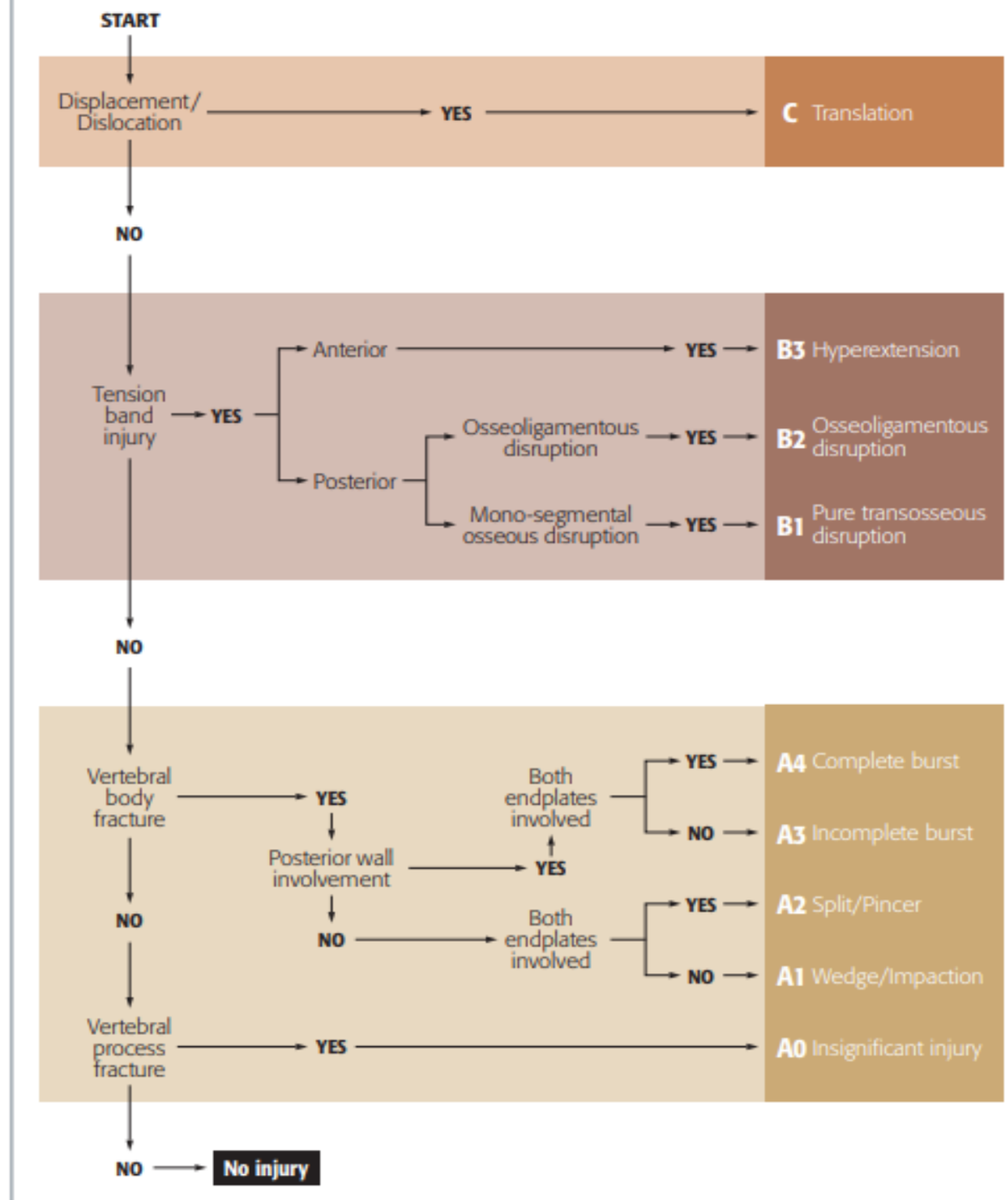


Subaxial Cervical Spine 2

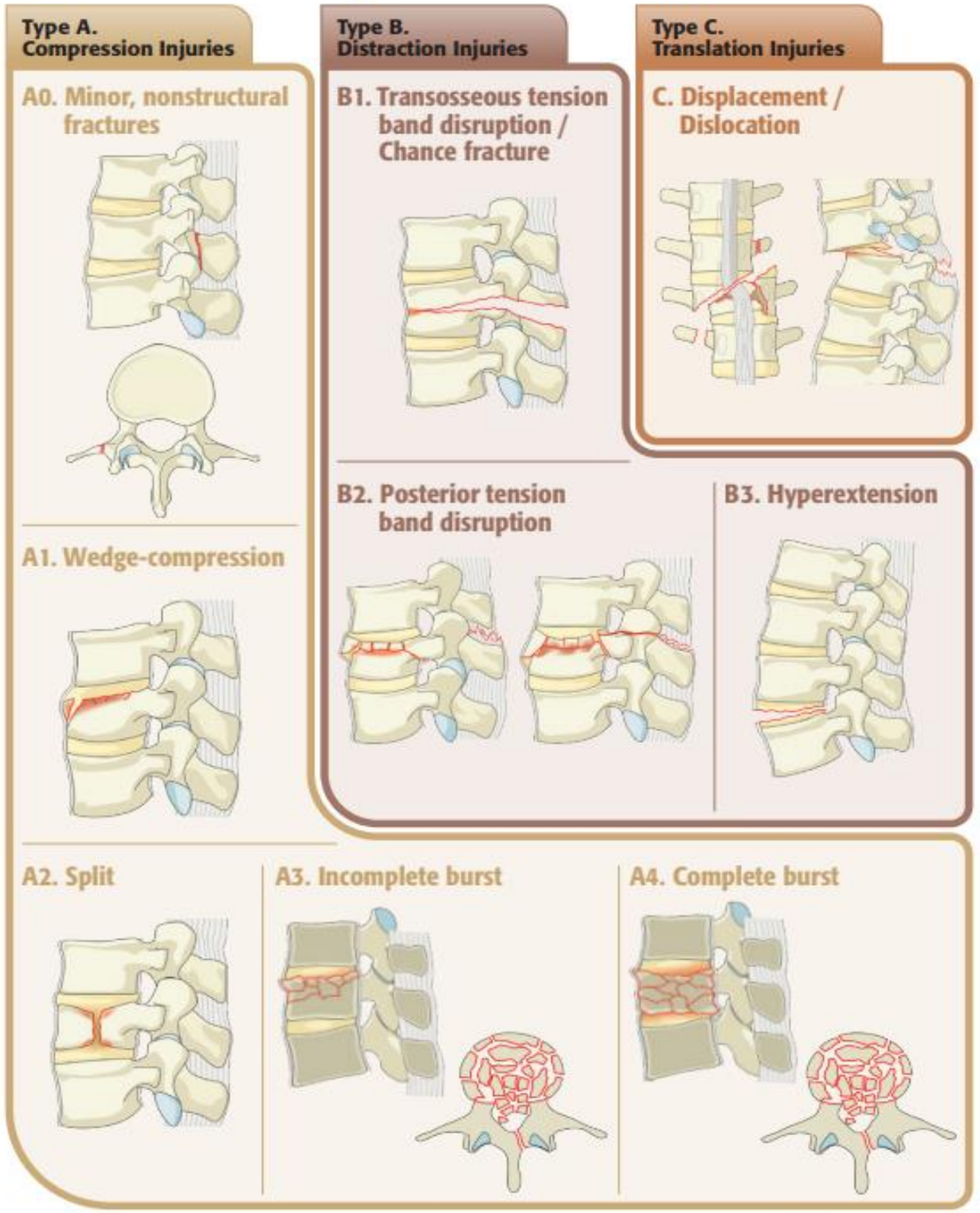
AOSPINE

AOSpine Subaxial Classification System

Algorithm for Morphologic Classification



Thoraco/Lumbar Spine 1

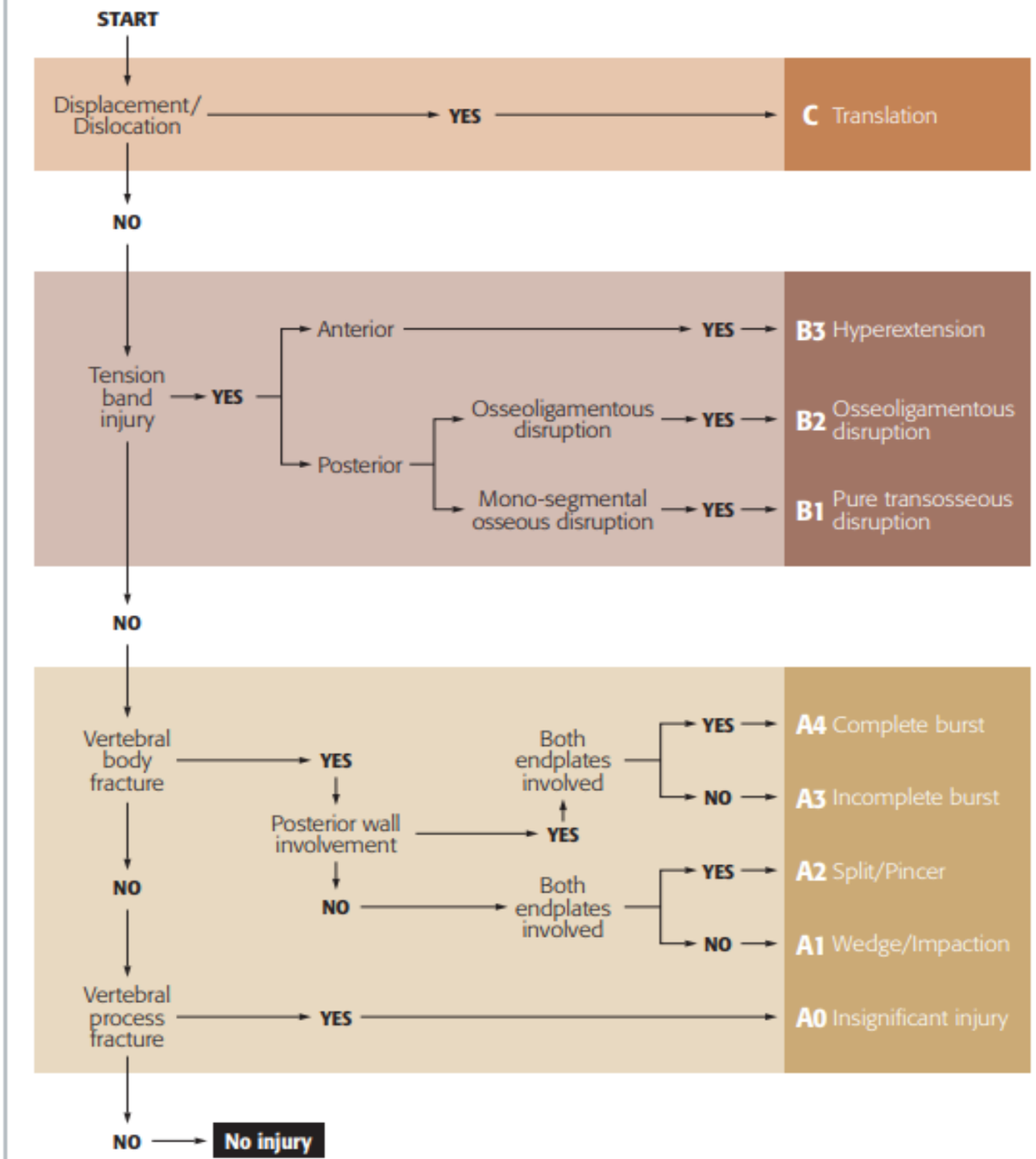


Thoraco/Lumbar Spine 2

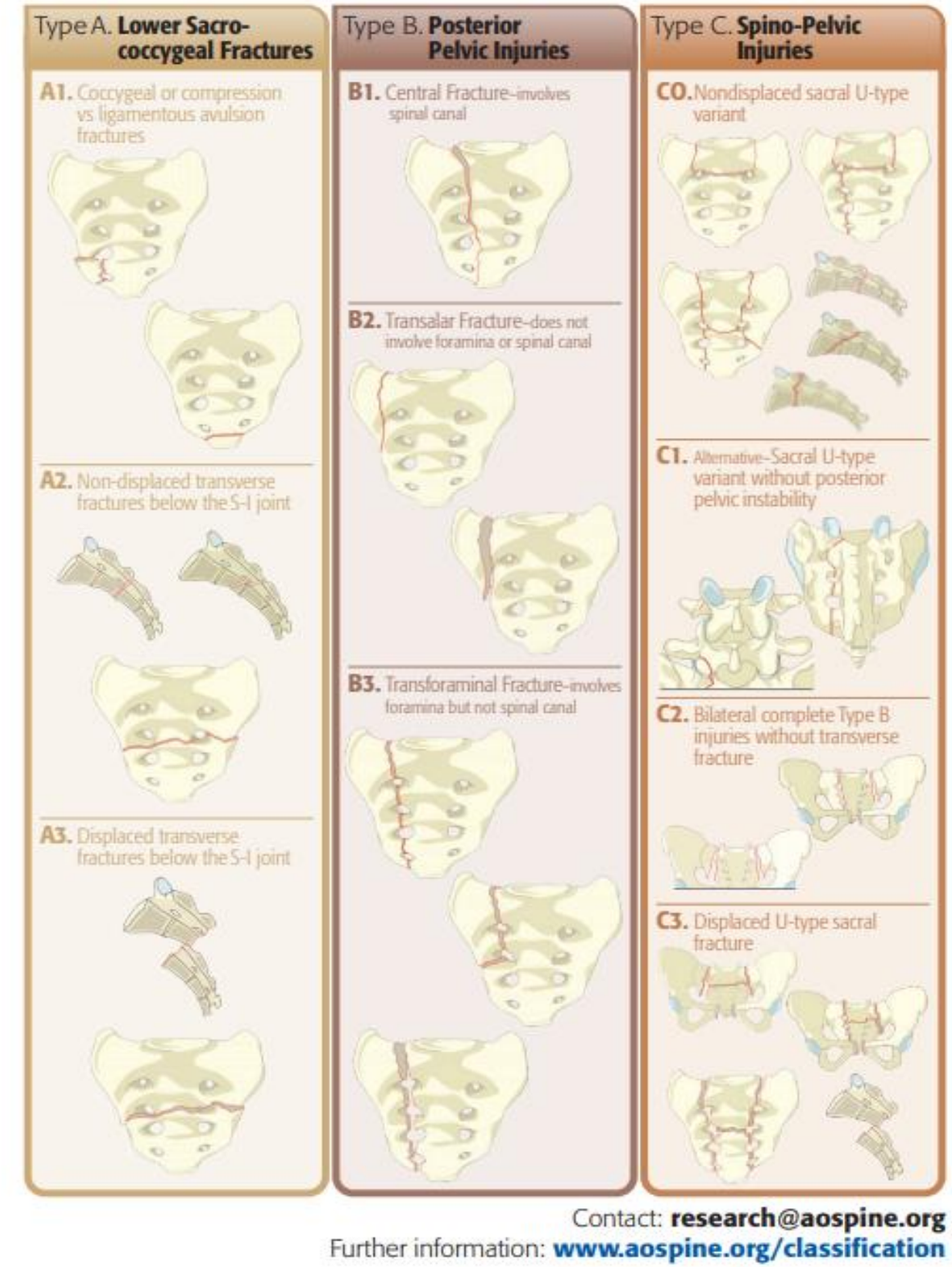
AOSPINE

AOSpine Thoracolumbar Classification System

Algorithm for Morphologic Classification



Sacral Spine 1



Sacral Spine 2

AOSPINE

AOSpine Sacral Classification System

Sacral Fractures–Overview

Hierarchical system progressing from least to most unstable

- **Type A. Lower Sacrococcygeal Injuries**
  No impact on posterior pelvic or spino-pelvic instability
- **Type B. Posterior Pelvic Injuries**
  Primary impact is on posterior pelvic stability
- **Type C. Spino-Pelvic Injuries**
  Spino-pelvic instability

Neurology

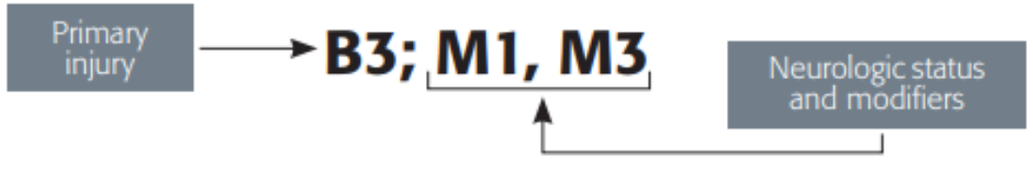
Type	Neurological
N0	No neurological deficits
N1	Transient neurological injury
N2	Nerve root injury
N3	Cauda Equina Syndrome/Incomplete SCI
N4	Complete SCI
NX	Cannot be examined
+	Continued spinal cord compression

Modifiers

Type	Description
M1	Soft tissue injury
M2	Metabolic bone disease
M3	Anterior pelvic ring injury
M4	Sacroiliac joint injury

Classification nomenclature

Transforaminal fracture (B3) high energy injury associated with anterior pelvic ring (M1) and soft tissue injury (M3)



Management of Spinal Cord Injury

Goal of the Treatment

decompression of the nerve elements
restaurate of the stability
restaurate of the spine anatomy
preserv the motion of the spine

Medical treatment of spinal injuries patients

Treatment of cardiovasculat complications:

In traumatic tetraplegia the
thoracolumbar (T1–L2) sympathetic outflow is interrupted, therefore
vagal tone become
unopposed and bradycardia and hypotension can become dominant:

Treat bradycardia under 50Hz and hypotenison
under 90Hgmm

Do not mistake hypotension for loss a fluids and
overinfuse patients in neurogen shock

Apply antiembolism stockings

If there are no medical or surgical
contraindications give lowmolecular weight
heparin within 72 hours

The mortality of polytraumatised patients increases with long surgical times, metabolic acidosis, hypothermia and coagulopathy

“damage control” principle- decrease surgical time thereby decreasing the systemic inflammatory response syndrome **(SIRS)**

Damage control principles

Timing is important for incomplete spinal cord lesions, surgery can improve neurological deficits

In case of complete lesion decompression and fixation should be also considered

Optimal intensive care circumstances can be made possible

Secondary systemic inflammatory reaction can be decreased

Damage control principles

Surgical indications for early spine surgery

- Neurological motor deficit (progressive paralysis)
- Spinal canal stenosis, secondary
  spinal cord damage
- Unstable spine fracture
- Open spine injury

Upper Cervical Spine Injury

Craniovertebral Junction Trauma Classification

1. Occipital condyle fractures
2. Atlanto-occipital dislocation
3. C1 fracture
4. Atlanto-axial instability (anterior, rotatory)
5. C2 fractures (dens, hangman’s fracture, complex fractures)

Determining factors for management planning

- Reducability
- Localisation of lesion (direction, extent)
- Etiology of lesion

Balance of proper decompression and instability

Difficulties in case of Injury of Craniocervical junction

- Hypermobility with heavy physiological load
- Diagnosis not easy – instability?
- No standardised treatment because of the special anatomy

Clinical Manifestation

- Asymptomatic
- Neural compression
  - Headache, neck pain
  - Dizziness, ataxia, gait disturbance
  - Diplopia, dysphagia
  - Tinnitus, nystagmus
- Elevated ICP
- Sudden death

