Internal Decapitation – High cervical spine injuries

Preventable deaths from Trauma

Peleg Ben-Galim MD
Houston, TX

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Disclosure

- Baylor College of Medicine (BCM) has applied for a patent on a method to stabilize the cervical spine and has licensed this to Persys medical.
- If Persys develops, manufactures and commercializes a technology covered by this license and pays royalties to BCM than some of the authors may receive royalties in the future.

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Advanced Trauma Life Support (ATLS)

A	Airway Maintenance with Cervical Spine Protection
B	Breathing and Ventilation
C	Circulation with Hemorrhage Control
D	Disability (Neurologic Evaluation)
E	Exposure and Environment

- Cervical spine protection is essential for saving life

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Cervical spine protection

http://www.thedaingerfieldbee.com/clients/thedaingerfieldbee/3-17-2009-9-12-03-AM-2197625.jpg

http://www.everythingfabiolus.com/wp-content/uploads/2009/01/crash5.jpg

http://cdn.wn.com/o25/ph//2009/02/04/4bab4b14b165d9978b34adc1e30f

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Immobilization Concept

Literature

Spinal immobilisation for trauma patients (Review)

Kwan I, Bunn F, Roberts I, on behalf of the WHO Pre-Hospital Trauma Care Steering Committee

THE COCHRANE COLLABORATION®

Authors' co

We did not The effect of spinal immobilisation on mortality, on mortality, neurological neurological injury, spinal stability and adverse effects in trauma patients remains uncertain. on is a major cause of preventable death in trauma patients, and spinal immobilisation, particularly of the cervical spine, can contribute to airway compromise, the possibility that immobilisation may increase mortality and morbidity cannot be excluded. Large prospective studies

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Prevention of catastrophic SECONDARY cervical trauma consequences

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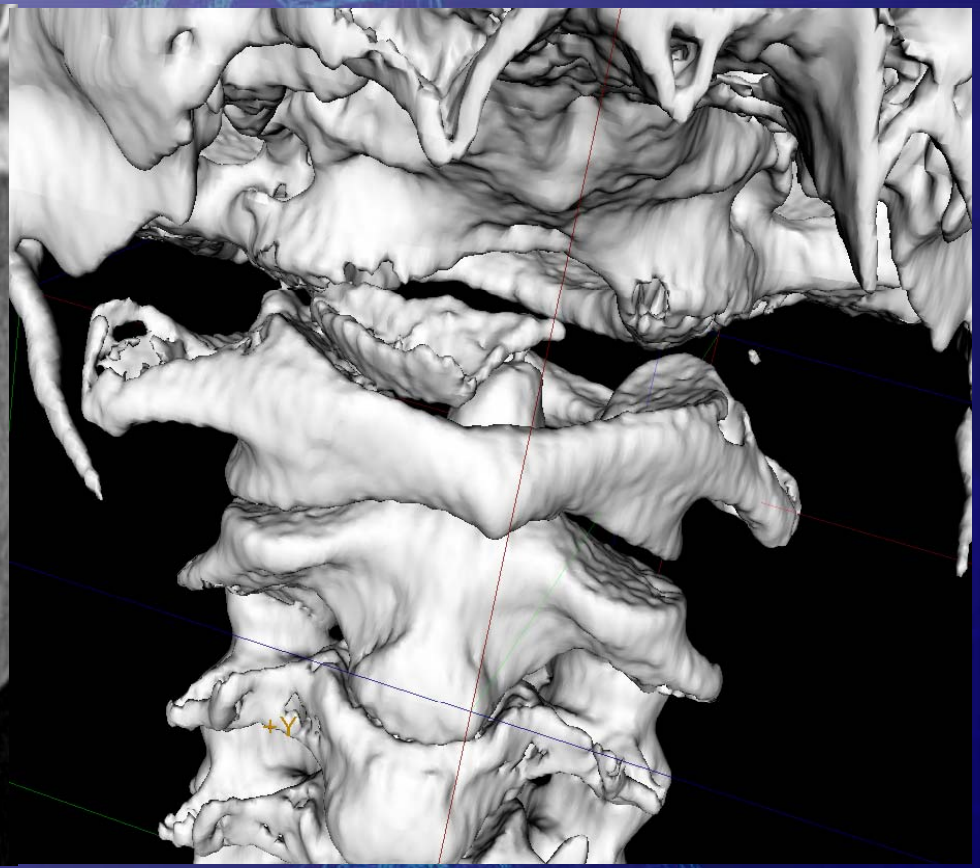
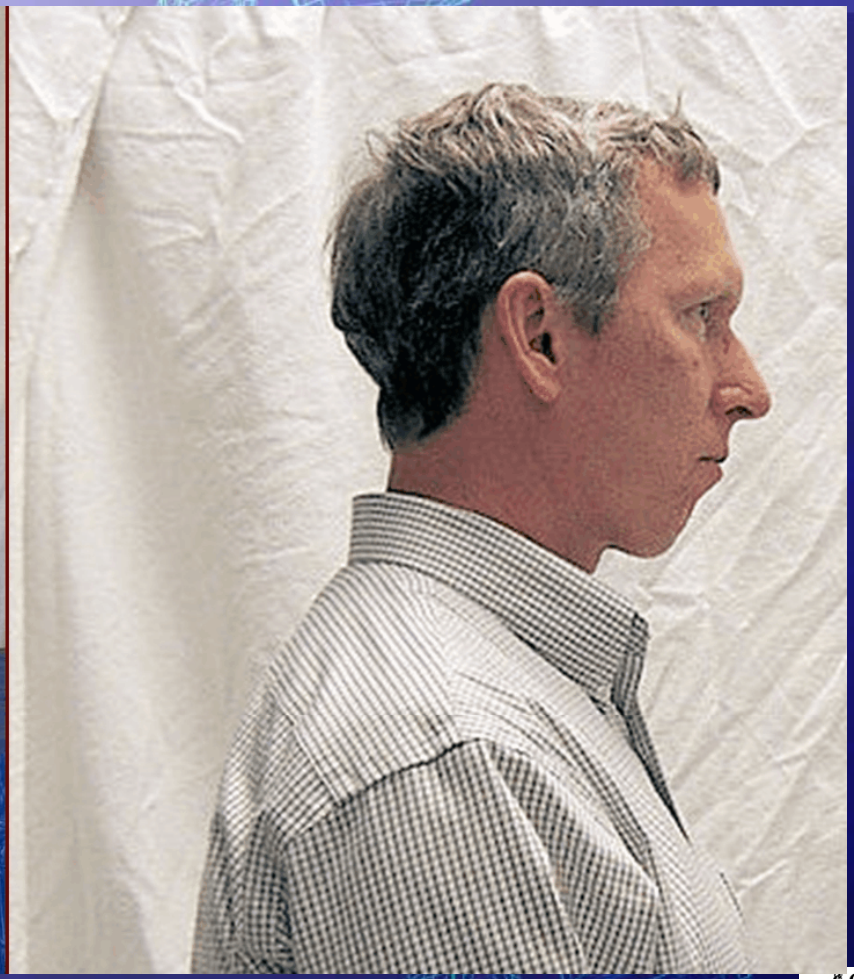
Secondary!!! High cervical quadriplegia



17 Y/O, FEMALE, HIGH ENERGY MVA

Hypothesis:
C-collars create distraction



What is known about Collar stabilization.

- Collars will limit head motion
- In healthy INTACT volunteers.

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Question:
What happens in the presence of a severely unstable cervical spine injury ?

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Clinical experience- Ben-Taub General Hospital