Rare injury

Survival: rare

Autopsy results of MVA show 10% incidence

Serious neurological deficit

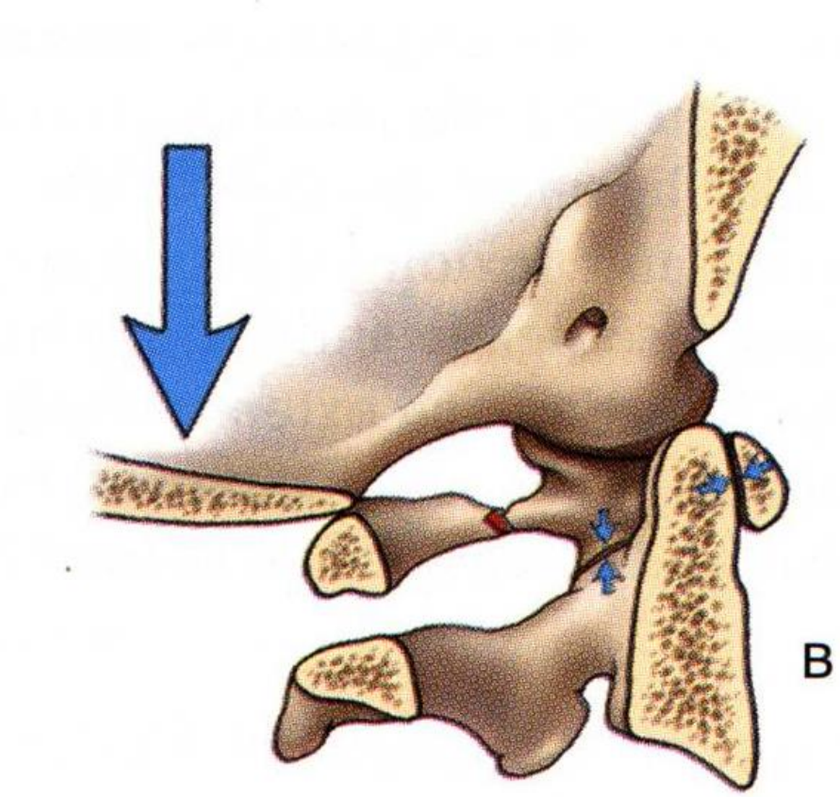
More common in children

Atlanto-occipital dislocation

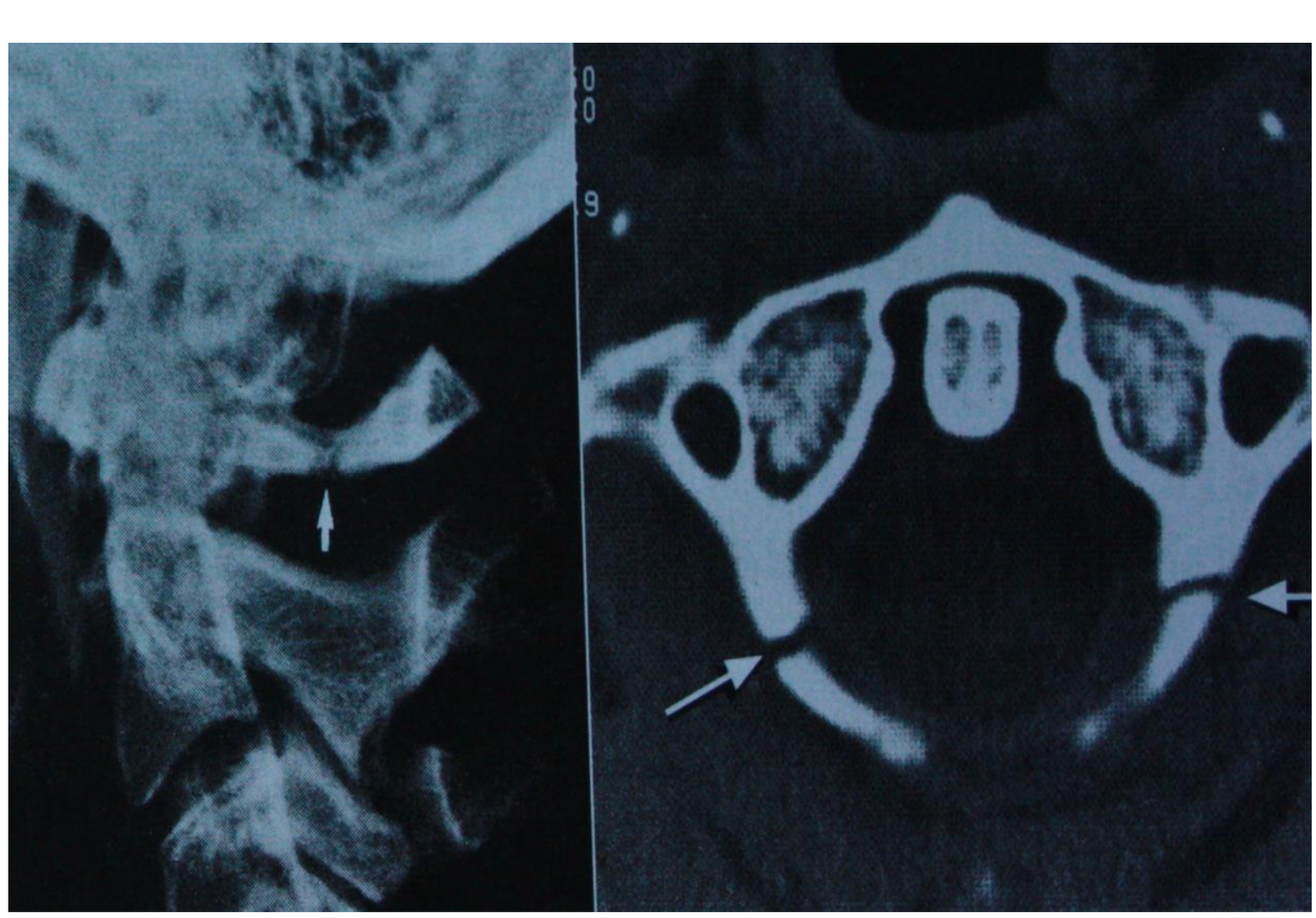
Classification of C1 fracture by Gehweiler

- I./ Isolated fracture of the anterior arch
- II./ Isolated fracture of the posterior arch
- III./ Combined ant.+post. arch fracture „Jefferson”
- Isolated fracture of the lateral mass
- Isolated fracture of the transverse process

Type II.
Posterior arch fracture

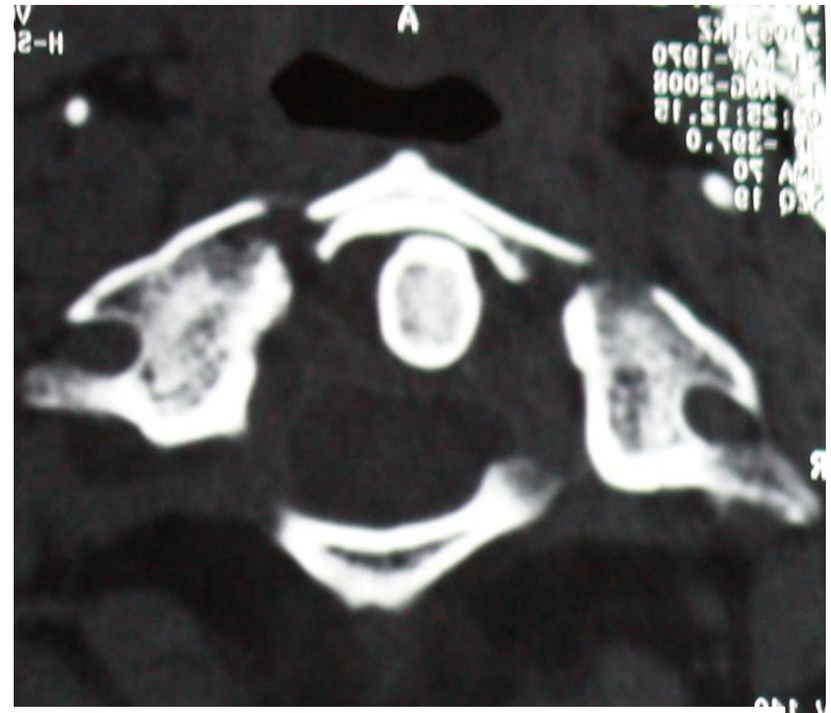


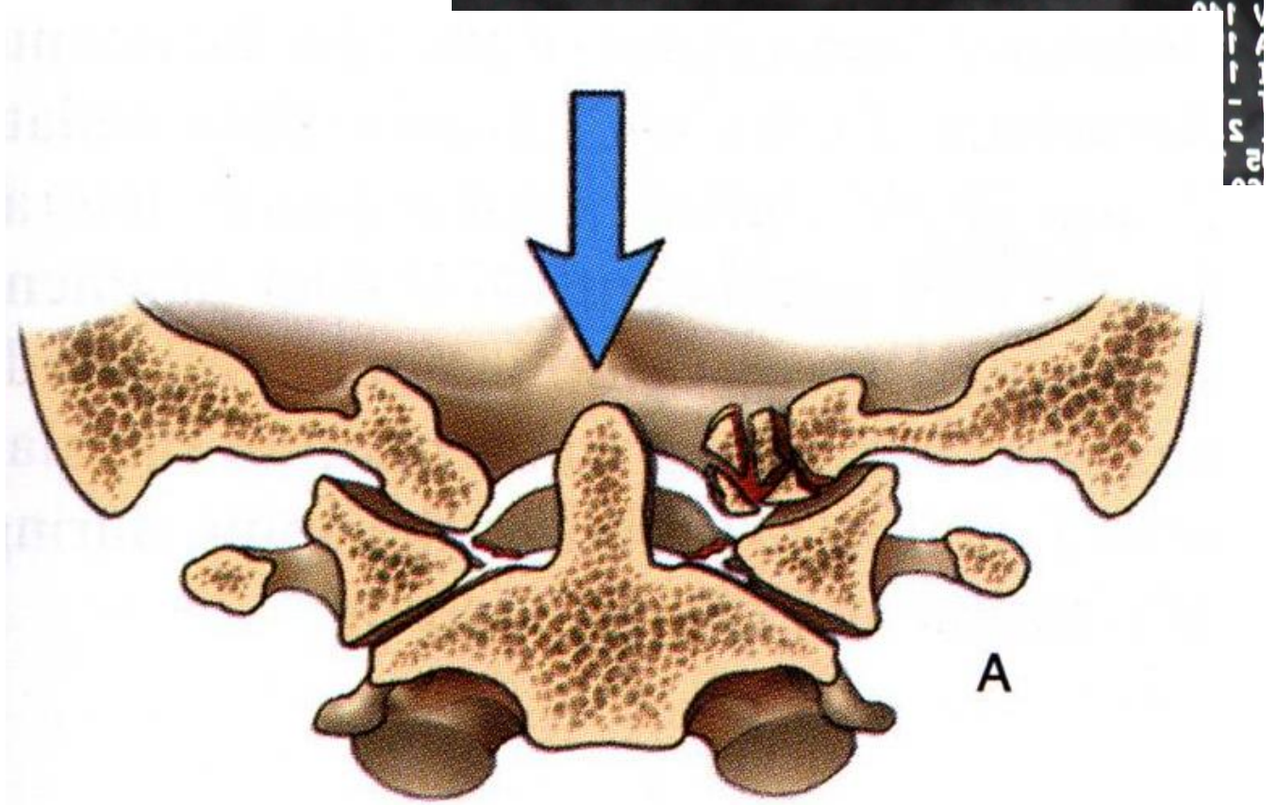
- 2% of all cervical spine injury
- Bilateral weakest point: sulcus of the vertebral artery
- Hyperextension combined axial compression
- Usually with dens fracture



Type III.
Ant.+Post.arch Fracture/Jefferson

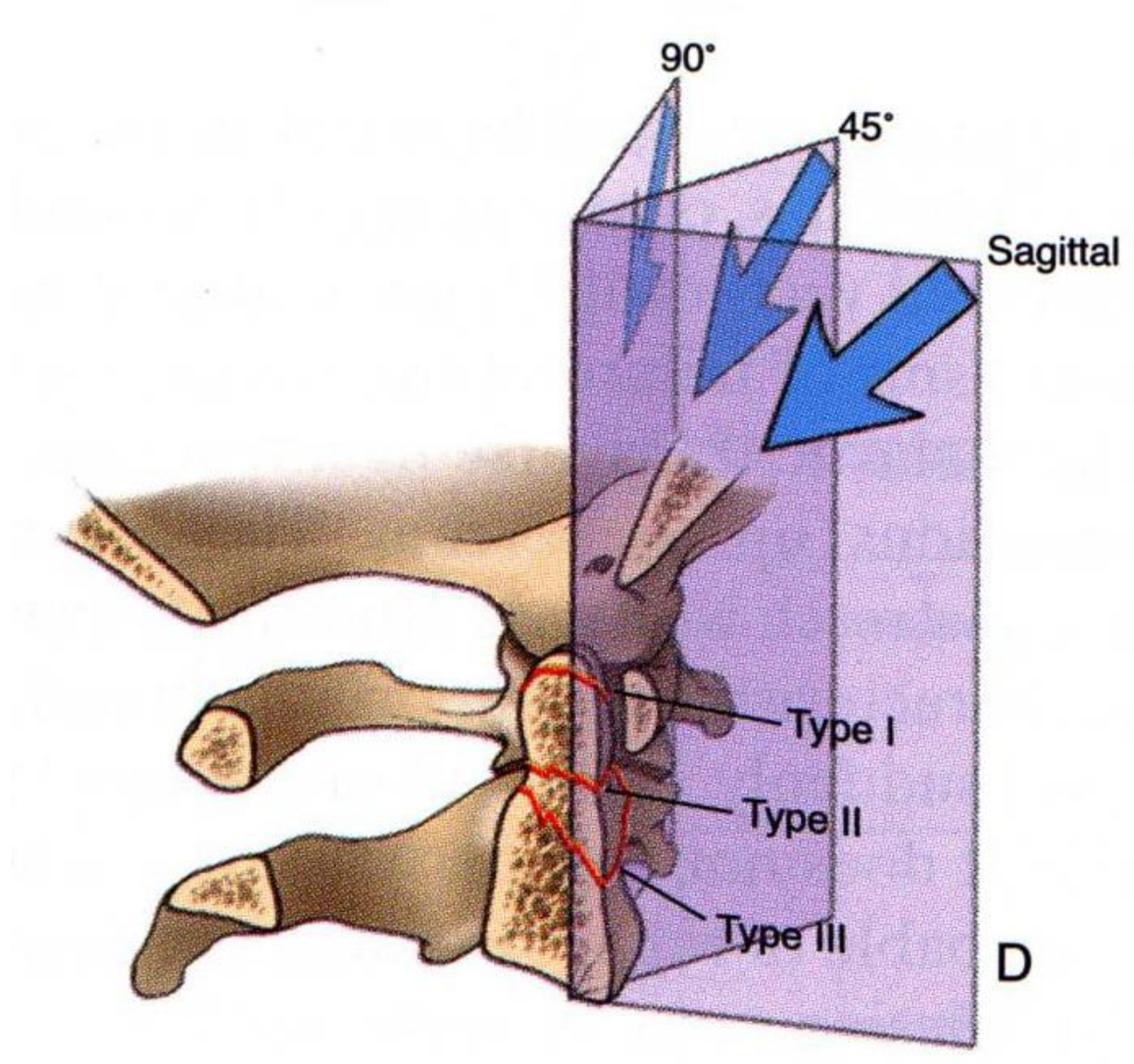
- 2% of all injury of the cervical spine
- Axial compression
- Lateral dislocation of the lateral masses
- May combine with the transverse ligament avulsion





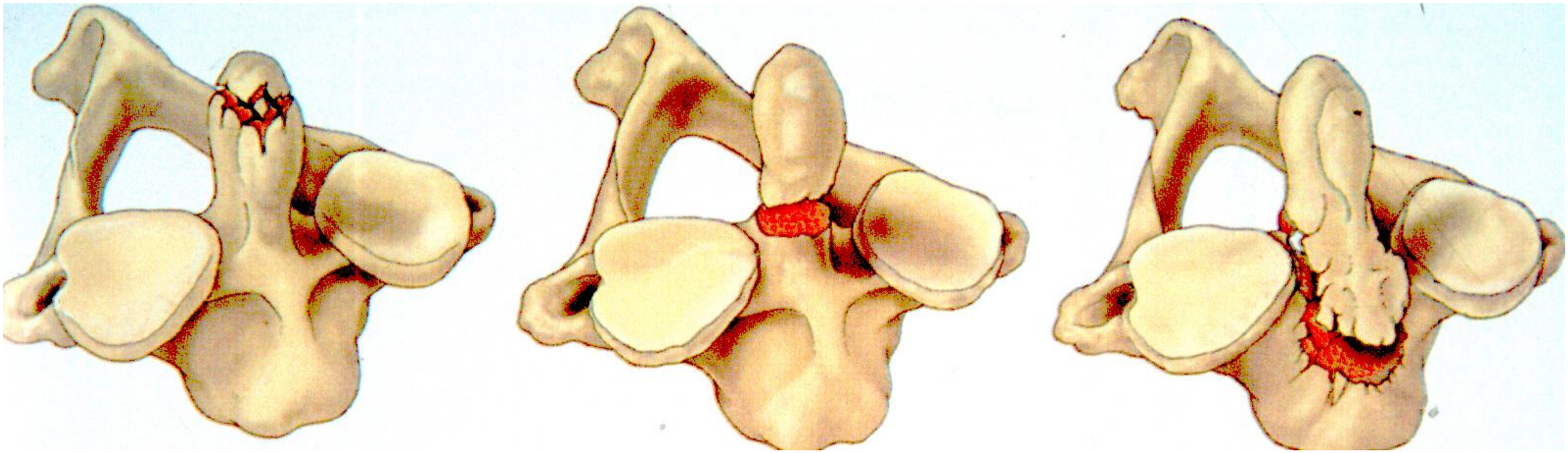
Dens fractures

- 18% of cervical spine fractures
- 25-40% die at site of accident
- 20% have neurological signs
- 45% neck pain is the only symptom
- Unknown % : unrecognised



Dens fractures

Anderson-D'Alonso classification



I. typ

II. typ

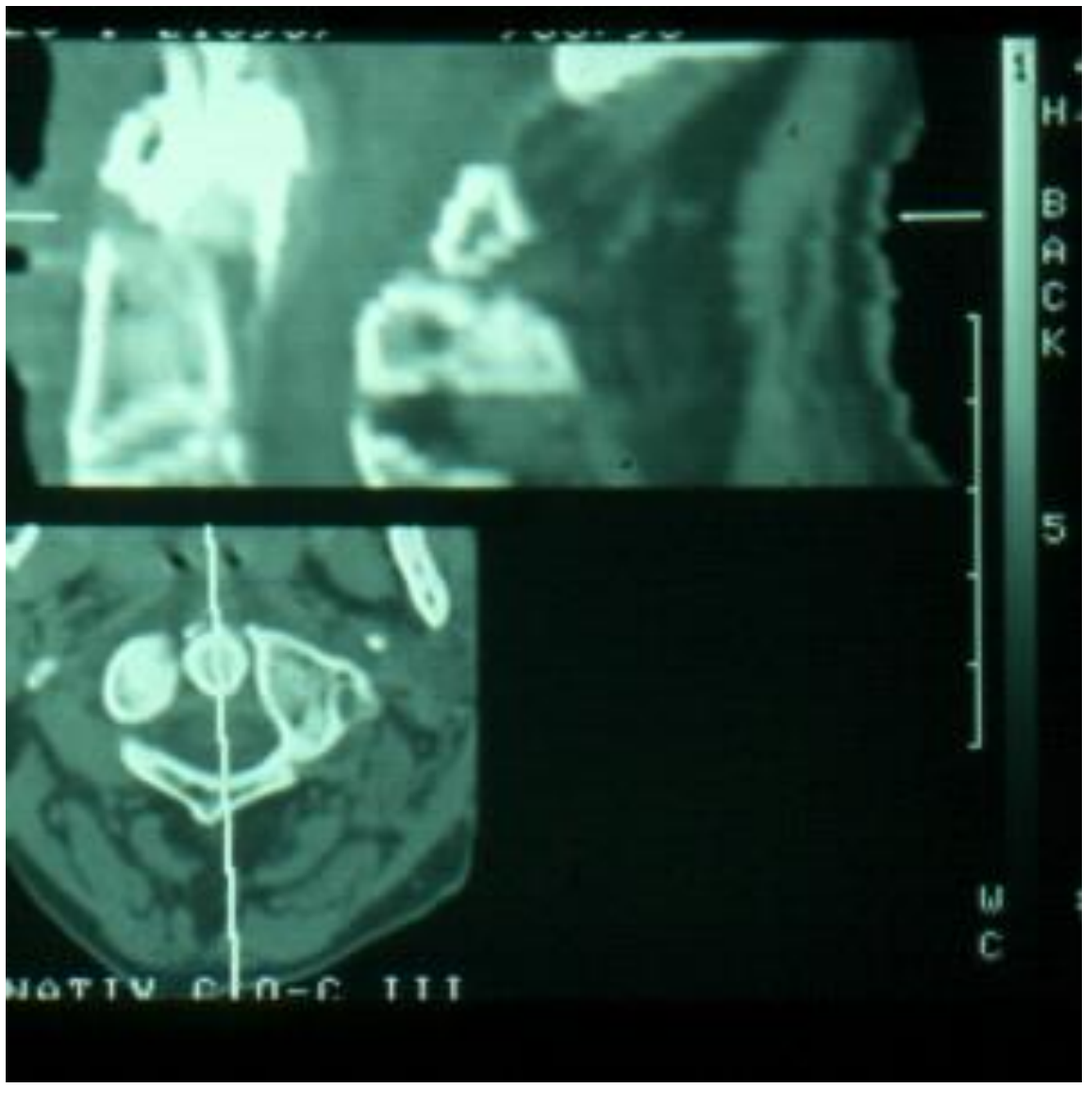
III. typ

Modified Classification of Dens fractures

- Fracture surface orientation and location determine the treatment plan

- **Group A**: oblique-posterior and horizontal
- **Group B**: oblique-anterior

Group A

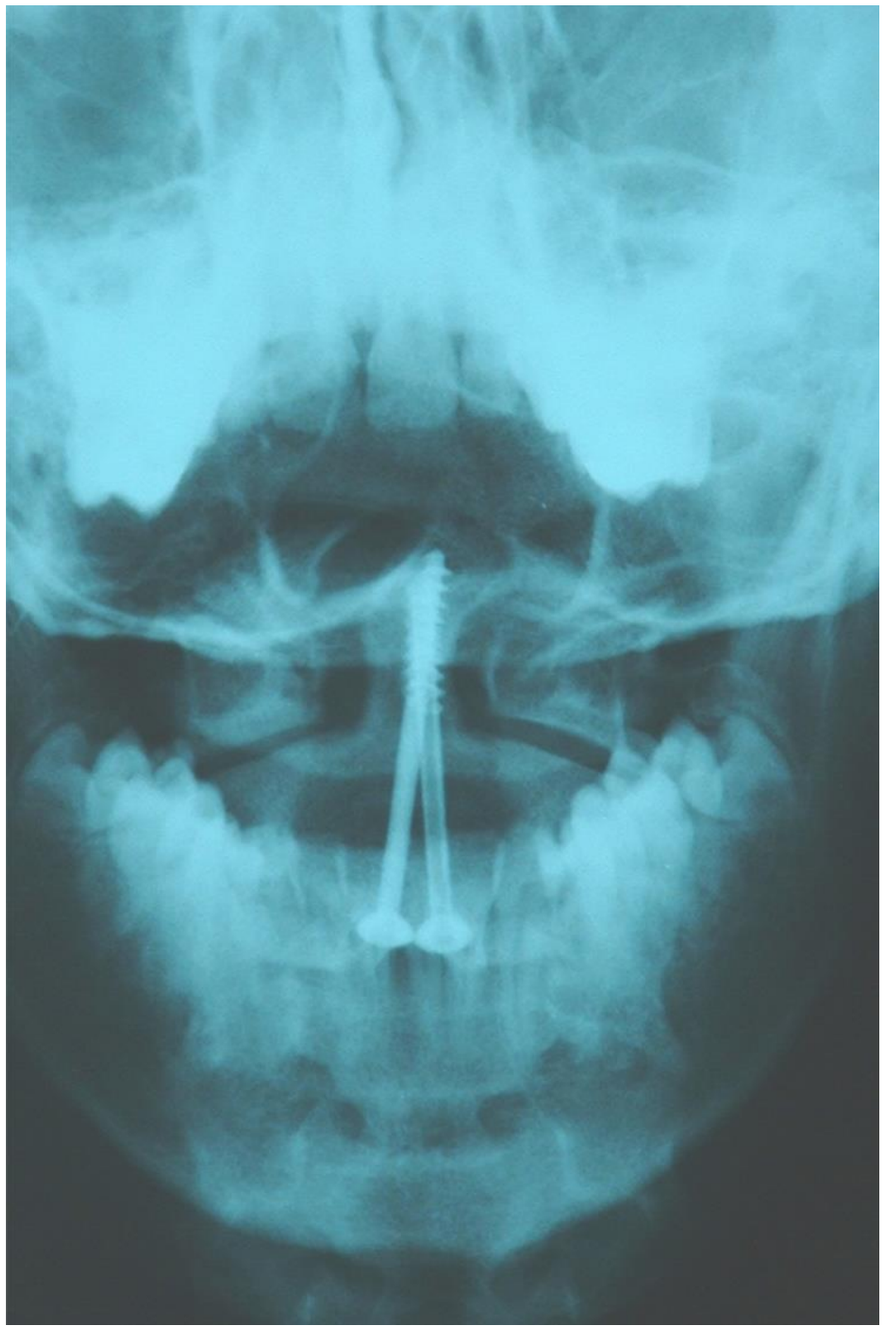


- **Group A**:

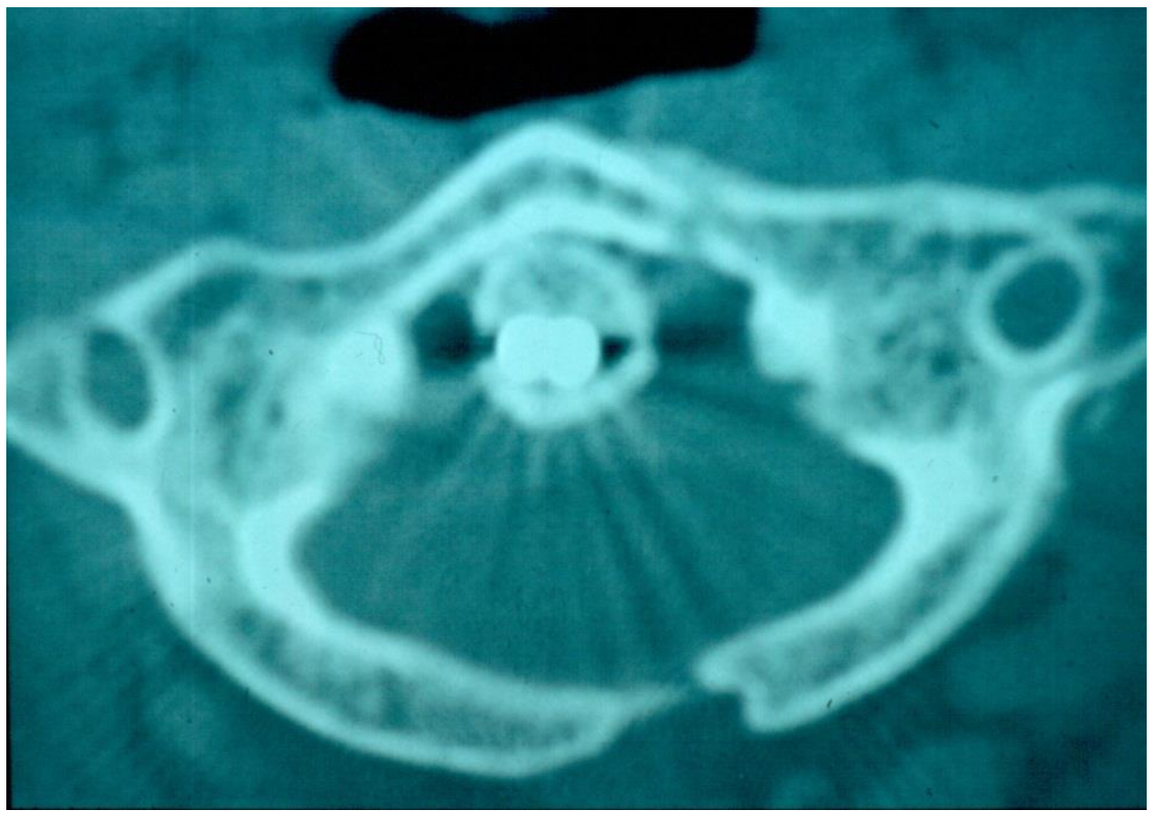
  oblique-posterior and horizontal

<u>Anterior screw fixation is recommended</u>

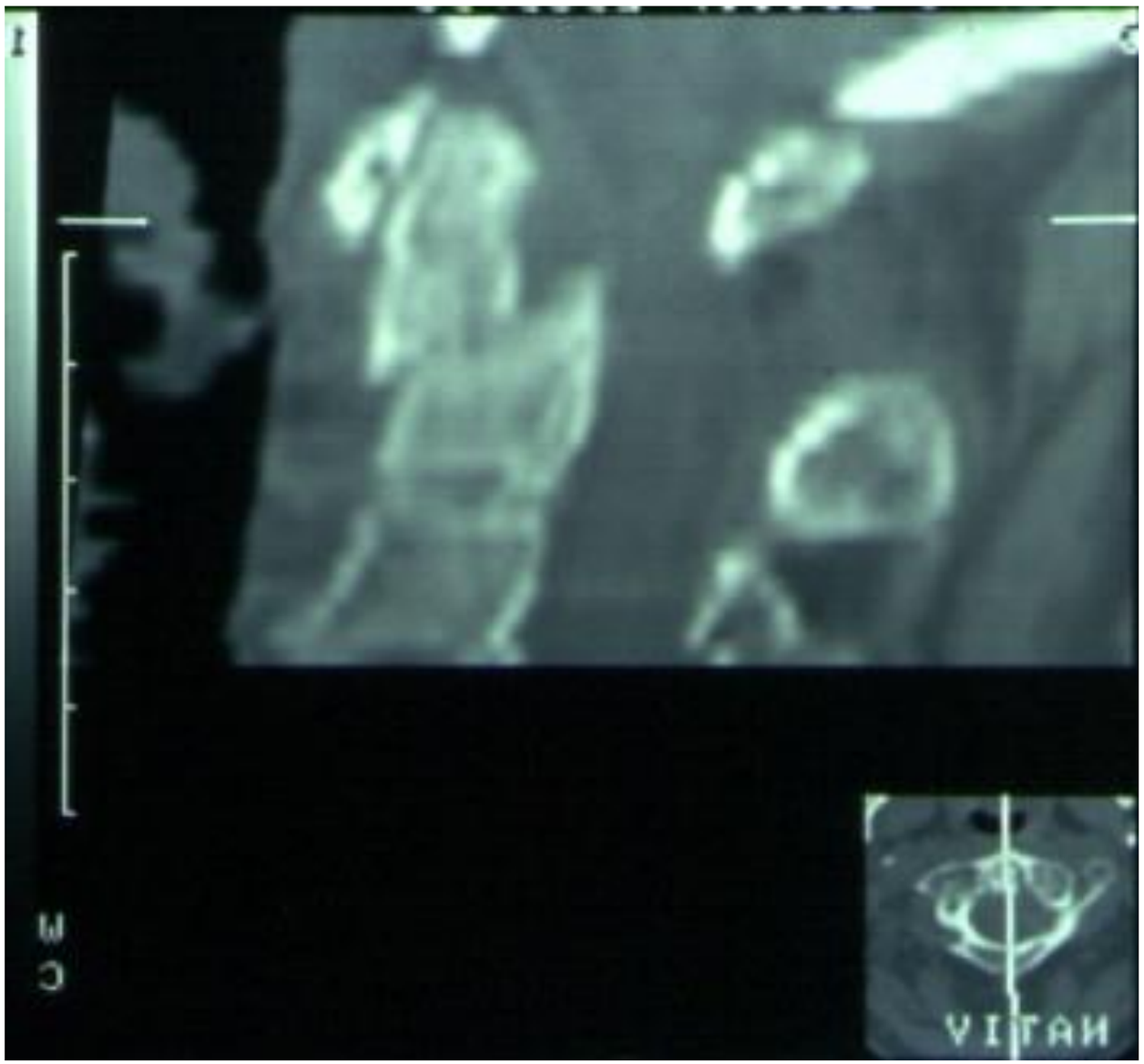
Group A fracture



Group A fracture



Group B



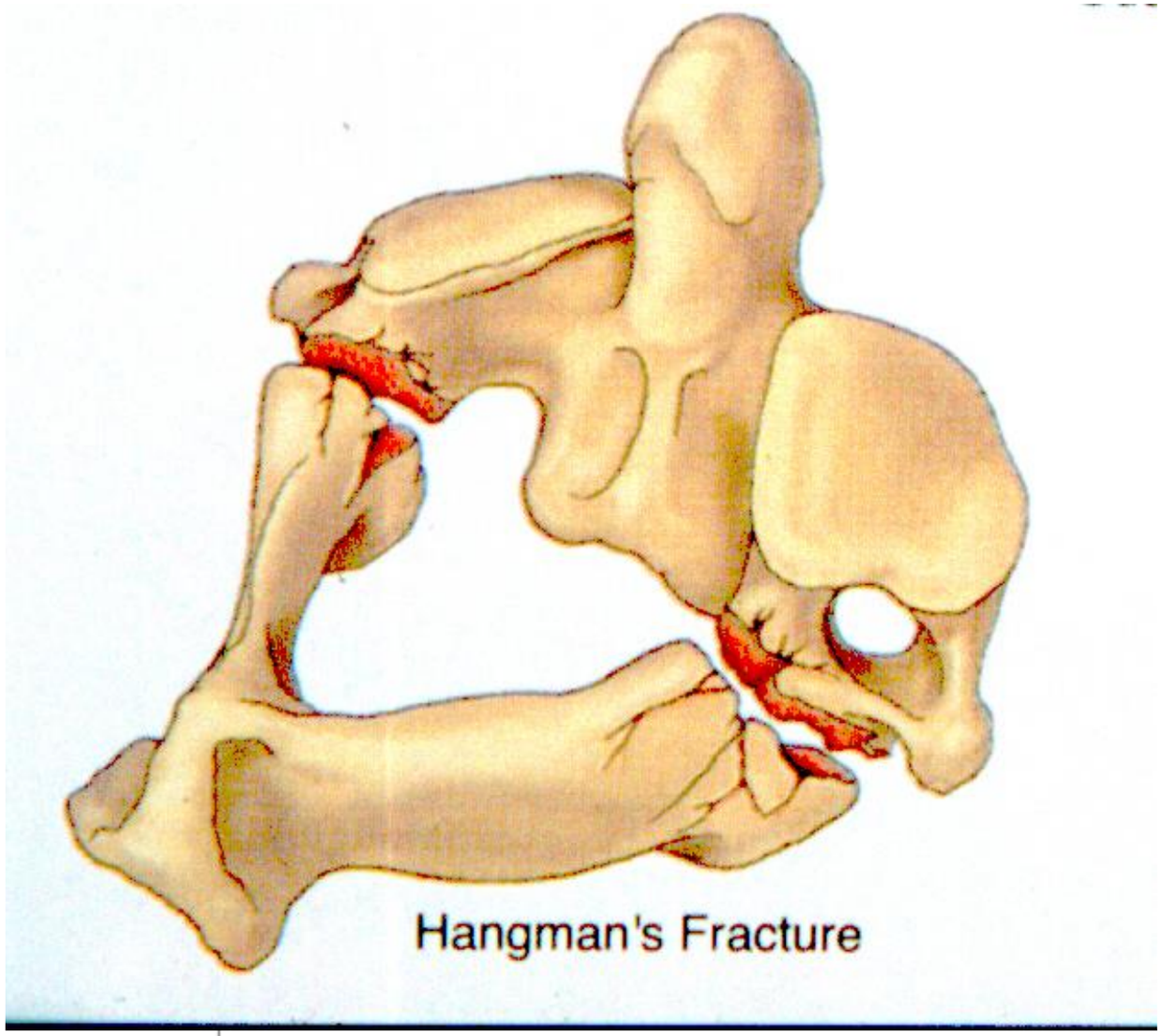
Group B:oblique-anterior

Application of Halo device is recommended

Or posterior C1-C2 fixation

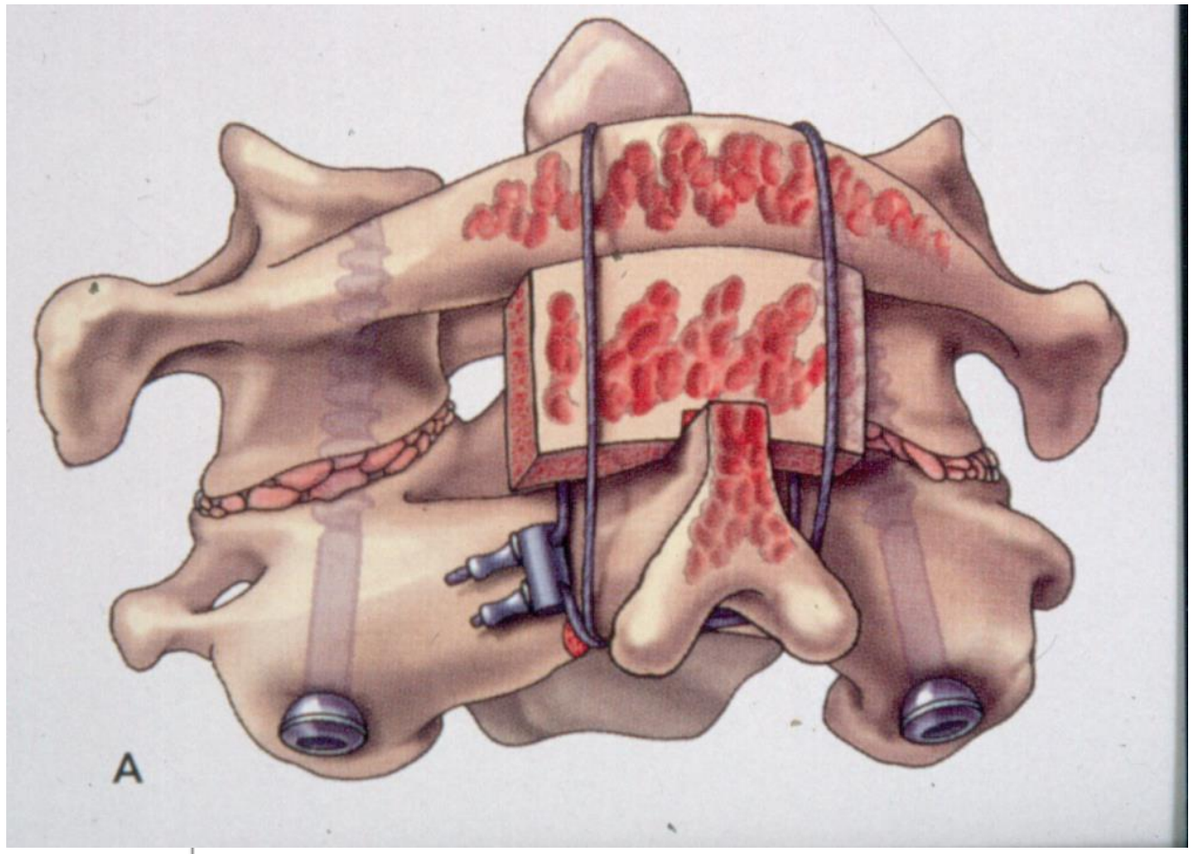
Hangman’s Fractures

- Hangman’s fractures
  - Traumatic C2 spondylolisthesis
  - Hyperextension and axial loading
  - Bilateral fractures of the pedicul
  - Stabil
  - Neurological deficit rear
  - Immobilisation

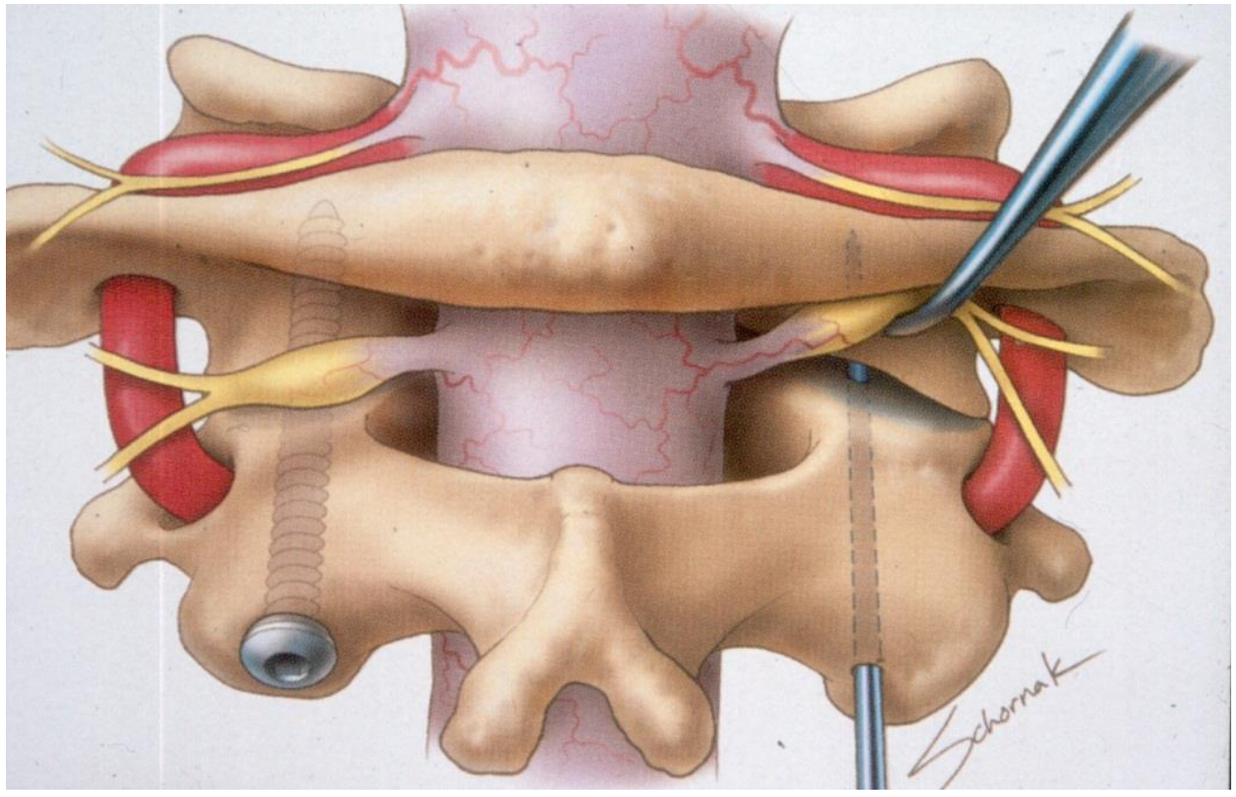


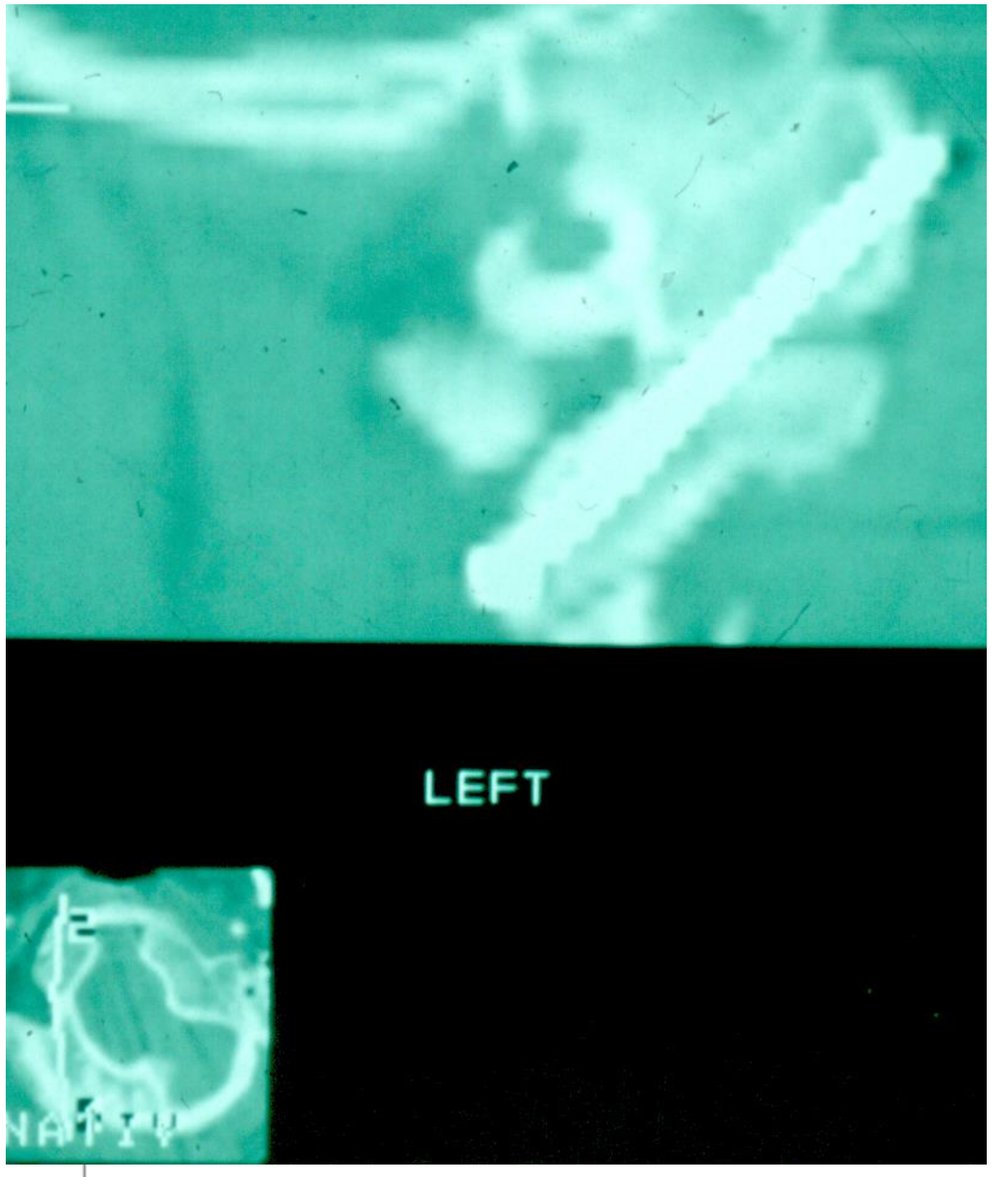
Posterior atlanto-axial Transarticular Screw Fixation (Magerl- Sonntag)

- Reduction:
  - Halo device
  - Prone position
  - Under fluoroscopy control
- Posterior approach
- C1-C2 transarticular screws
- C1-C2 cable, bone graft

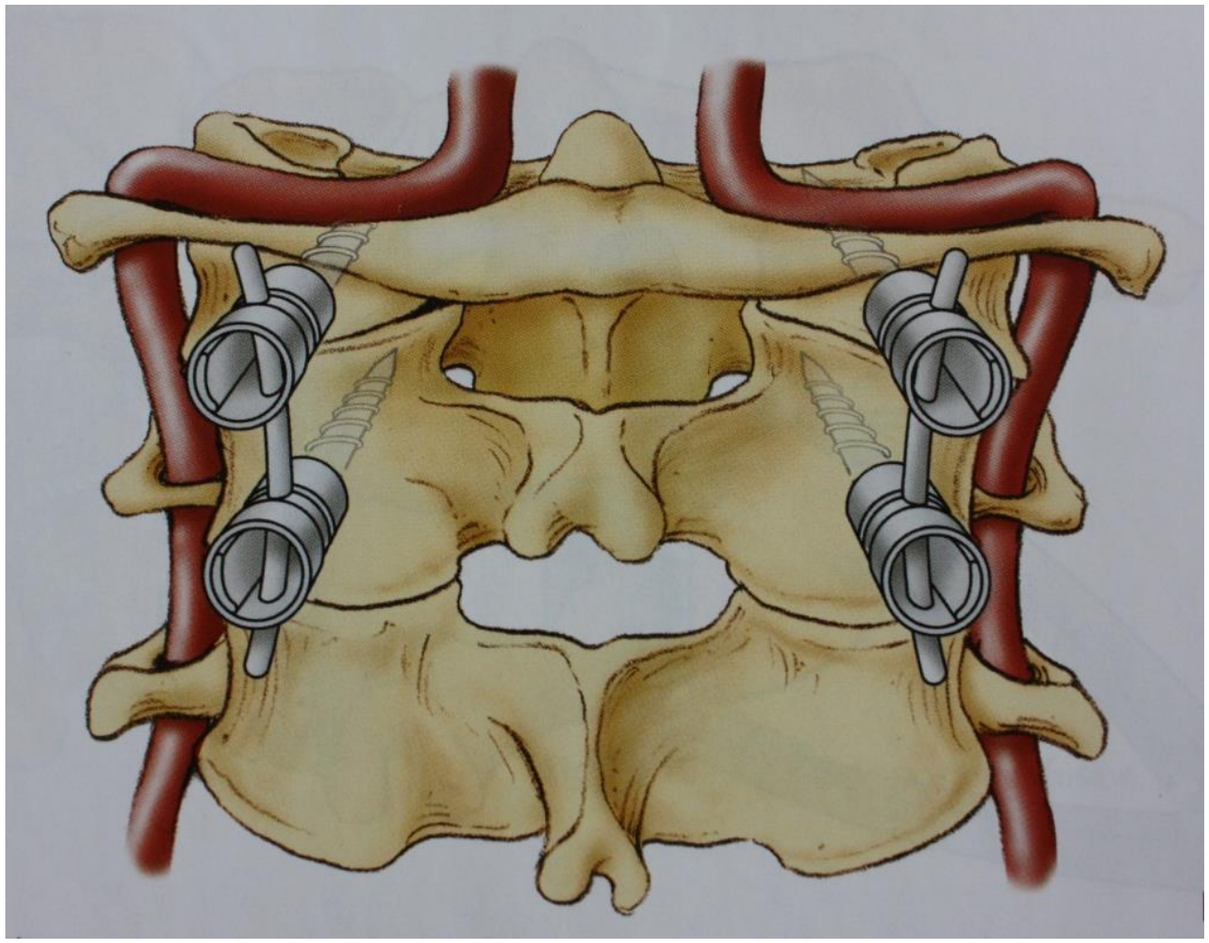


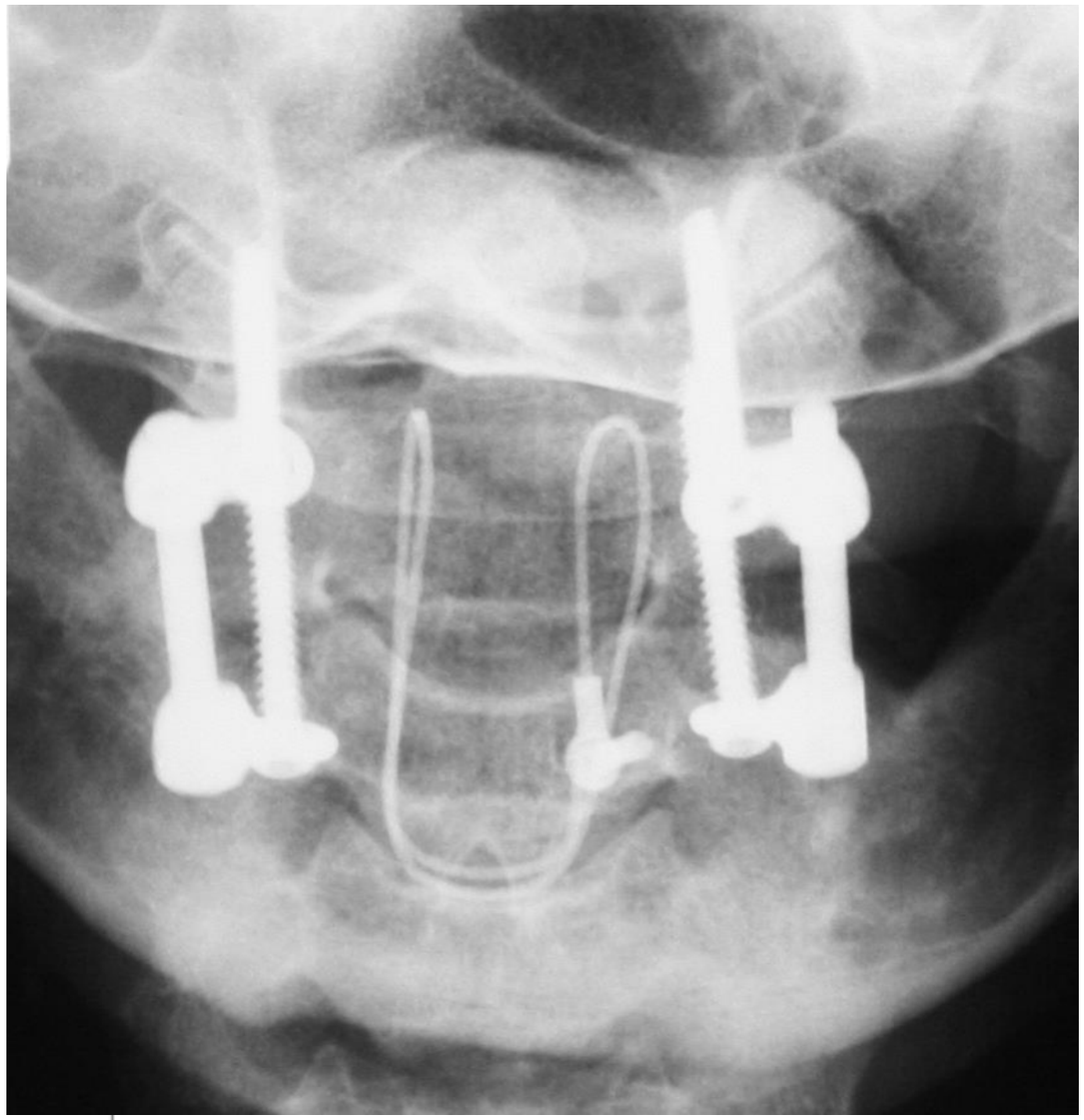
Posterior atlanto-axial Transarticular Screw Fixation (Magerl- Sonntag)



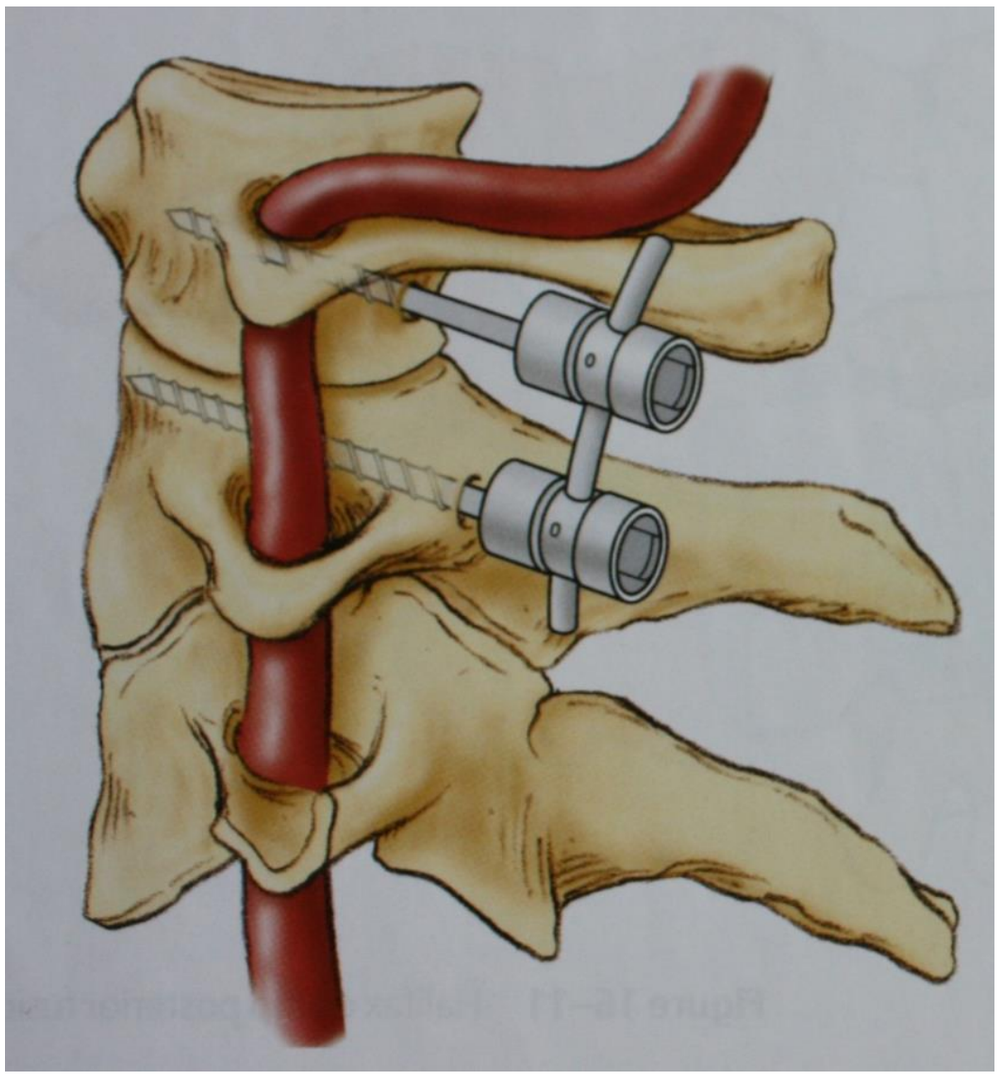


Posterior atlanto-axial Screw Fixation C1-2 according to Harms





Posterior atlanto-axial Screw Fixation C1-2 according to Harms



Subaxial Cervical Spine Injury

- Understand injury pathophysiology and biomechanics
- Fracture classification
- Understand the advantages/ disadvantages of various surgical approaches
- Work within your level of familiarity and experience

Surgical decision making

What is SLIC?

- SLIC is a comprehensive classification system for subaxial cervical trauma
- Addresses the question of whether the patient will benefit from surgery
- Incorporates information about injury pattern, severity, treatment considerations, and prognosis into a unifying scoring system to guide management
- SLIC score is based on the assessment of 3 domains, which are considered independent predictors of clinical outcome:

Morphology of Injury	Disco-ligamentous Integrity	Neurologic Status

SLIC Score

Vaccaro et al Spine 2007; 32 (21) 2365-2374

The Subaxial Injury Classification and Severity Score System (SLIC)

Characteristic	Points
Morphology	
No abnormality	0
Compression	1
Burst	2
Distraction (*e.g.*, facet perch, hyperextension)	3
Rotation/Translation (*e.g.*, facet dislocation, unstable teardrop or advance-staged flexion compression injury)	4
Discoligamentous complex	
Intact	0
Indeterminate (*e.g.*, isolated interespinous widening, MRI signal changes only)	1
Disrupted (*e.g.*, widening of the disk space, facet perch or dislocation, kyphotic deformity)	2
Neurological status	
Intact	0
Root injury	1
Complete cord injury	2
Incomplete cord injury	3
Continuous cord compression in setting of neuro deficit (Neuro Modifier)	1

SLIC Classification

4< non operative
4= operative/nonoperative
4> operative

- SLIC is a valid and reliable tool for the classification of subaxial cervical spine injury

- SLIC is based on the assessment of three domains, which are independent predictors of clinical outcome:

Morphology of Injury	Disco-ligamentous Integrity	Neurologic Status

(Click on links to review)

- The score of each domain is added to give the total SLIC score, which helps determine whether surgery is indicated

SLIC Score

4< non operative
4= operative/nonoperative
4> operative

Why early or urgent decompressive surgery ?

- to prevent deterioration of neurological deficit
- to improve the neurological outcome
-to reduce the length of hospital stay
-to facilitate mobilization
-to reduce the rate of immobilisation complications

Closed reduction

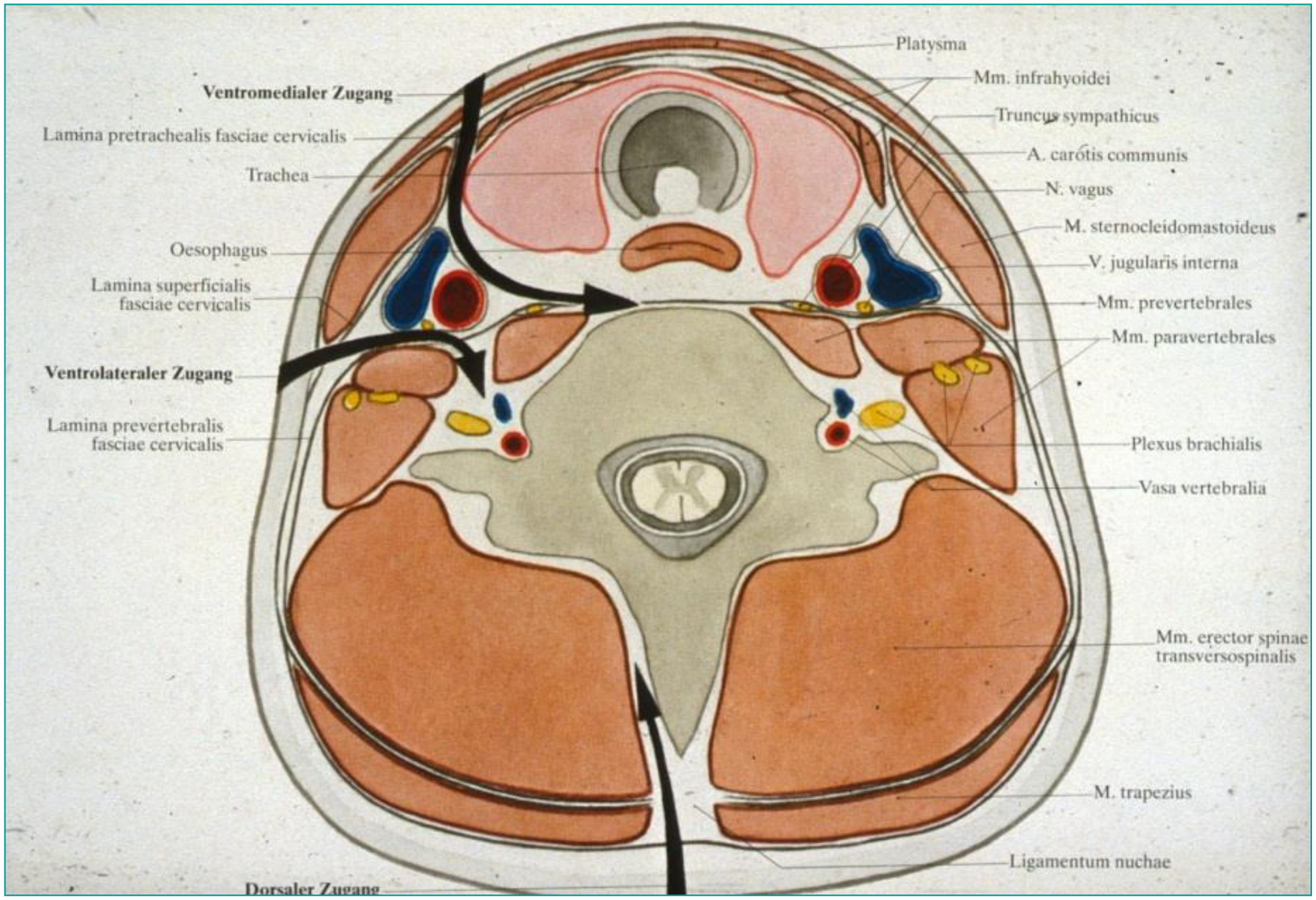
- Fast
- Patient general awake and able to monitor
- After reduction can wait for surgery
- Makes surgery technically easier
- Can have deterioration from overdistraction, unrecognized other injury
- Not always possible
- Will eventually need surgery