Harris County Hospital District

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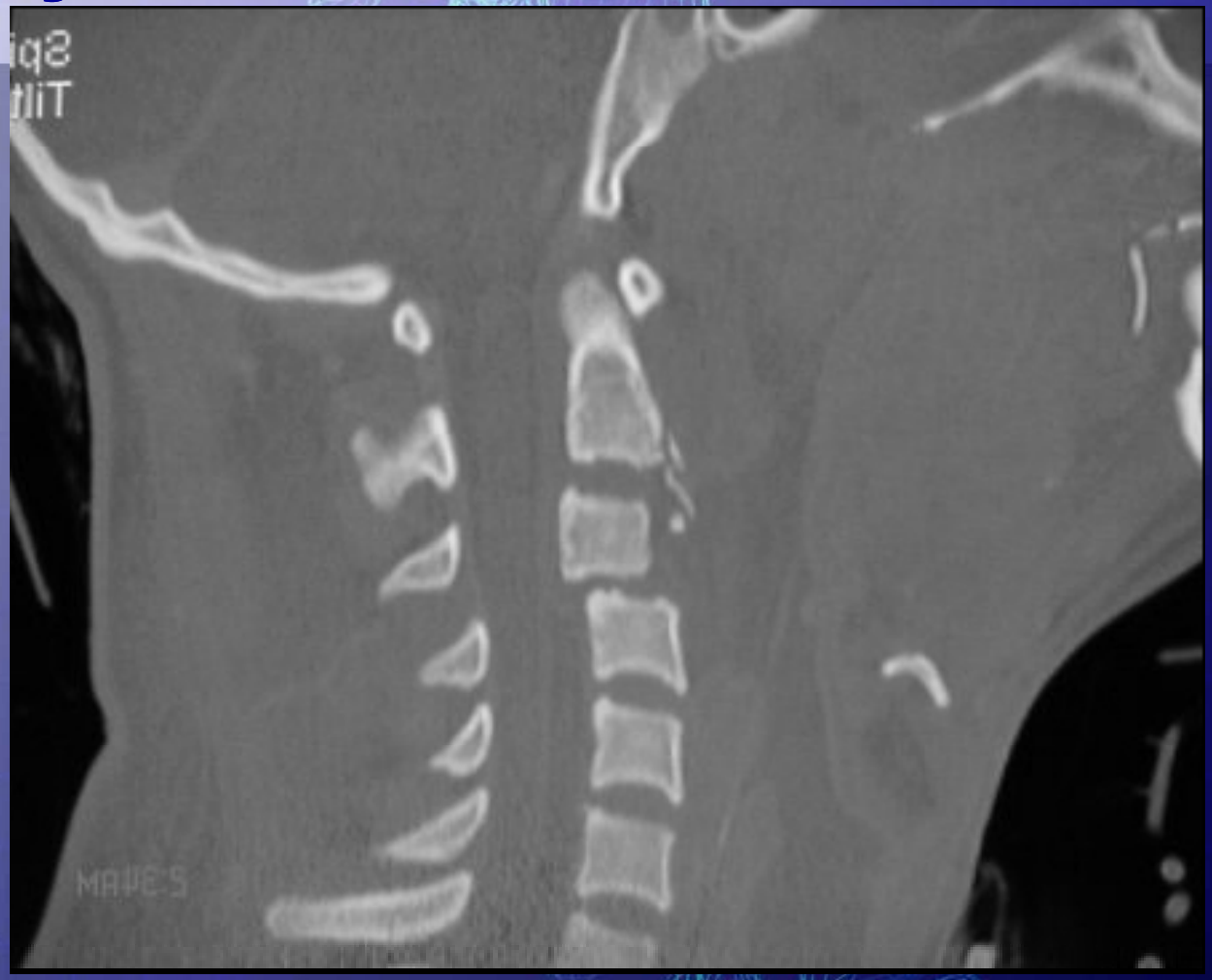
Case No. I
High velocity MVA

- 25 Y/O male
- Mandible #
- No Collar



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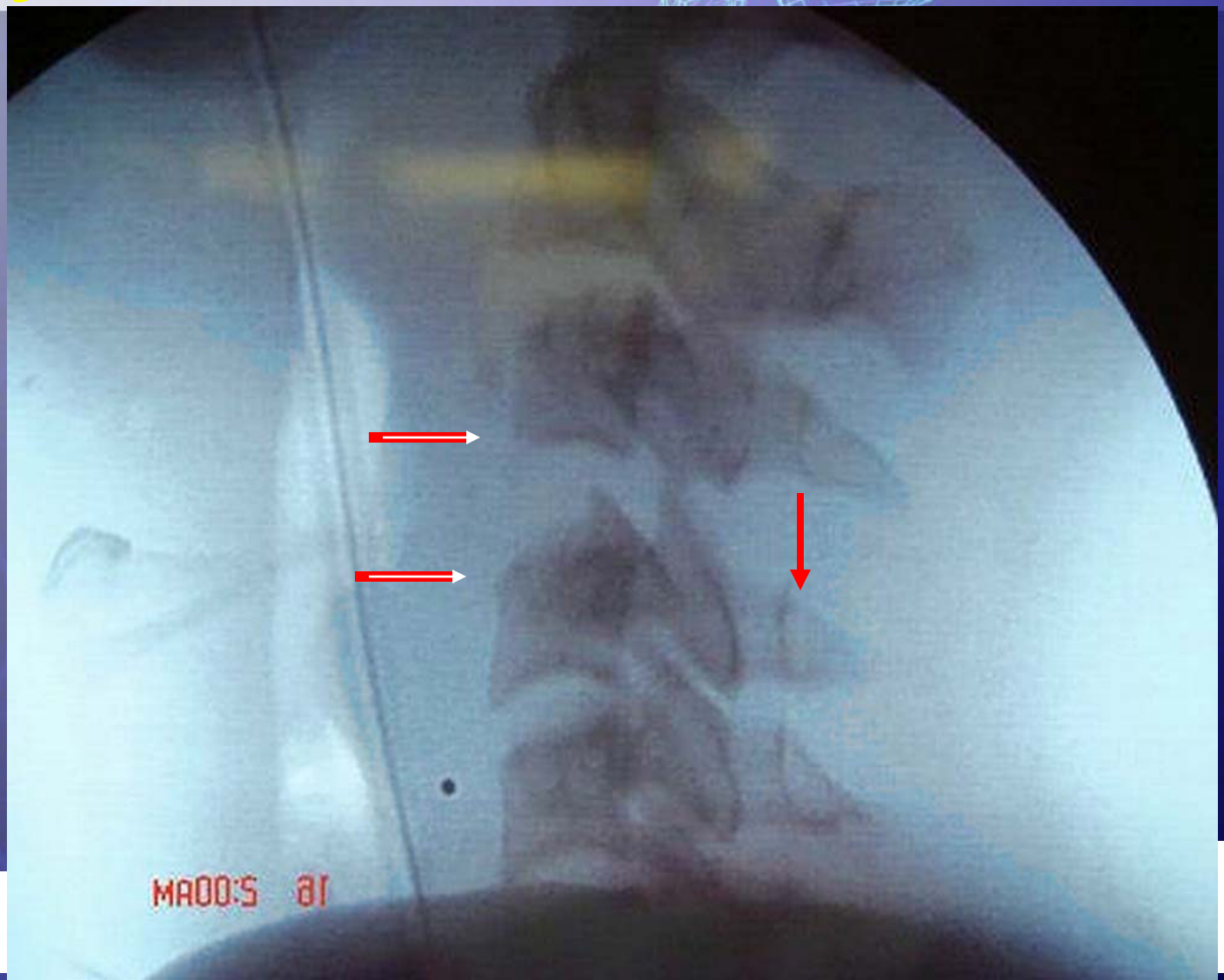
Case No. I

In line stabilization and collar application directly caused this C3-C4 distraction



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Case No. II – Dissociative injuries are susceptible to distractive forces