Approaches: Options

Anterior
- Midline
- Anterolateral

Posterior
- Midline
- Transmuscular

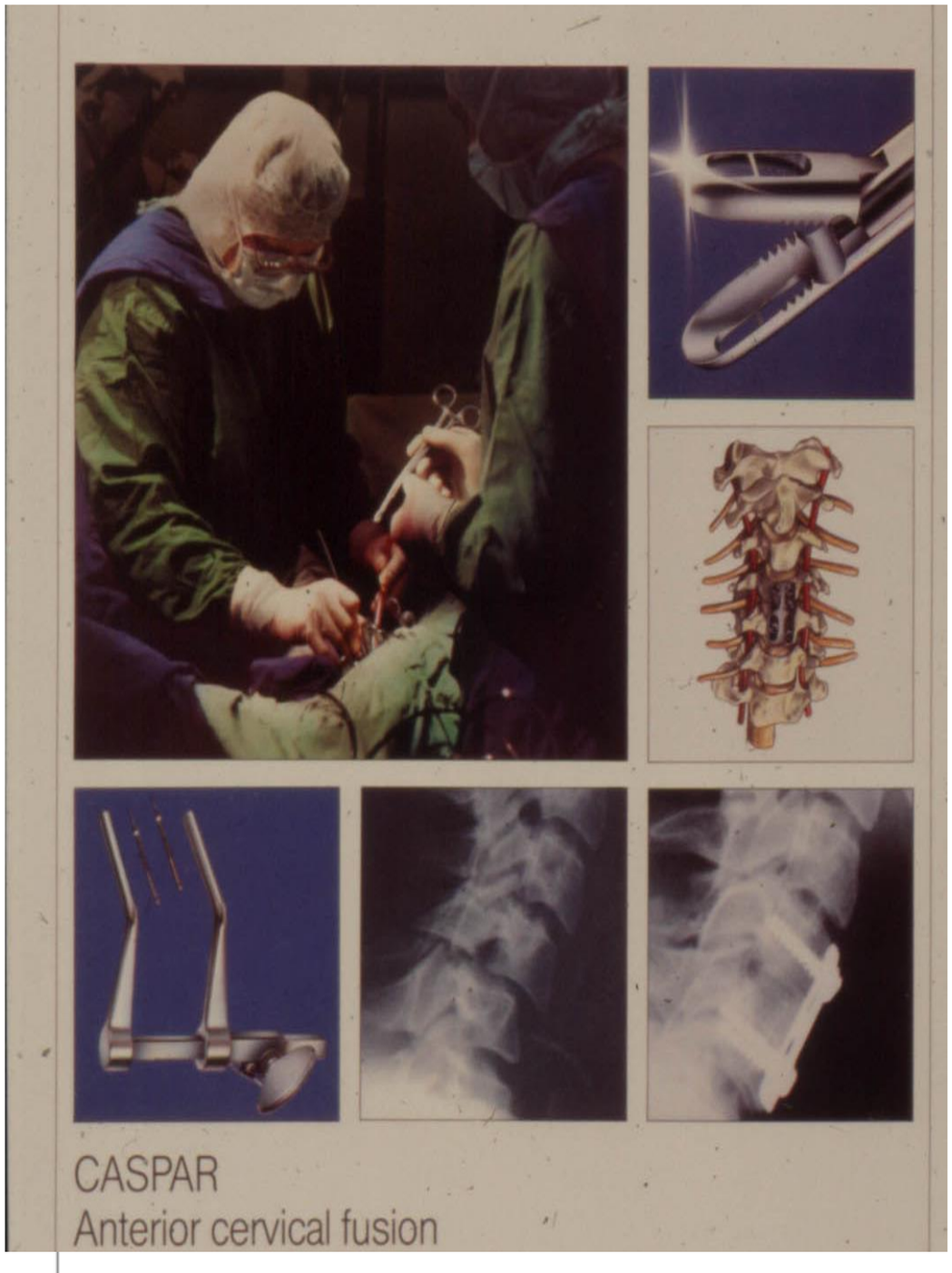
Combined



Classic anterior approach, decompression,
fusion with plate (Caspar)
Posterior approach, reduction, fusion
(screw + plate or rods, frame + cable)
Combined anterior-posterior approach

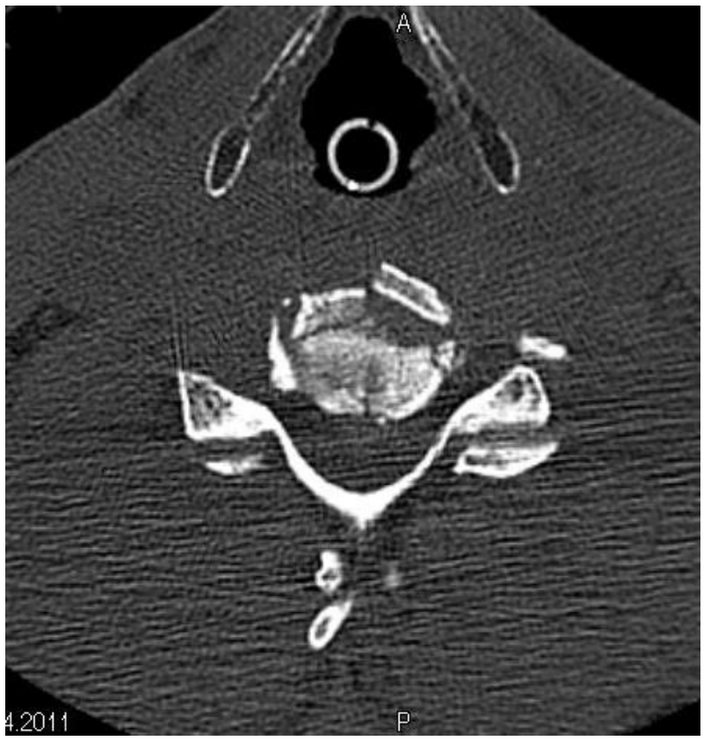
Surgical treatment of subaxial cervical spine

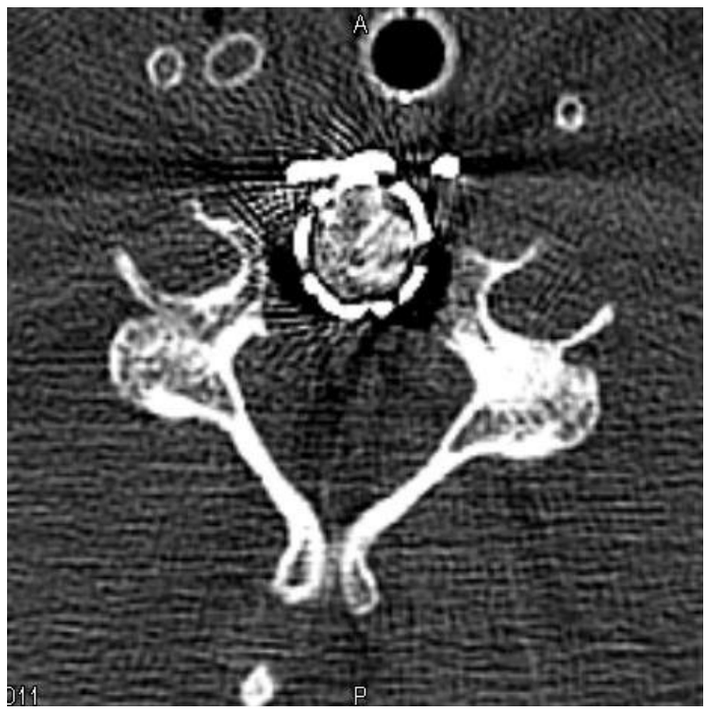
Anterior cervical fusion according Caspar: Gold Standard

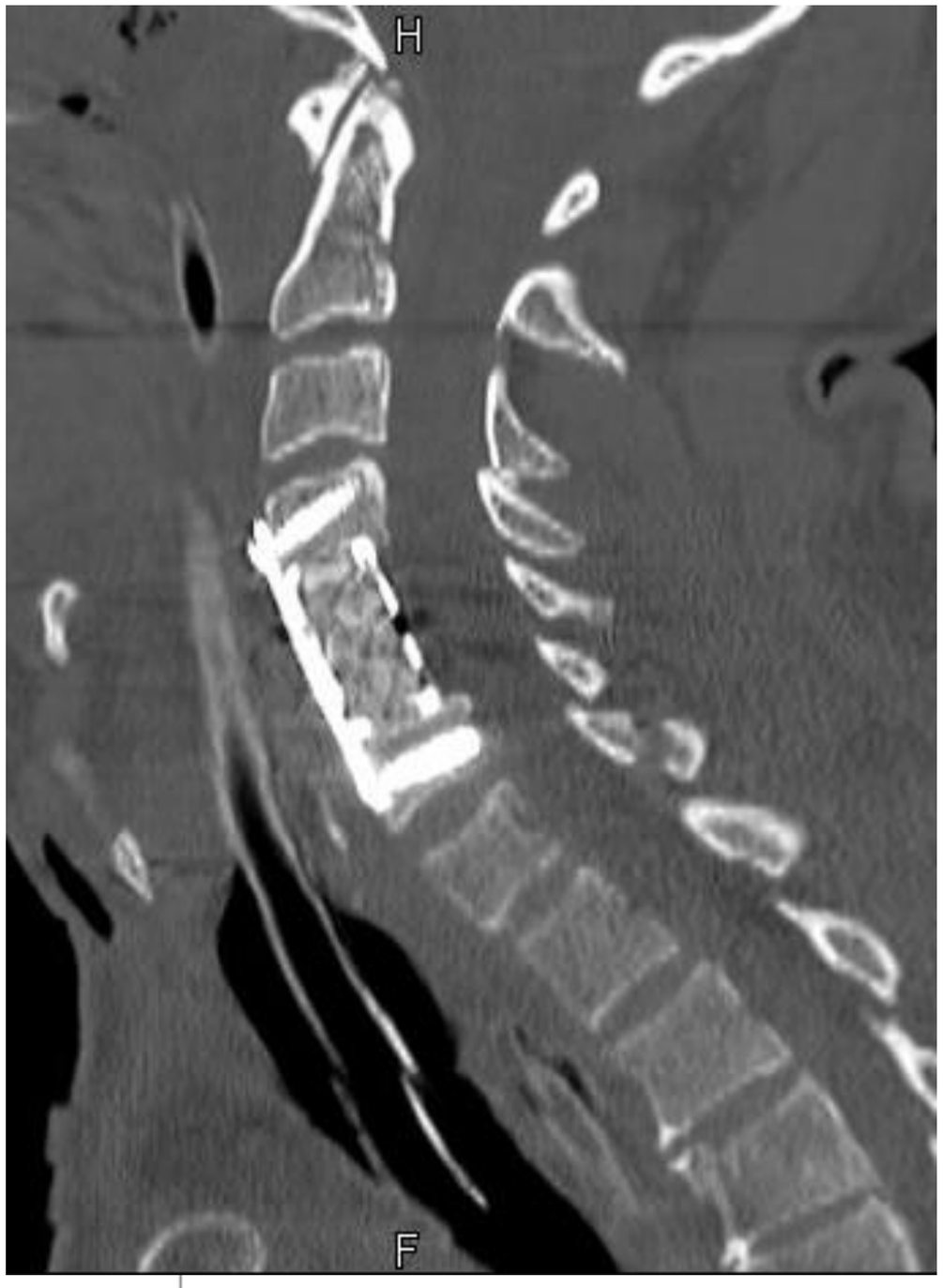


Anterior

C5 AO Type A 4. burst fractures treated with anterior aproach corpectomy







Anterior Approach

Advantages

- Avoid prone positioning
- Disc herniations can be removed
- High fusion rate
- Maintenance of lordosis

Disadvantages

- Biomechanically inferior to posterior approach
- Hoarseness, dysphagia risk
- Risk of failure with endplate/facet fractures

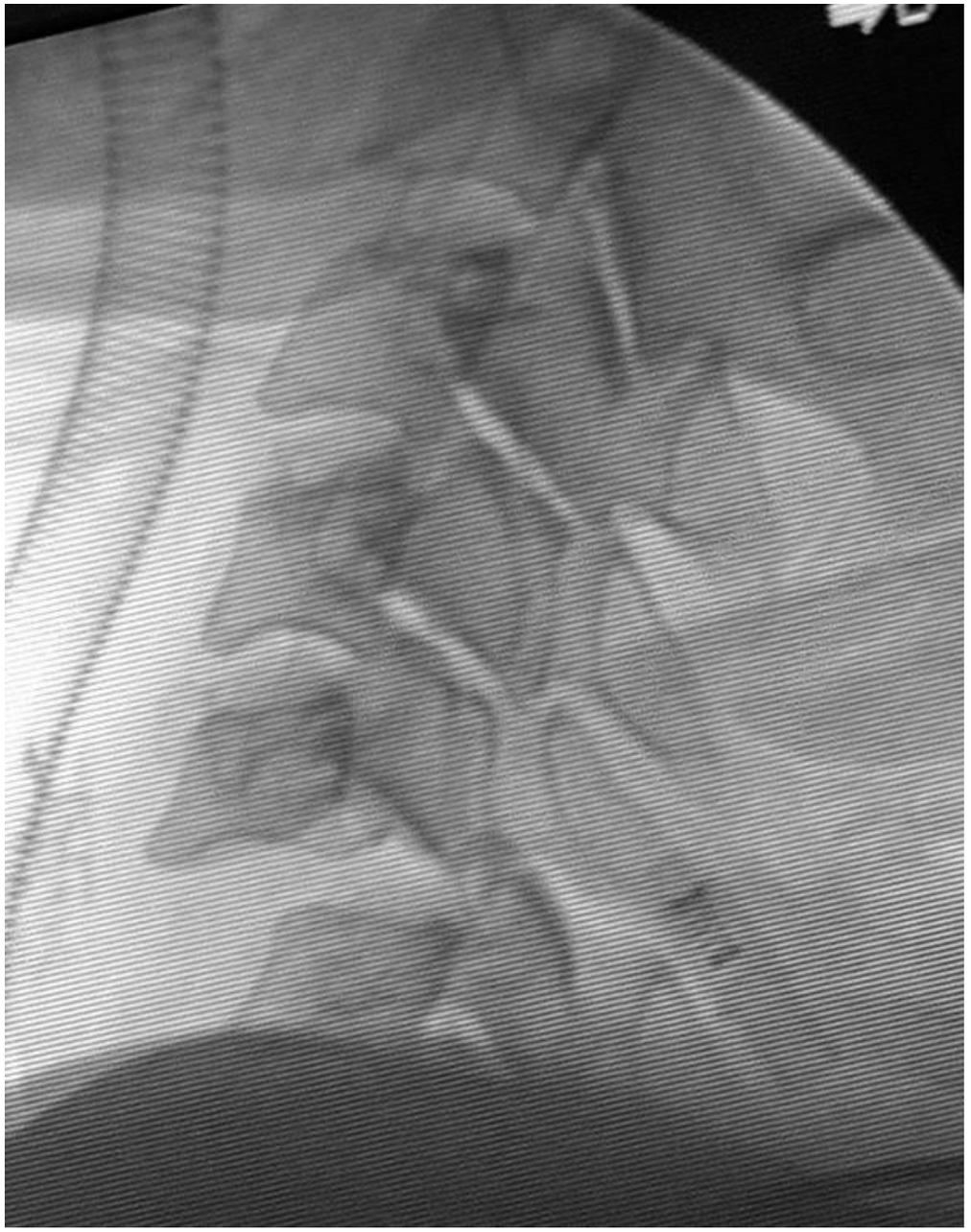
Posterior Approach

Advantages

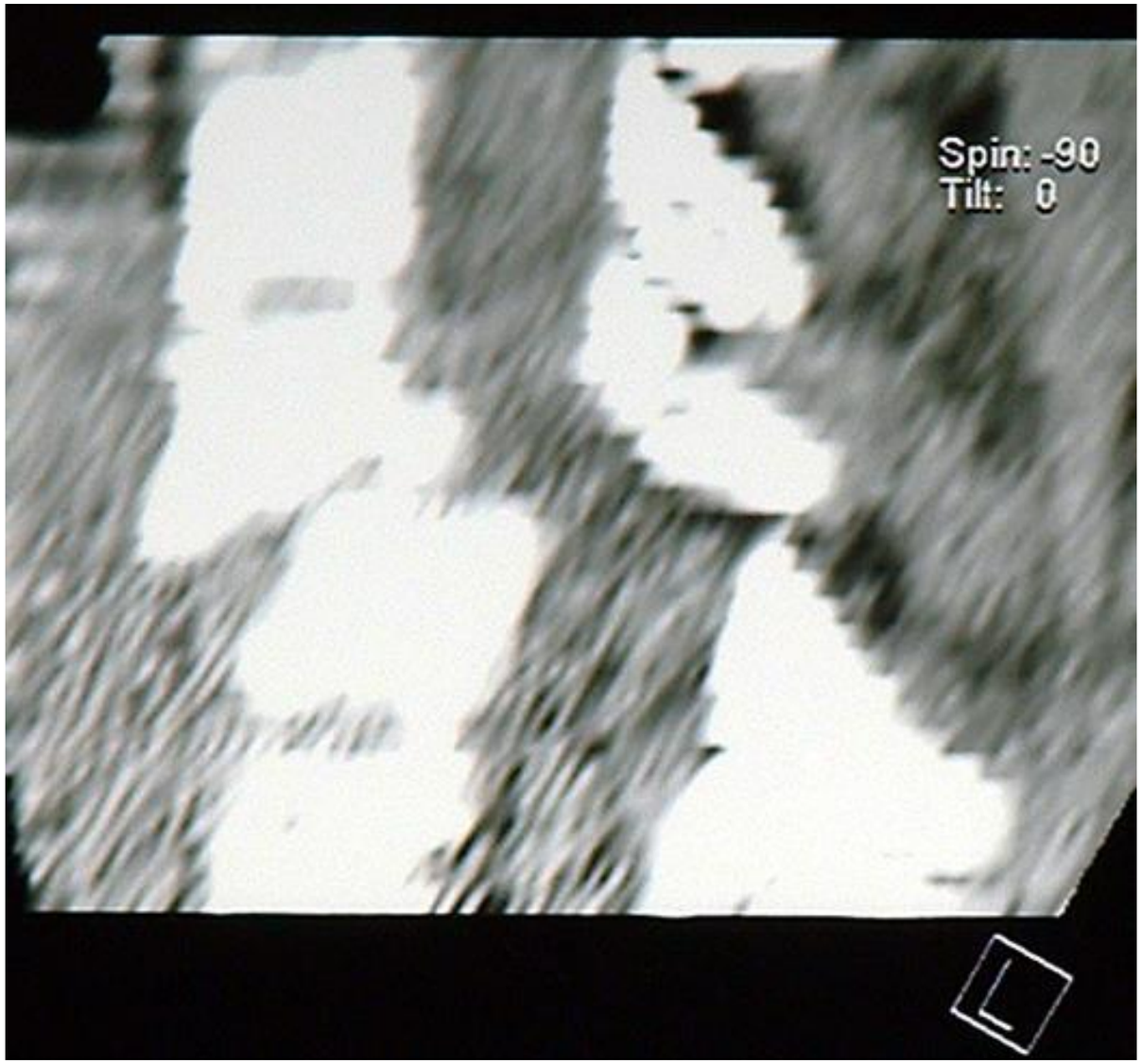
- Biomechanically robust
- Familiar to surgeons
- High success rate
- Allows direct open reduction

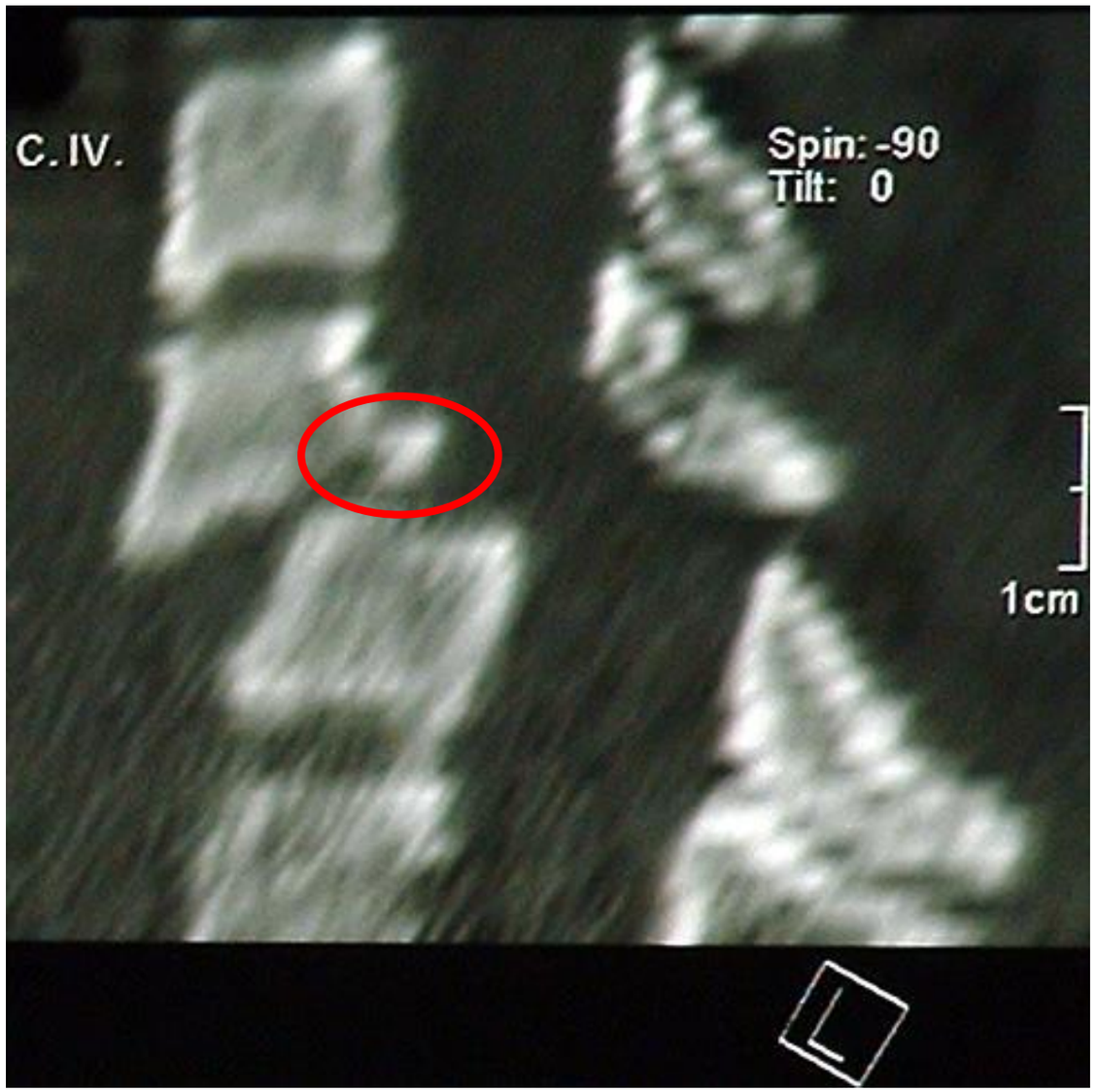
Disadvantages

- Wound infection rate
- Inability to prevent segmental kyphosis with disc collapse