- In hospital flouroscopy

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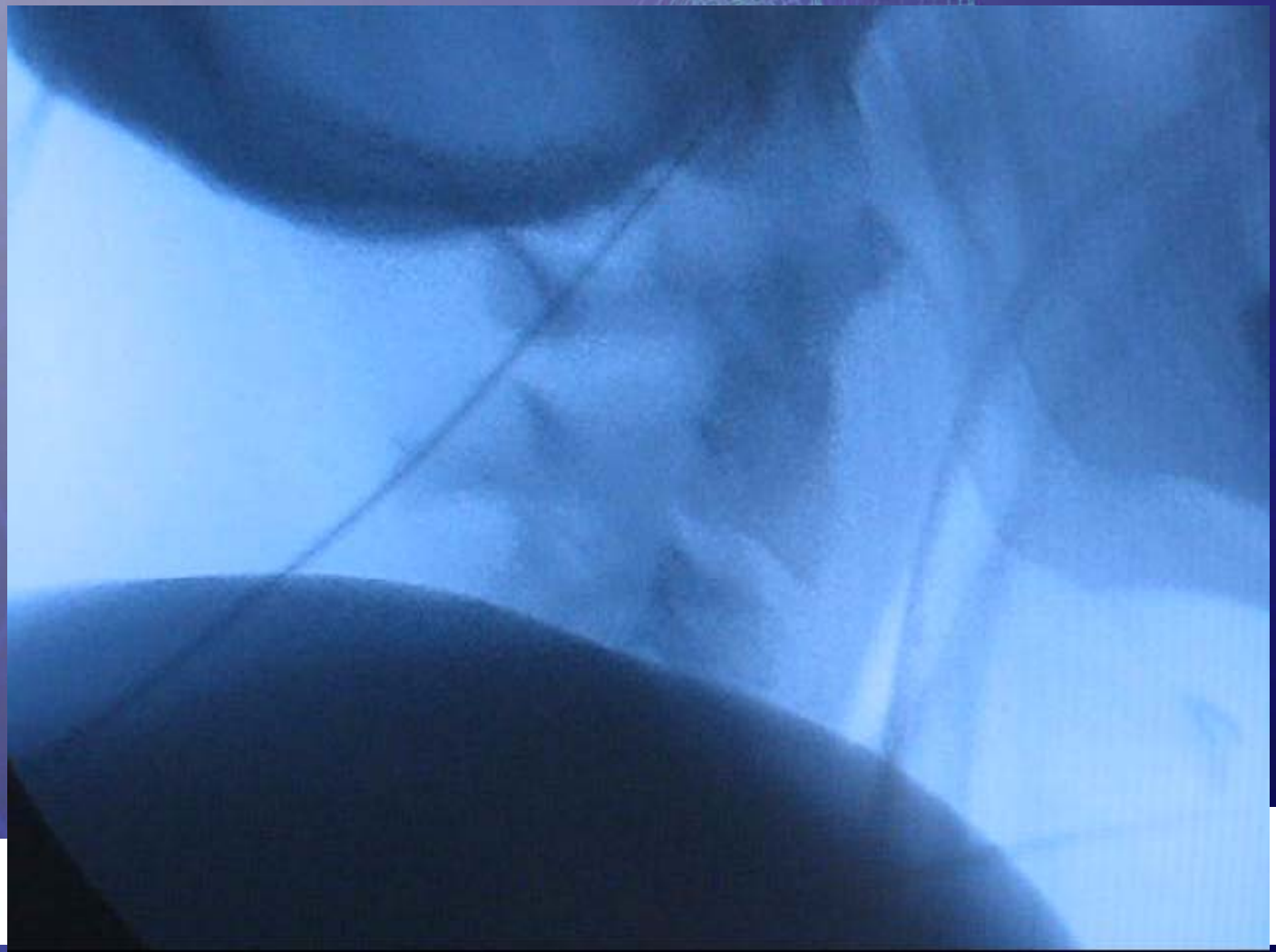
Case No. III

- In hospital flouroscopy



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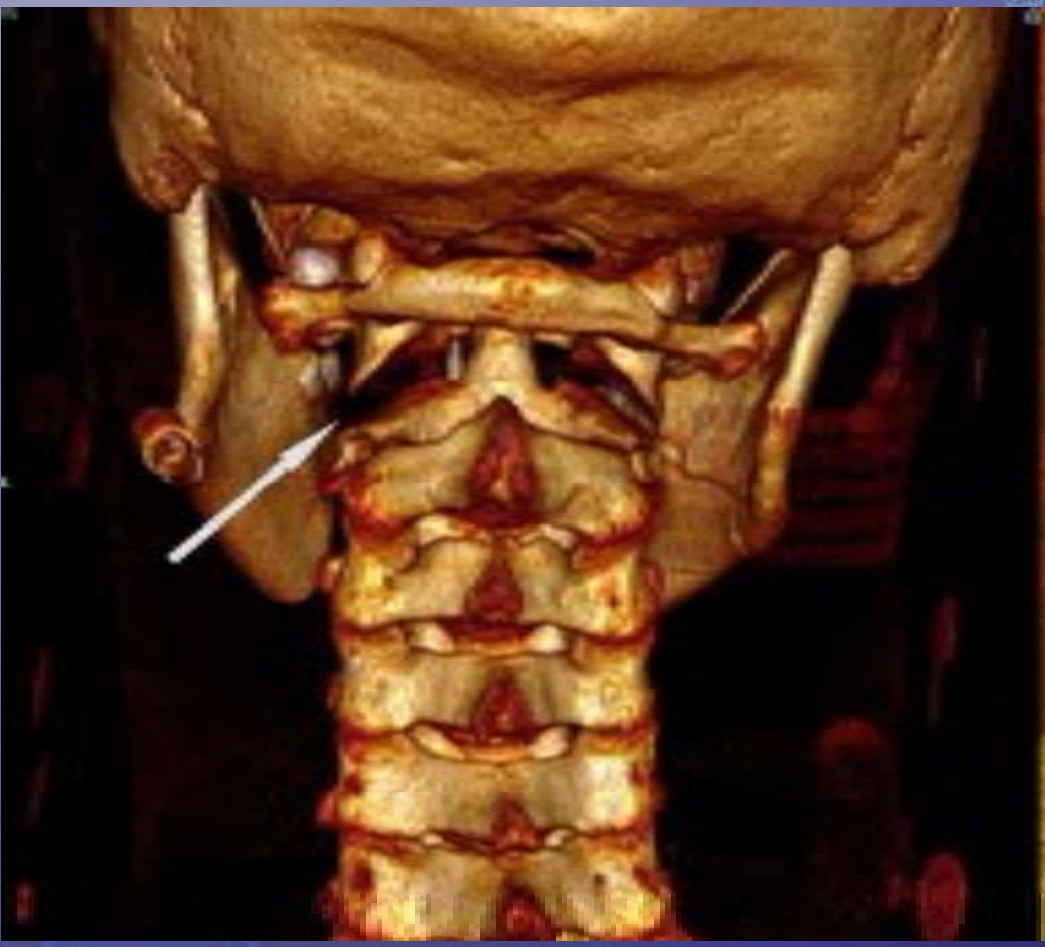