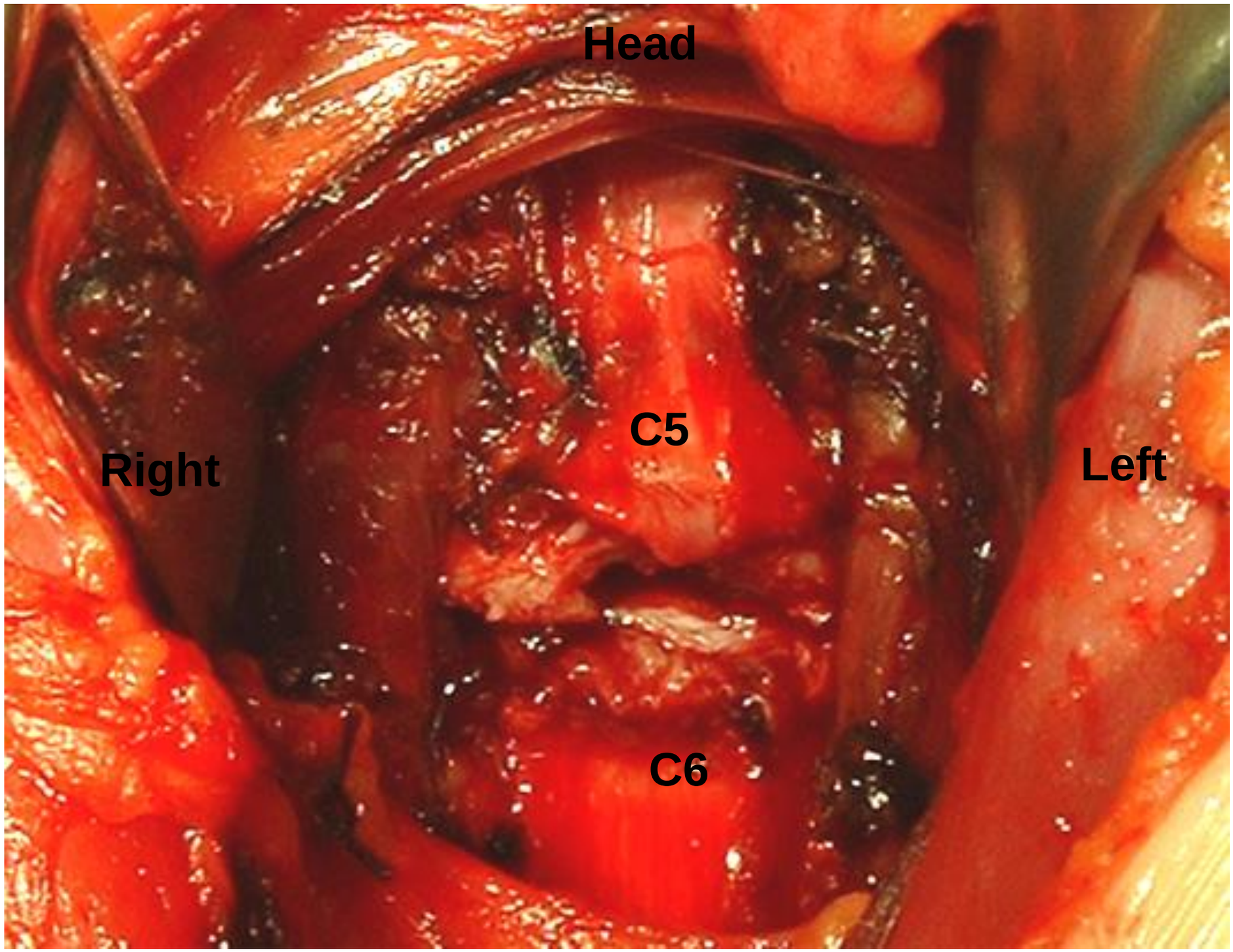
FRONT-BACK-FRONT
C5-C6 TypeC fractures bilateral locked, facet no neurological defict

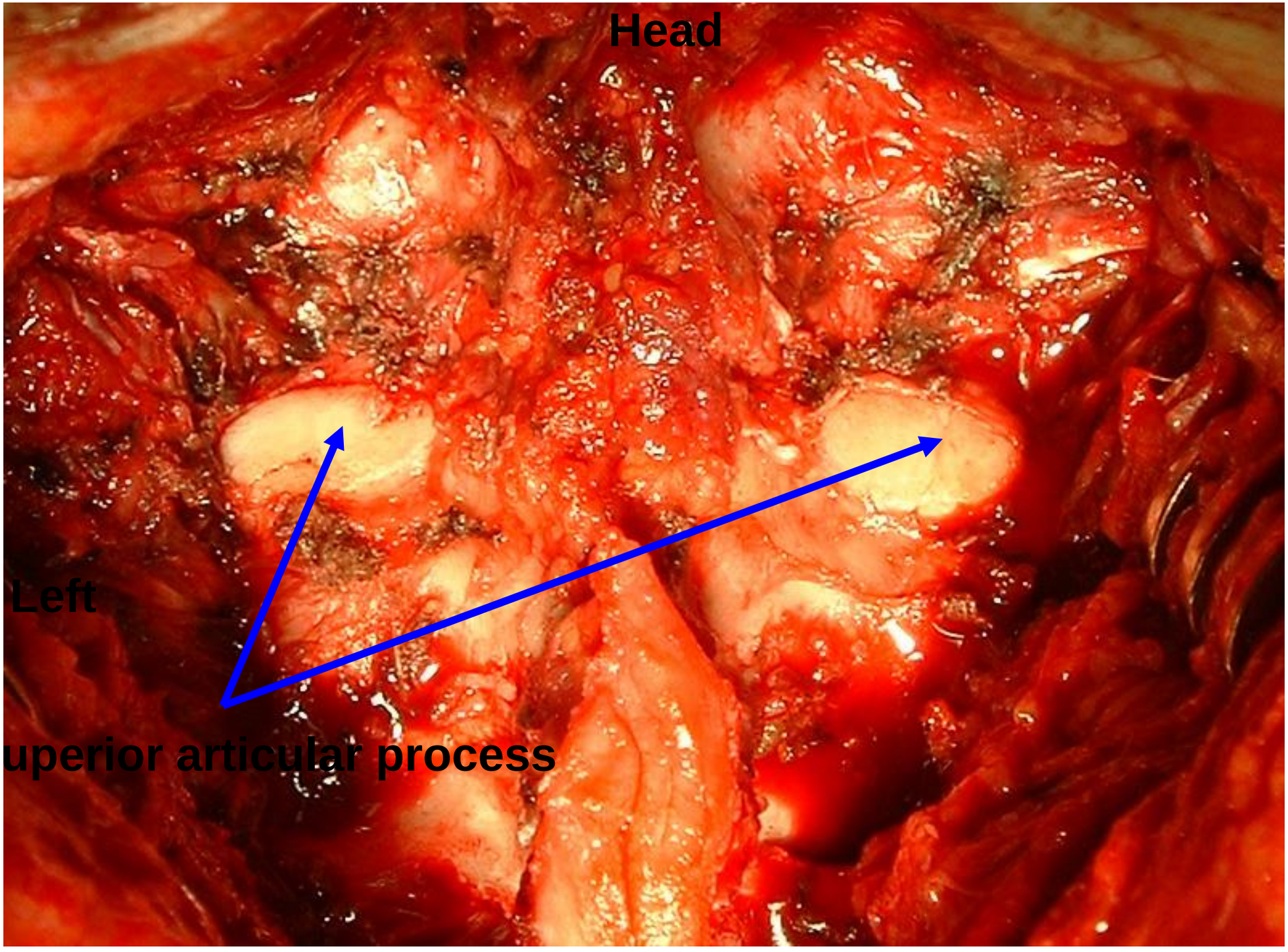




FRONT-BACK-FRONT
C5-C6 TypeC fractures
bilateral locked, facet no
neurological defict

FRONT-BACK-FRONT
C5-C6 TypeC fractures bilateral locked, facet no neurological defect





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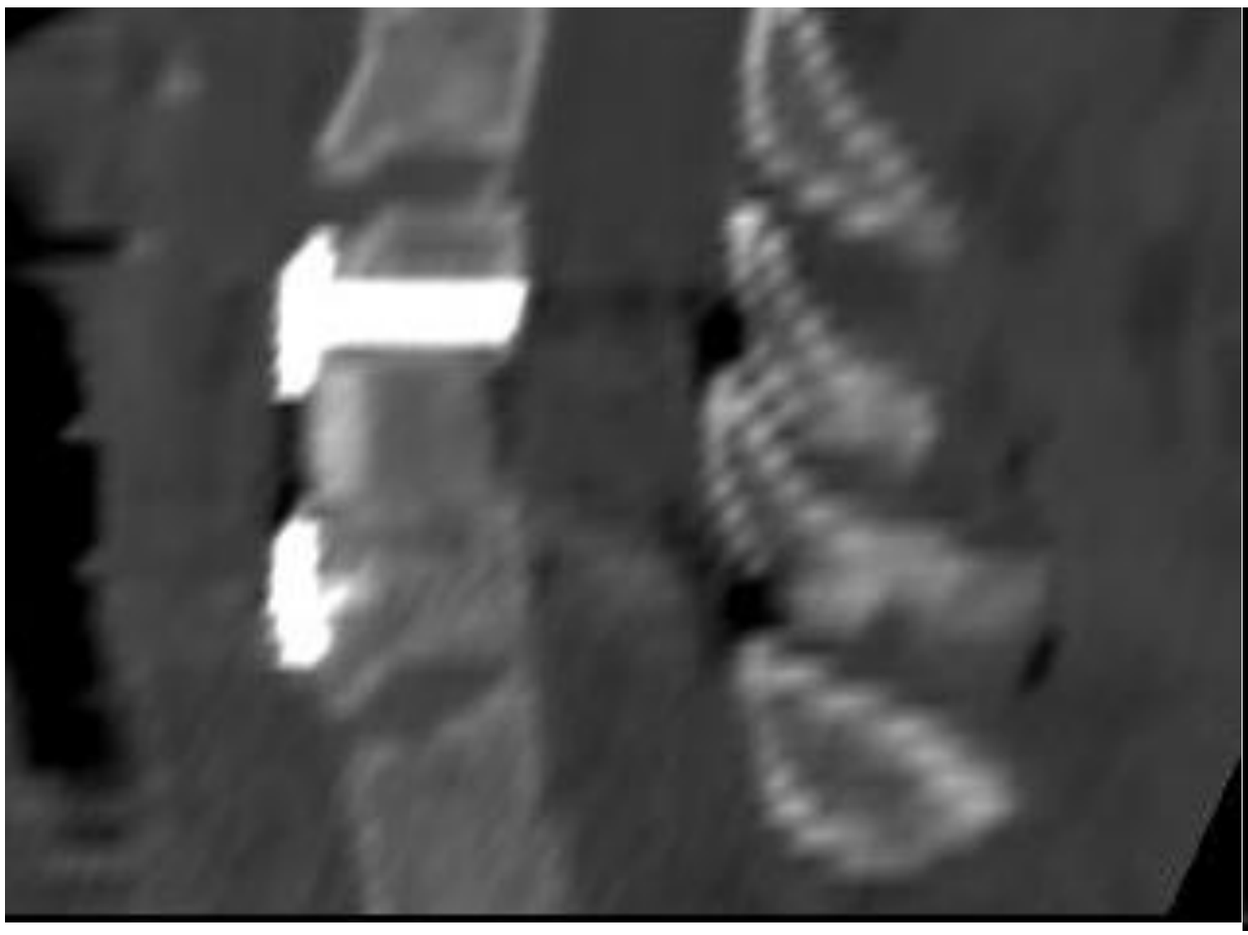
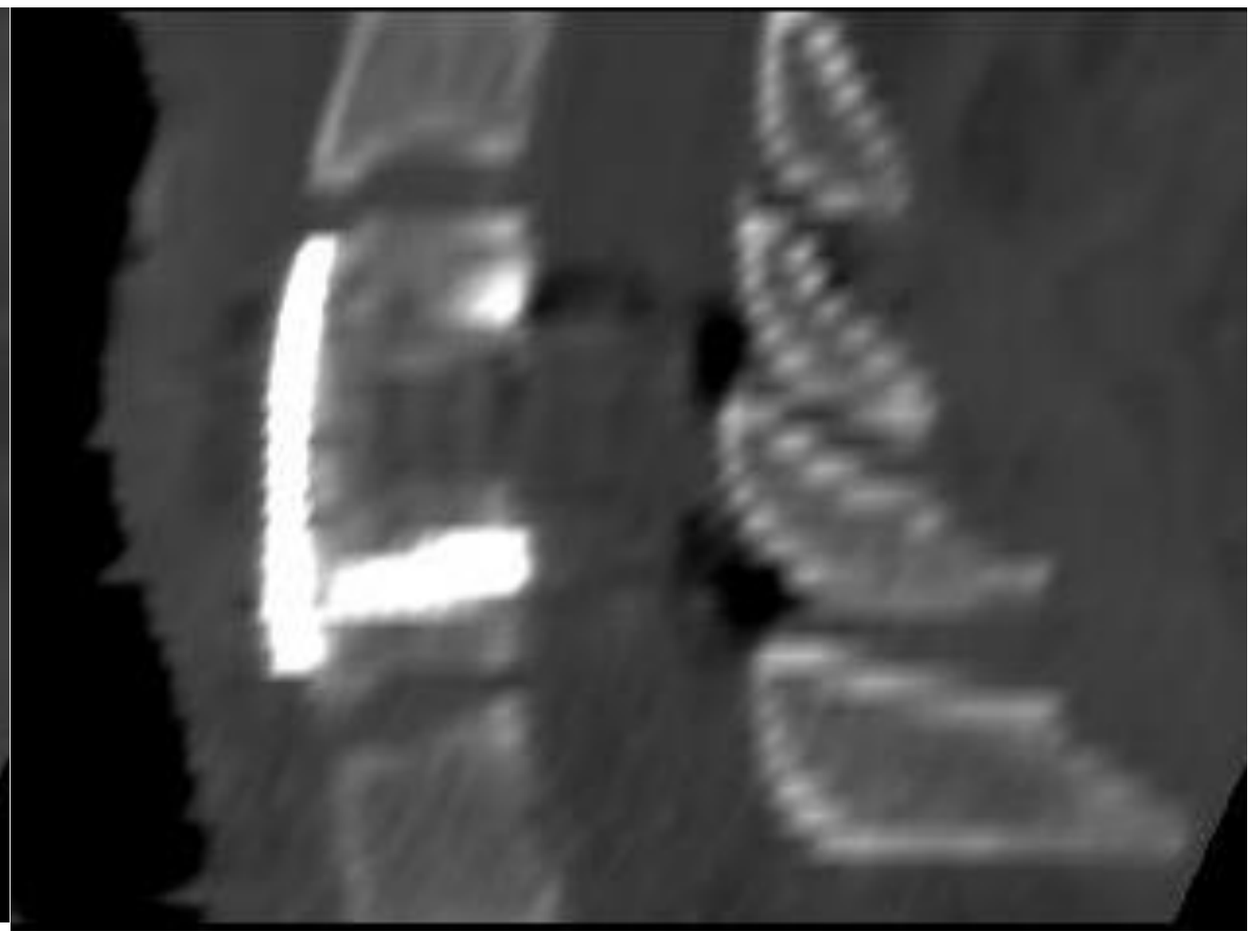




FRONT-BACK-FRONT
C5-C6 TypeC fractures
bilateral locked, facet no
neurological defict

Thoracic and Lumbar Spine Injury

1. Morphologic classification

This is based on the Magerl classification modified by the AOSpine Classification Group.
For this evaluation radiograms and CT scans with multiplanar reconstructions are essential.
In some cases additional MR images might be necessary. Three basic types are identified
on the basis of the mode of failure of the spinal column:

- **Type A:** Compression injuries. Failure of anterior structures under compression.
- **Type B:** Failure of the posterior or anterior tension band.
- **Type C:** Failure of all elements leading to dislocation or displacement.

A.

B.

C.

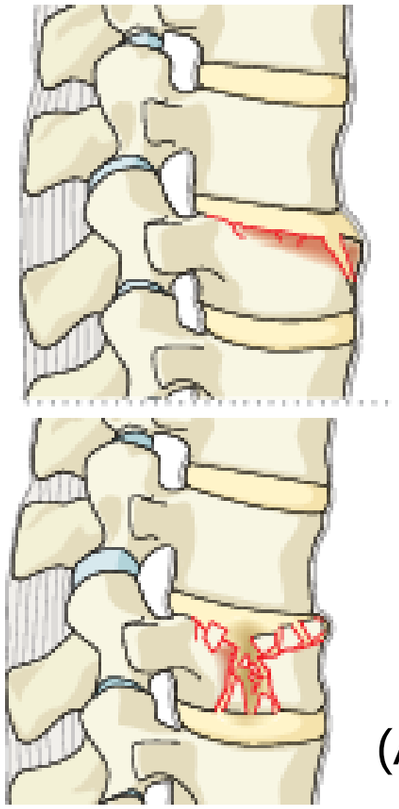
Type A

Describe injury to the vertebral body without tension band (PLC) involvement.
There are five subtypes and no further sub-classification.
These subtypes are also used as description of vertebral body fracture in B and C Types.

Type		Description
A0	**Minor, nonstructural fractures**	Fractures, which do not compromise the structural integrity of the spinal column such as transverse process or spinous process fractures.
A1	**Wedge-compression**	Fracture of a single endplate without involvement of the posterior wall of the vertebral body.
A2	**Split**	Fracture of both endplates without involvement of the posterior wall of the vertebral body.
A3	**Incomplete burst**	Fracture with any involvement of the posterior wall; only a single endplate fractured. Vertical fracture of the lamina is usually present and does not constitute a tension band failure.
A4	**Complete burst**	Fracture with any involvement of the posterior wall and both endplates. Vertical fracture of the lamina is usually present and does not constitute a tension band failure.

Thoracolumbal injuries
AO classification Type A –compression fracture

A1.



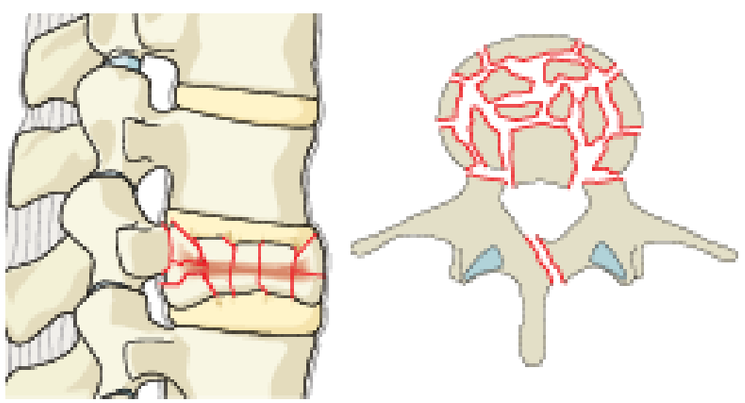
A1. : **stable** (‘log roll’) **no surgery**

A 2.

(A .2.3.)

A2.: **stable** (expect for when nucleus pulposus is between the fractued fragments, ventral fixation is needed later)- **no surgery**

A 3.