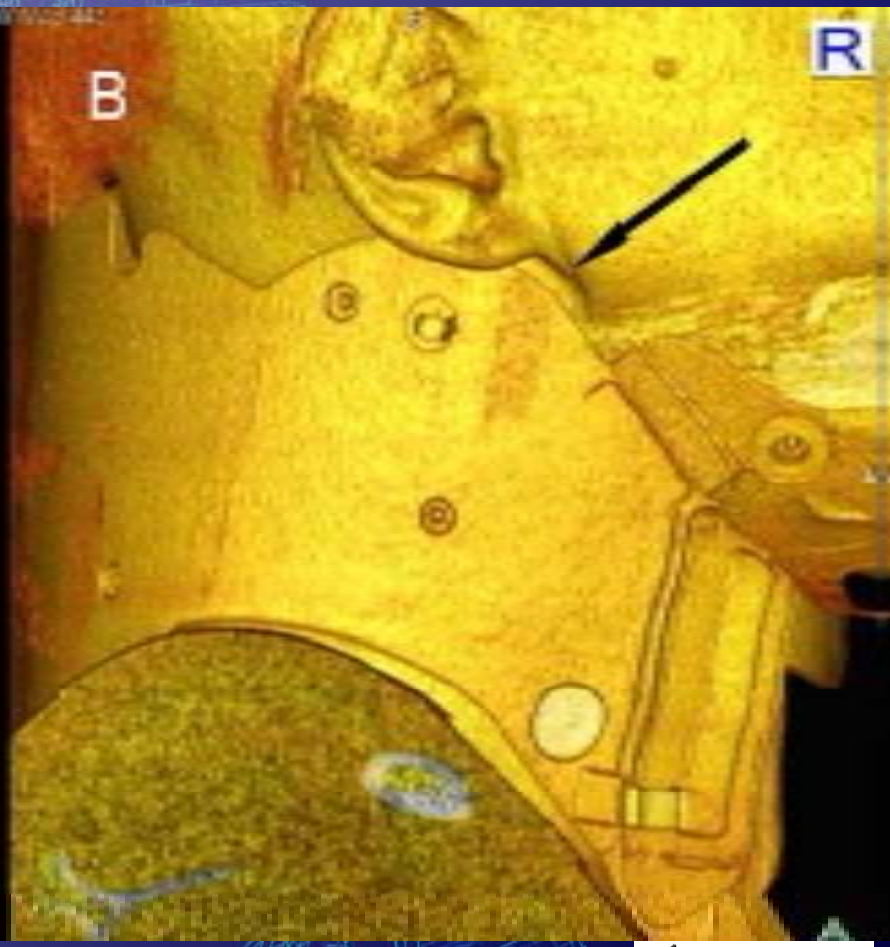
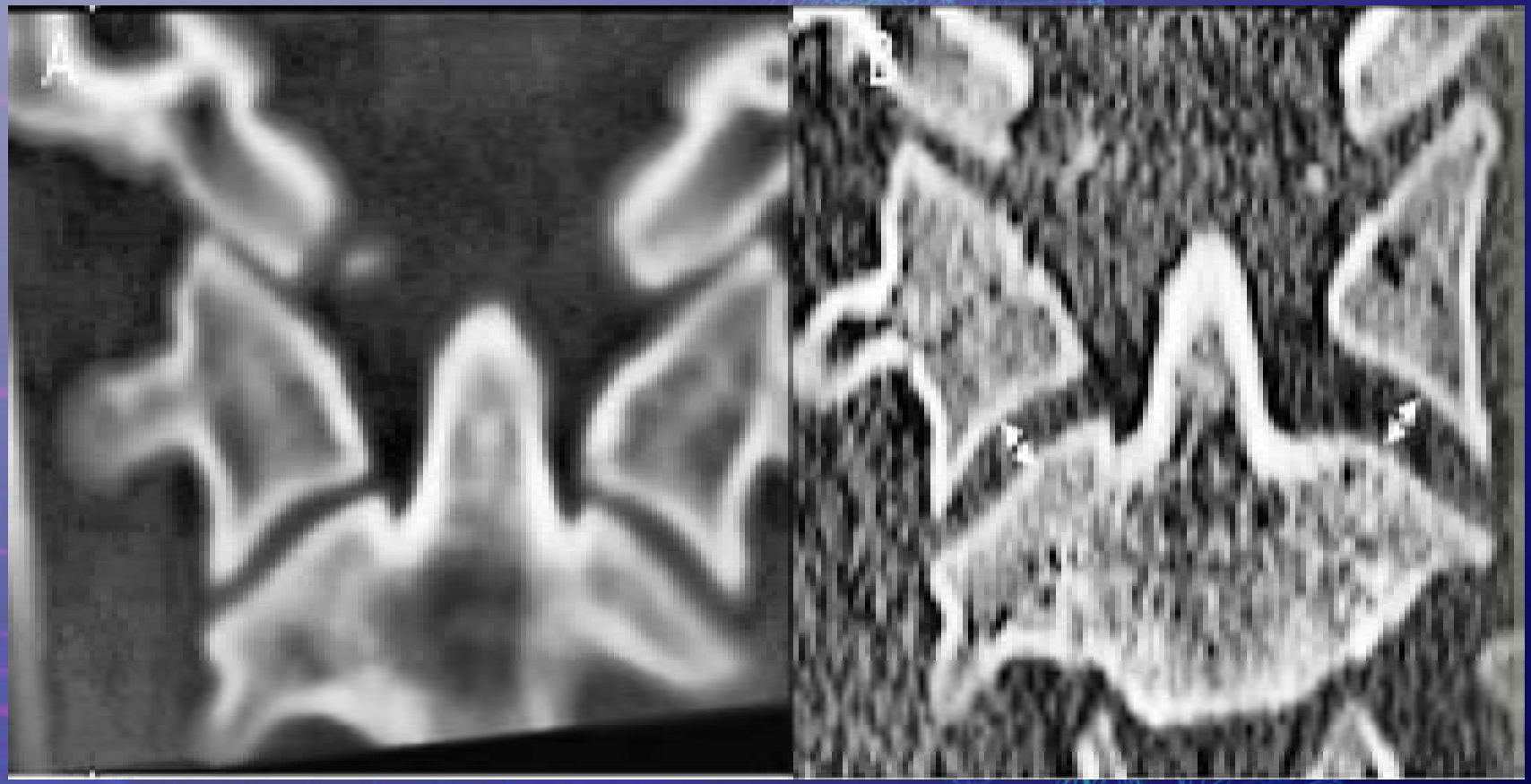
Distraction 2nd collar application