A3.: unstable - **percutaneous dorsal instrumentation**

Type B

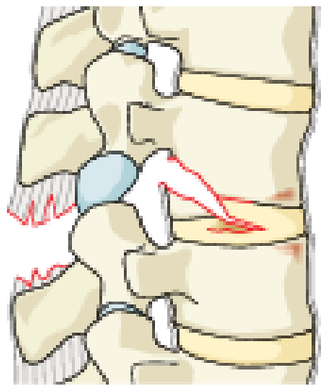
Describe the failure of posterior or anterior constraints (in case of TL this is the tension band or PLC / Posterior Ligamentary Complex or the anterior longitudinal ligament).
Is to be combined with subtypes A when appropriate. There are three subtypes:

Type		Description
B1	**Transosseous tension band disruption / Chance fracture**	Monosegmental pure osseous failure of the posterior tension band. The classical Chance fracture.
B2	**Posterior tension band disruption**	Bony and/or ligamentary failure of the posterior tension band together with a Type A fracture. Type A fracture should be classified separately.
B3	**Hyperextension**	Injury through the disk or vertebral body leading to a hyperextended position of the spinal column. Commonly seen in ankylotic disorders. Anterior structures, especially the ALL are ruptured but there is a posterior hinge preventing further displacement.

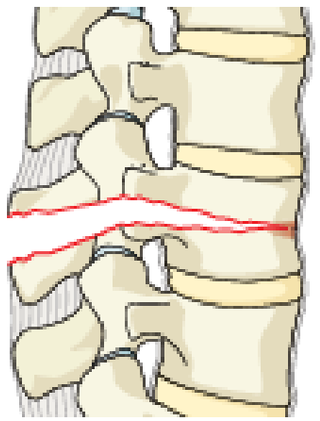
Thoracolumbal injuries

AO classification Type B – compression fracture

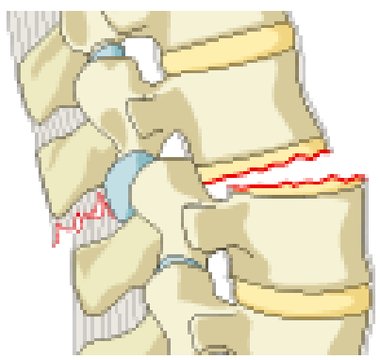
B1.



B2.



B3.



Can closed reposition be done?

-damage control , **percutan dorsal fixation**

Closed reposition can not be done?

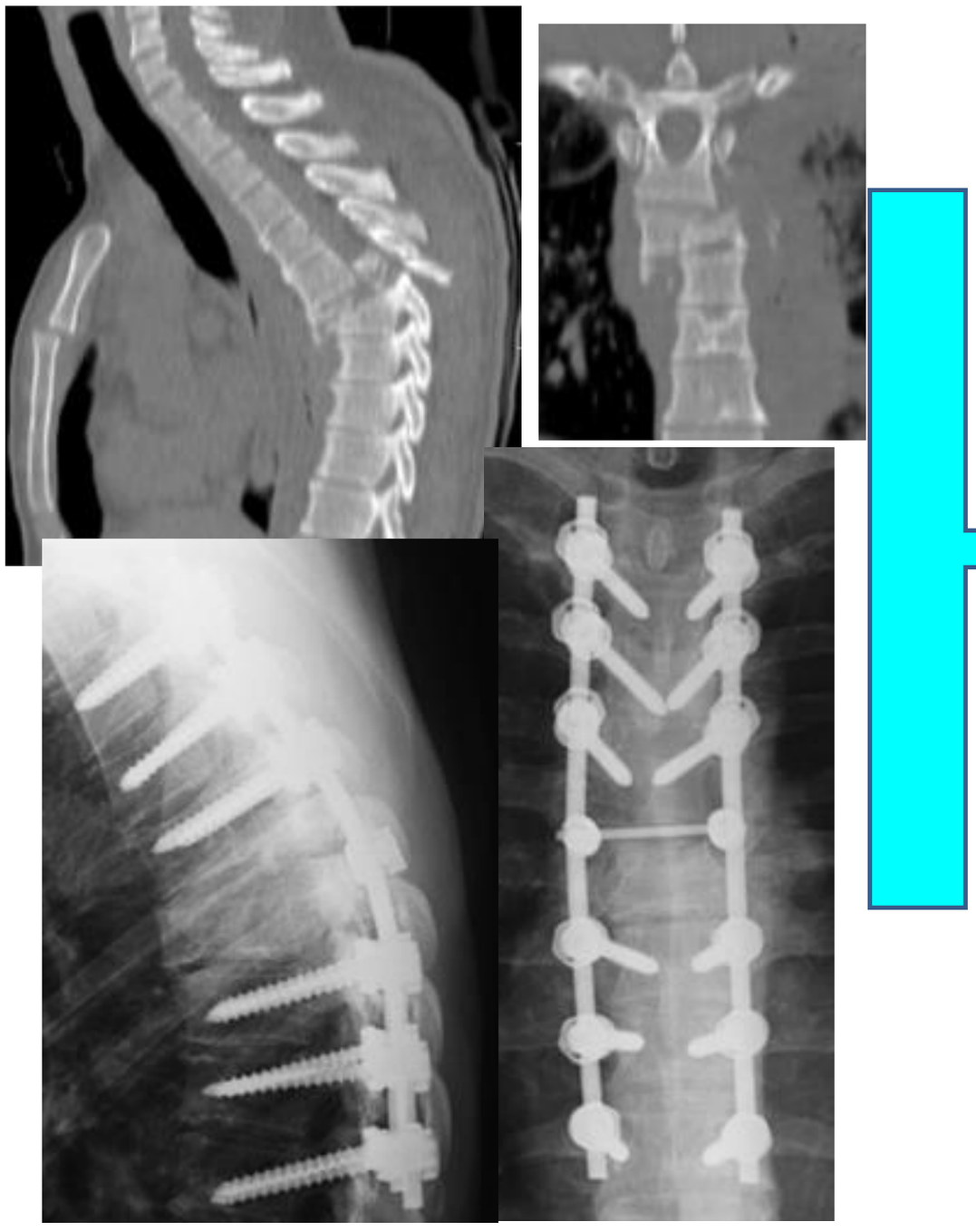
or **decompression is needed**?

-Standard open surgery with ventral fixation later

Type C

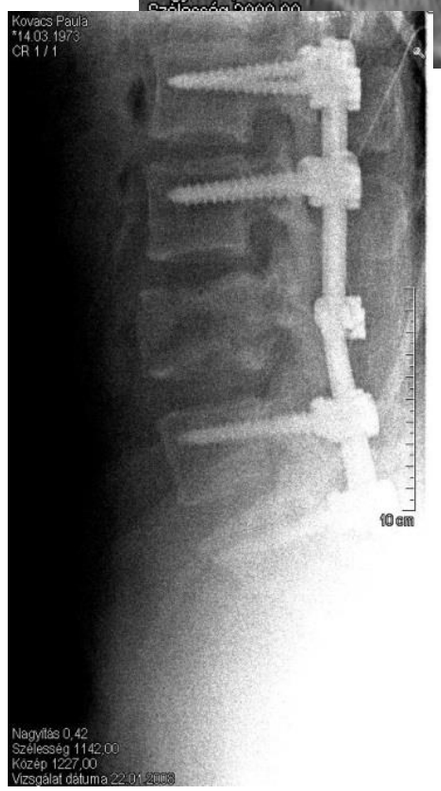
Describe displacement or dislocation.
There are no subtypes as because of the dissociation between cranial and caudal segments various configurations are possible in different images.
Is combined with subtypes of A if necessary.

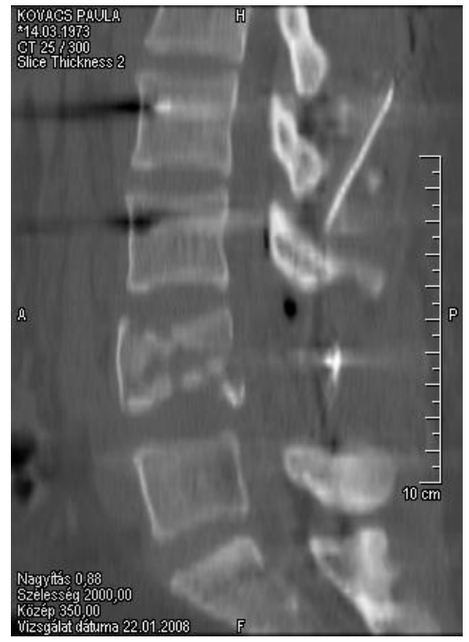
Thoracolumbal injuries
AO C – rotation



- ~~Closed repostition~~
- Decompression is needed
- Percutan instrumentaion is not sufficient
- **Later ventral surgery can be done**

- Initial Damage Control (decompression and stabilisation) is recommended





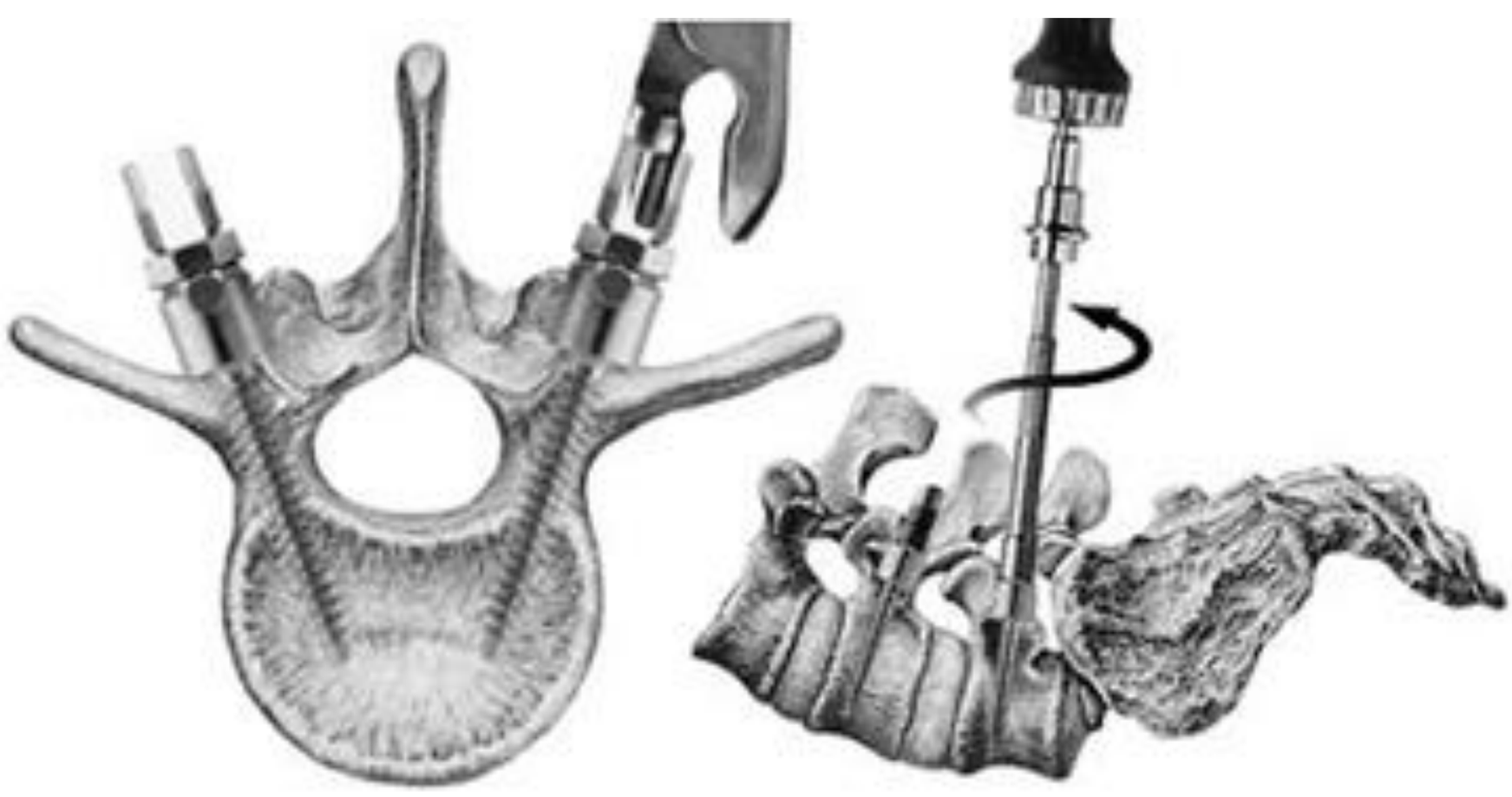
Thoracic and Lumbar Spine Injuries

Postrior Transpedicular fixation

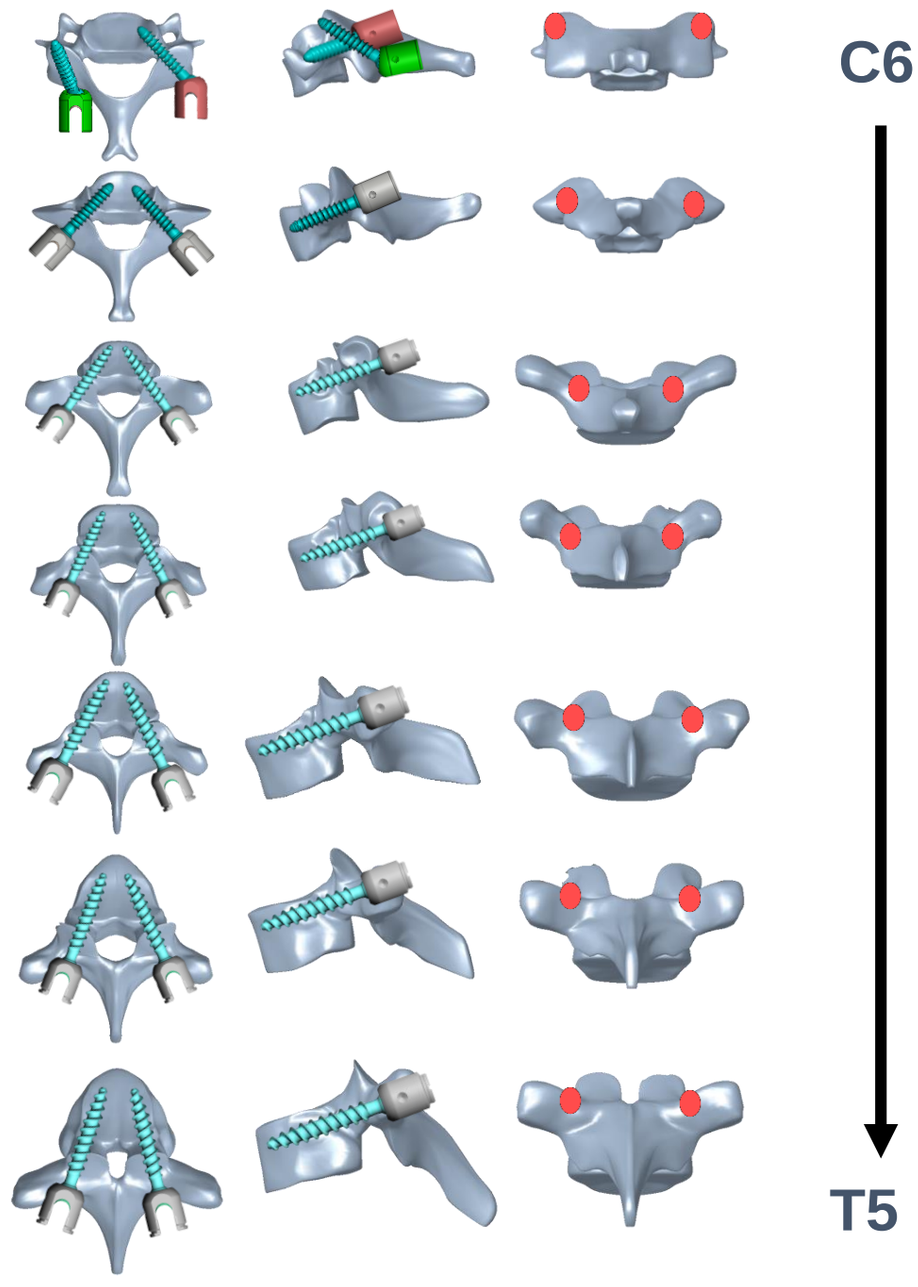
- Pedicel connects the anterior (vertebral body) and the posterior (facet joints and lamina) half of the vertebra

- Biomechanical advantages

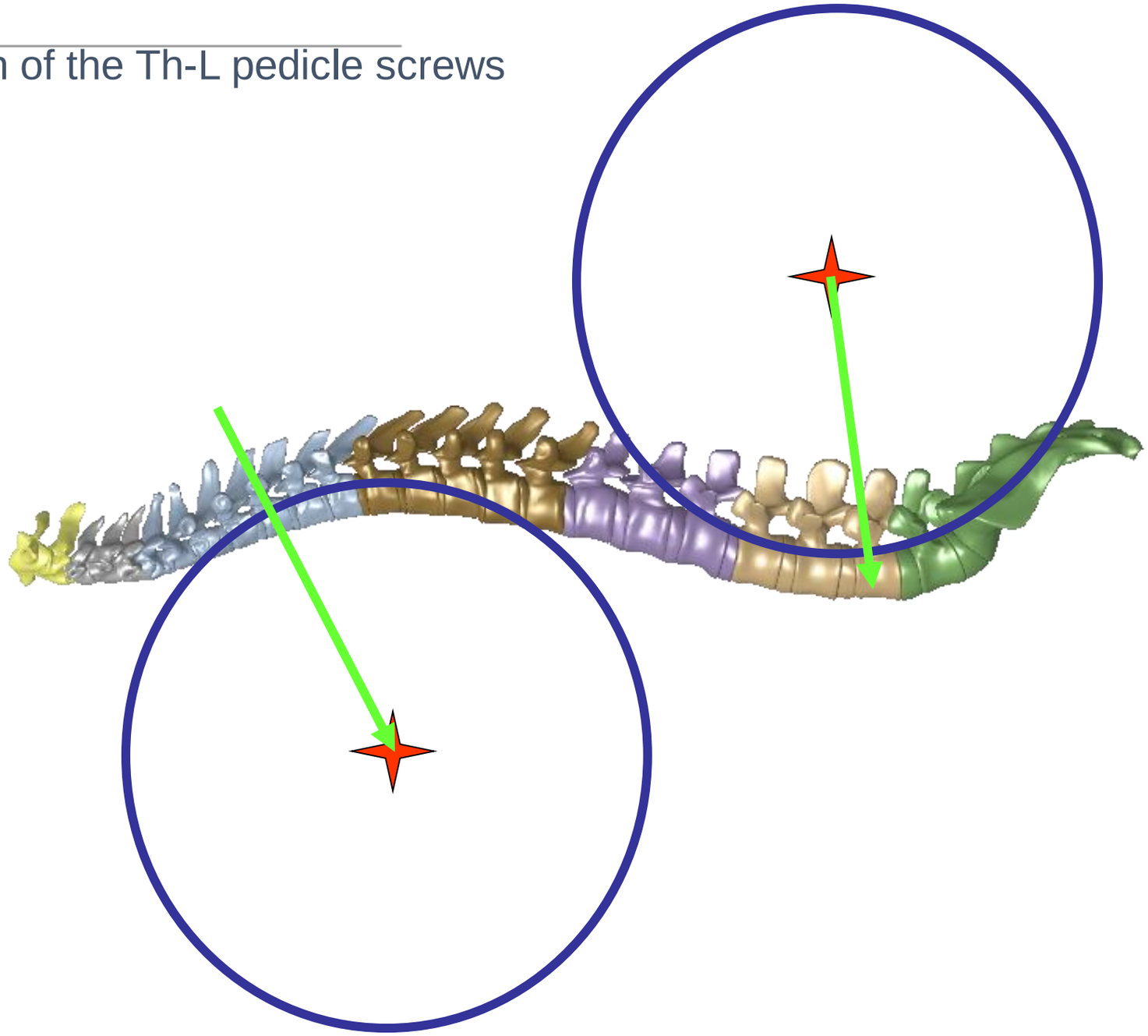
- Relevance in spinal instrumentation



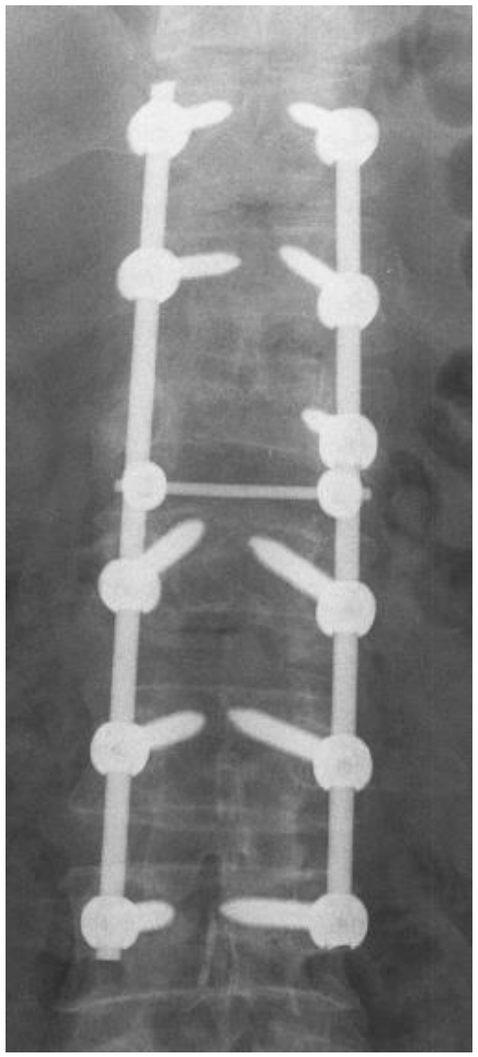
Entry points for transpedicular screws

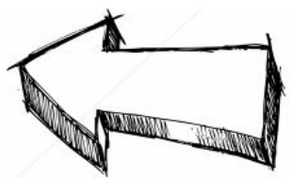


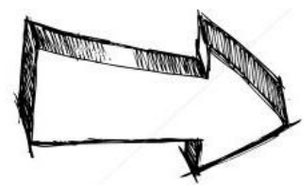
Direction of the Th-L pedicle screws

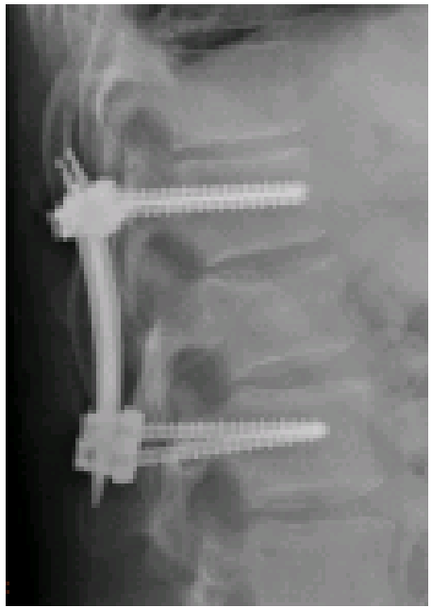


Primary definitve care vs. Damage controll





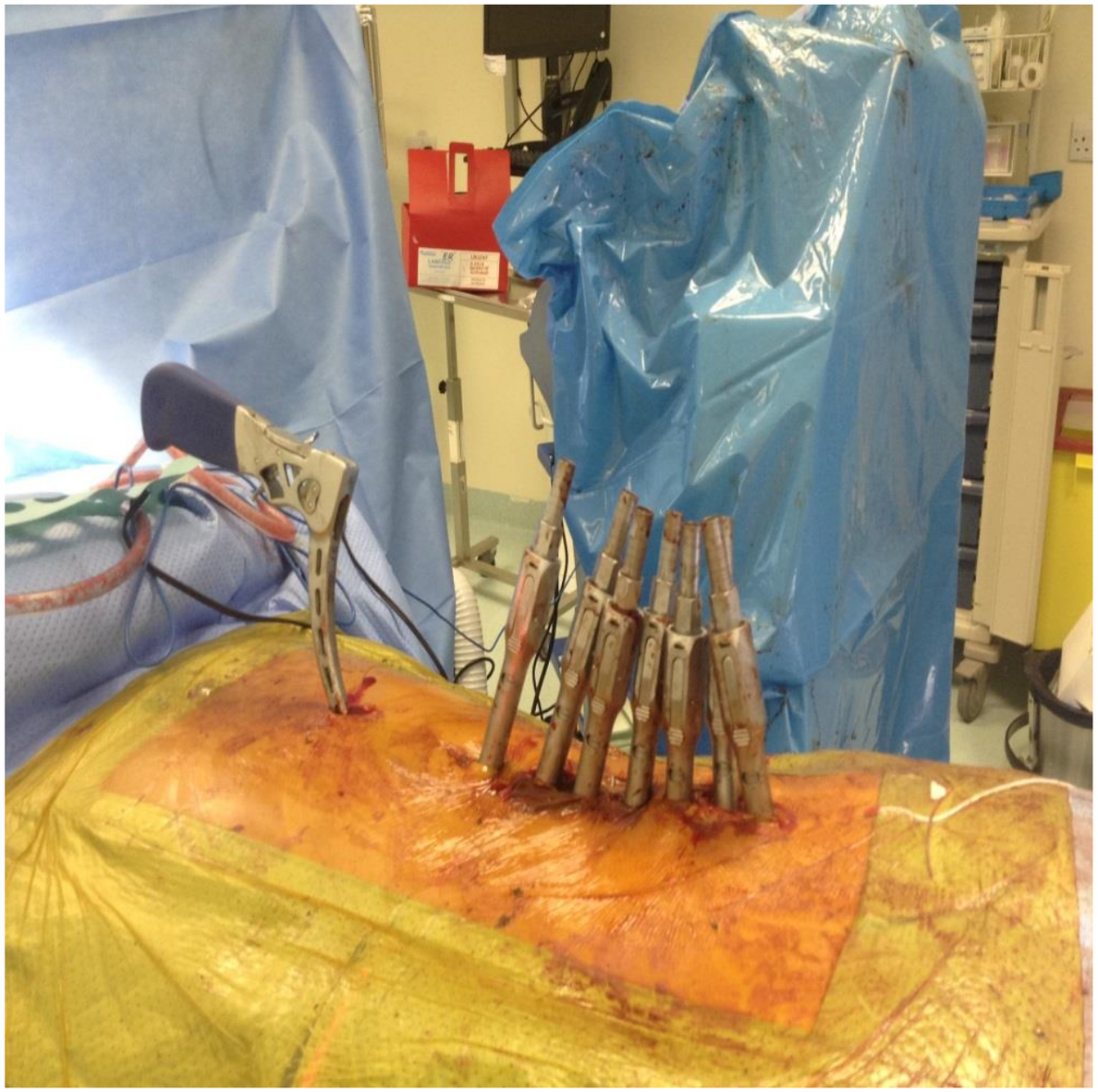




Coagulopathy? Acidsos? Hypothermia?

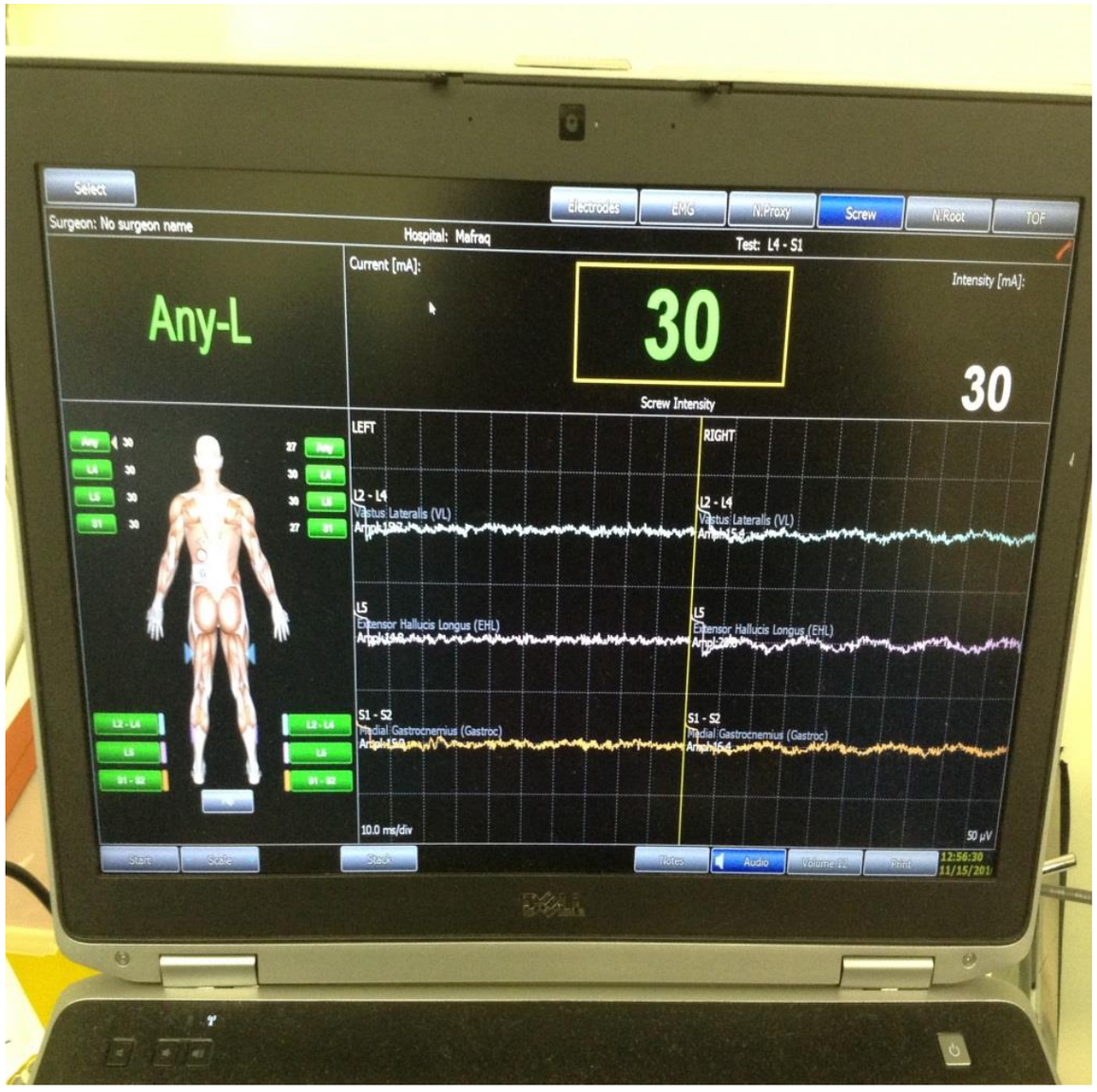
Concomittant injuries?

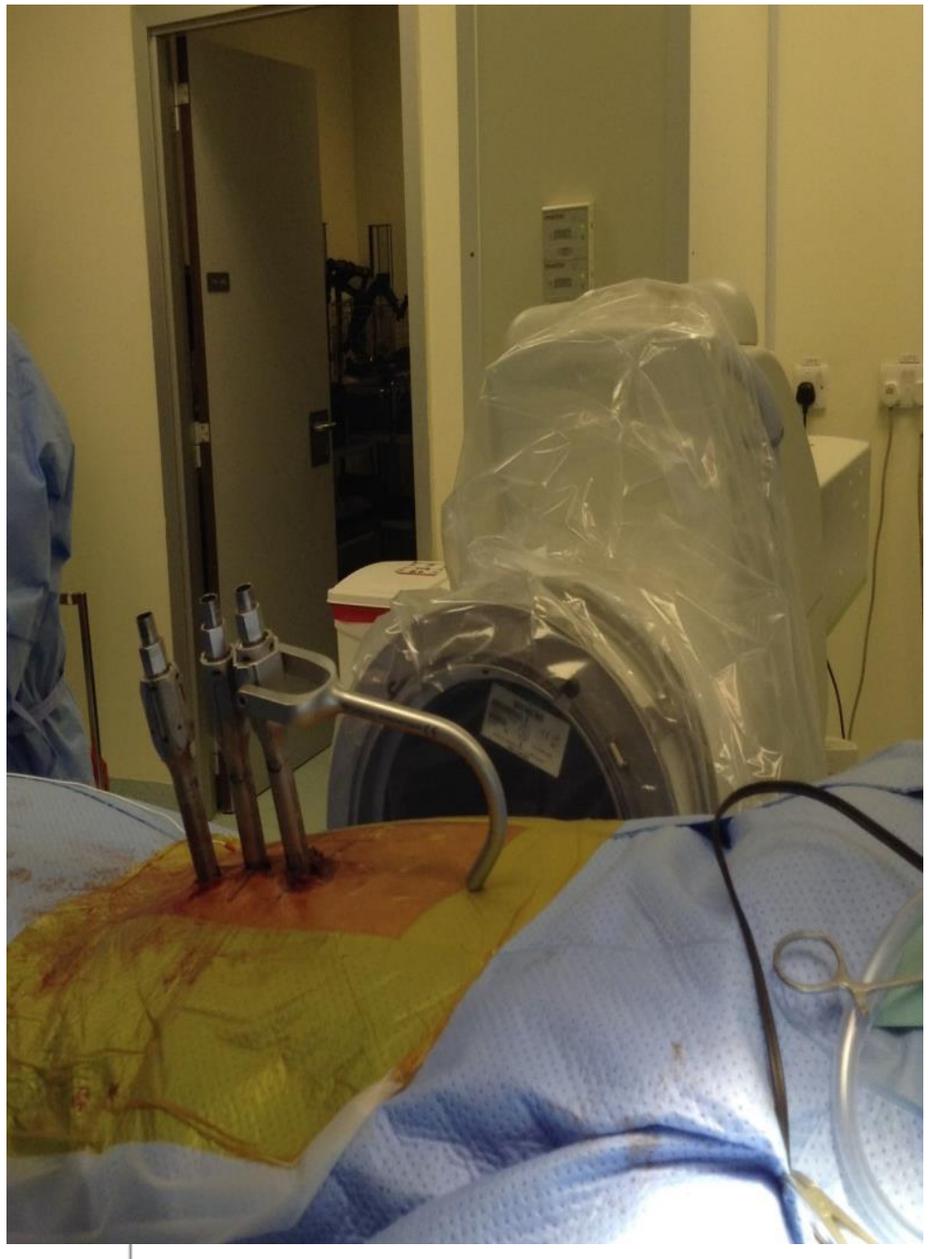
Surgeons experience?



Percugtan MIS (minimal invasive surgery) spinal fixations

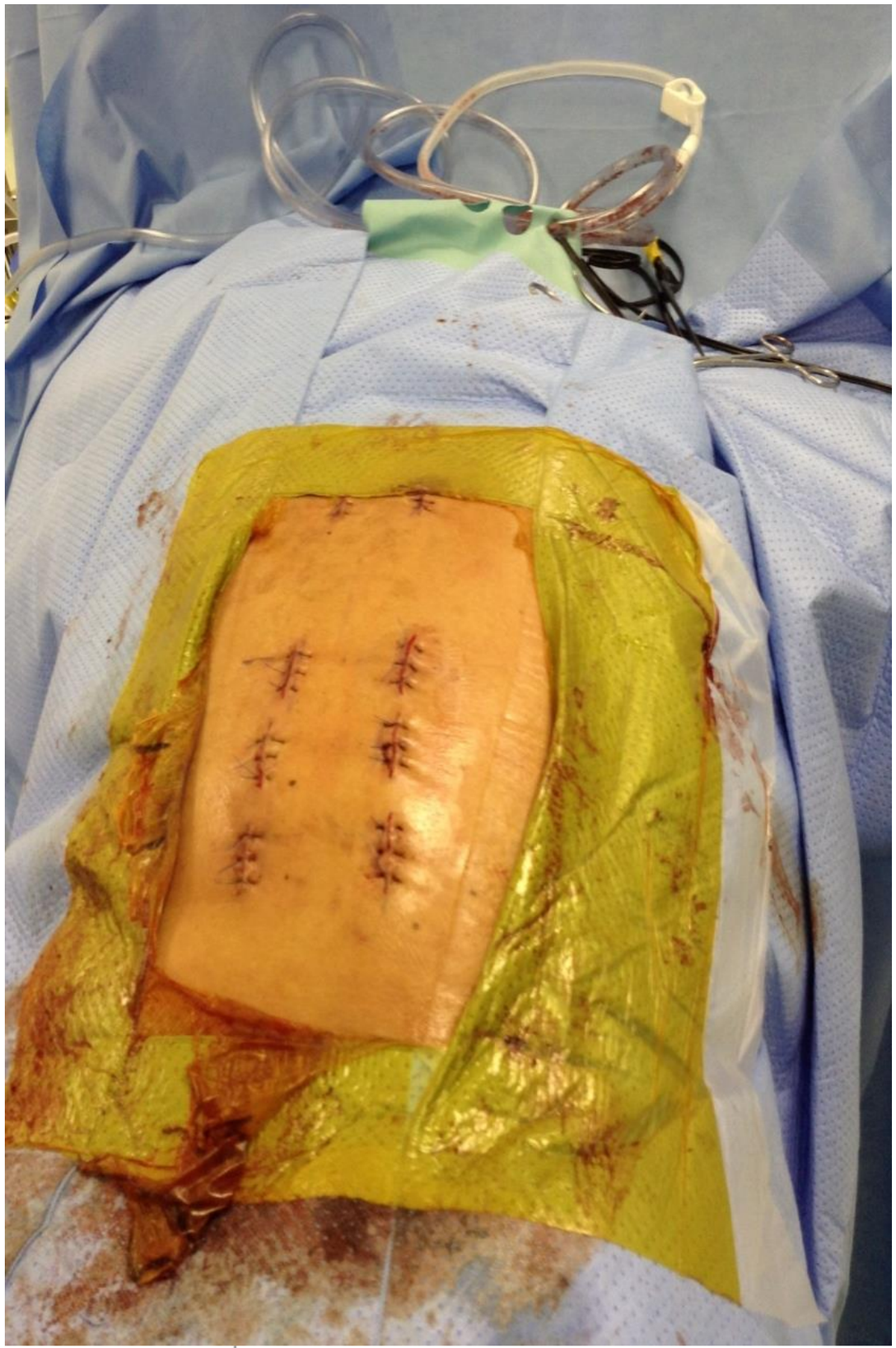
Intraoperativ Neuromonitor





Intraoperative monitor

Postoperative surgical field MIS



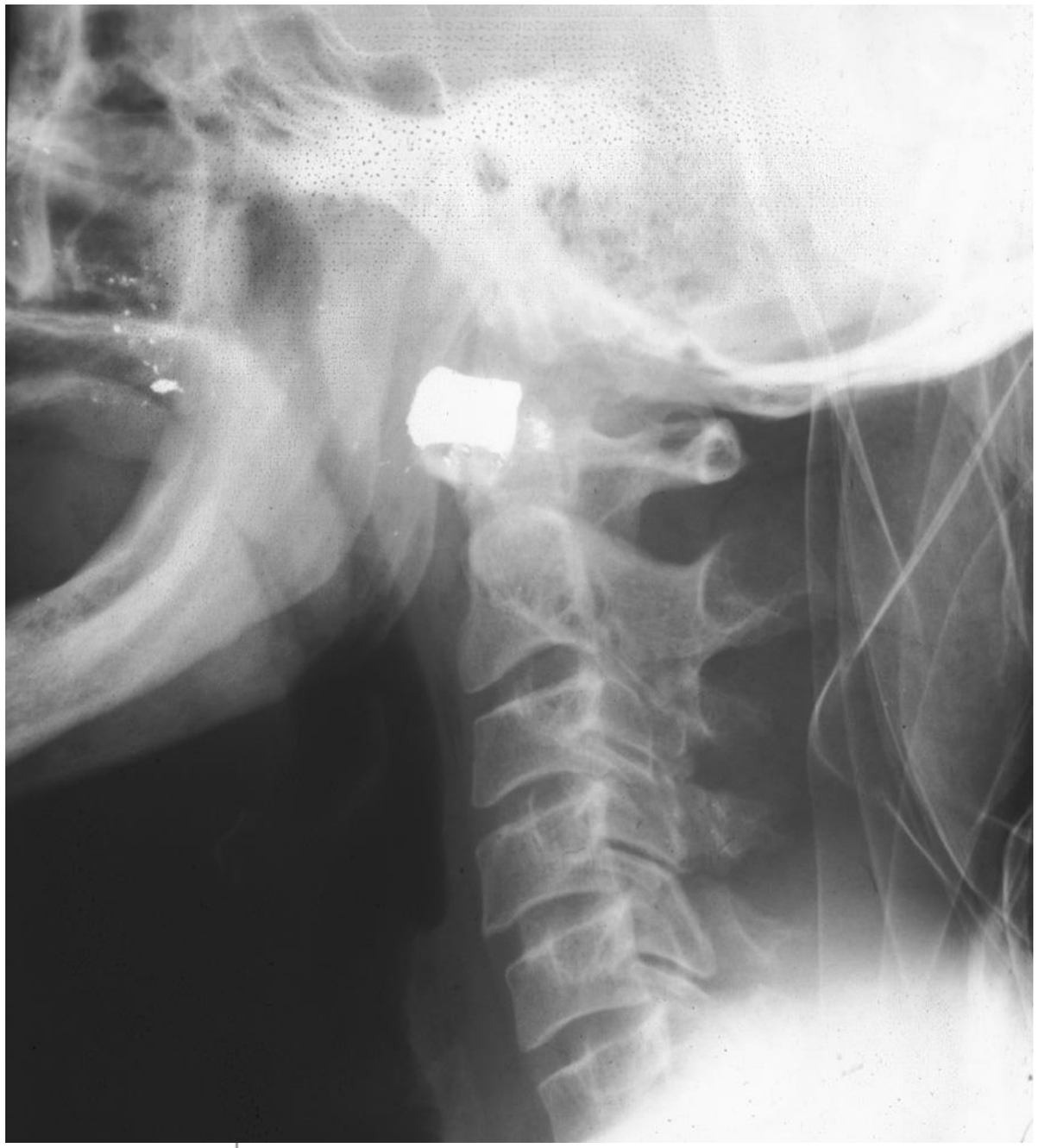
- Dorsal operation first
- Prone position is not contraindicated for polytrauma patients
- Ventral surgery should only be done after patient is stable and healed

Summary thoracolumbar spine injuries treatement

Gunshot Injury to the Spine

Penetrating injury

Rare
Under 35 year old male patients
Debridement
Removal of the bone and the projectil from thespinal canal
Dura repare advisible



Summary

Every injured patient should be considered and treated as a spine injured

If any suspect of spine injury the whole spine should be considered instable untill the opposite has proven.

Take Home Messages

Thank You