With and without C-Collar



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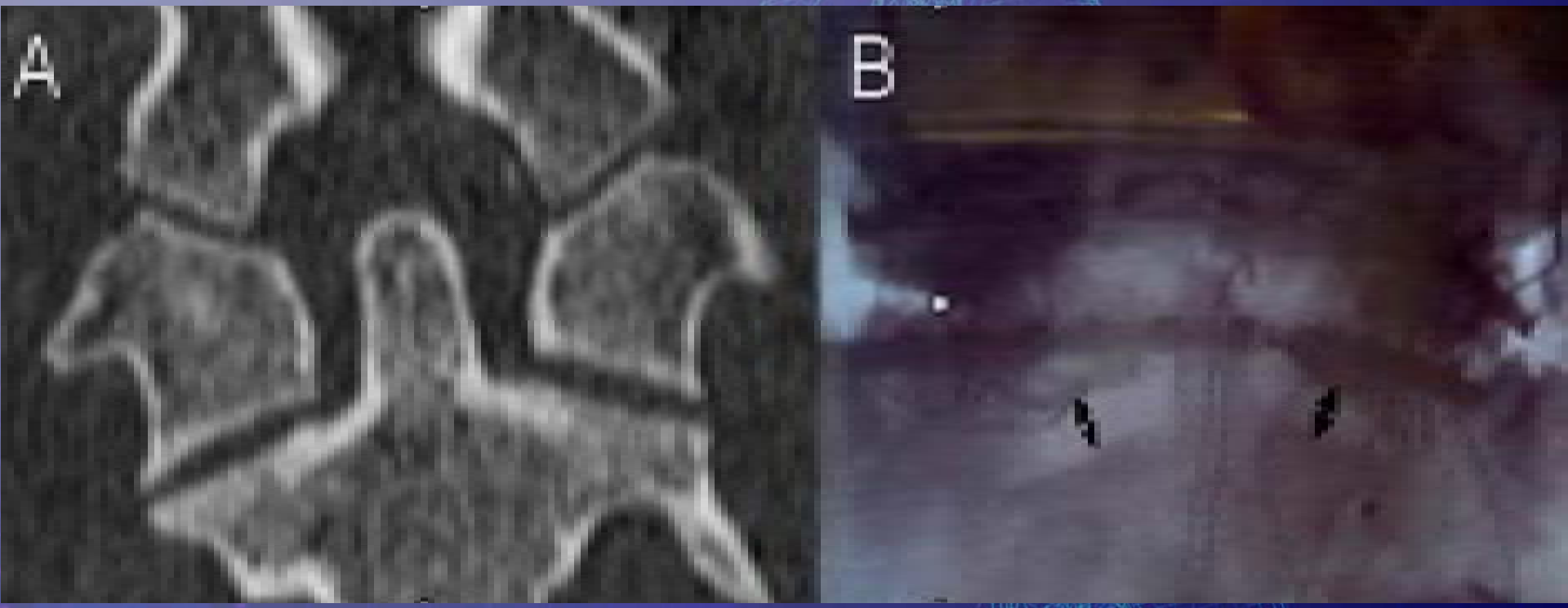
Case No. VI

Collar application directly caused this C1-C2 distraction

With and without C-Collar



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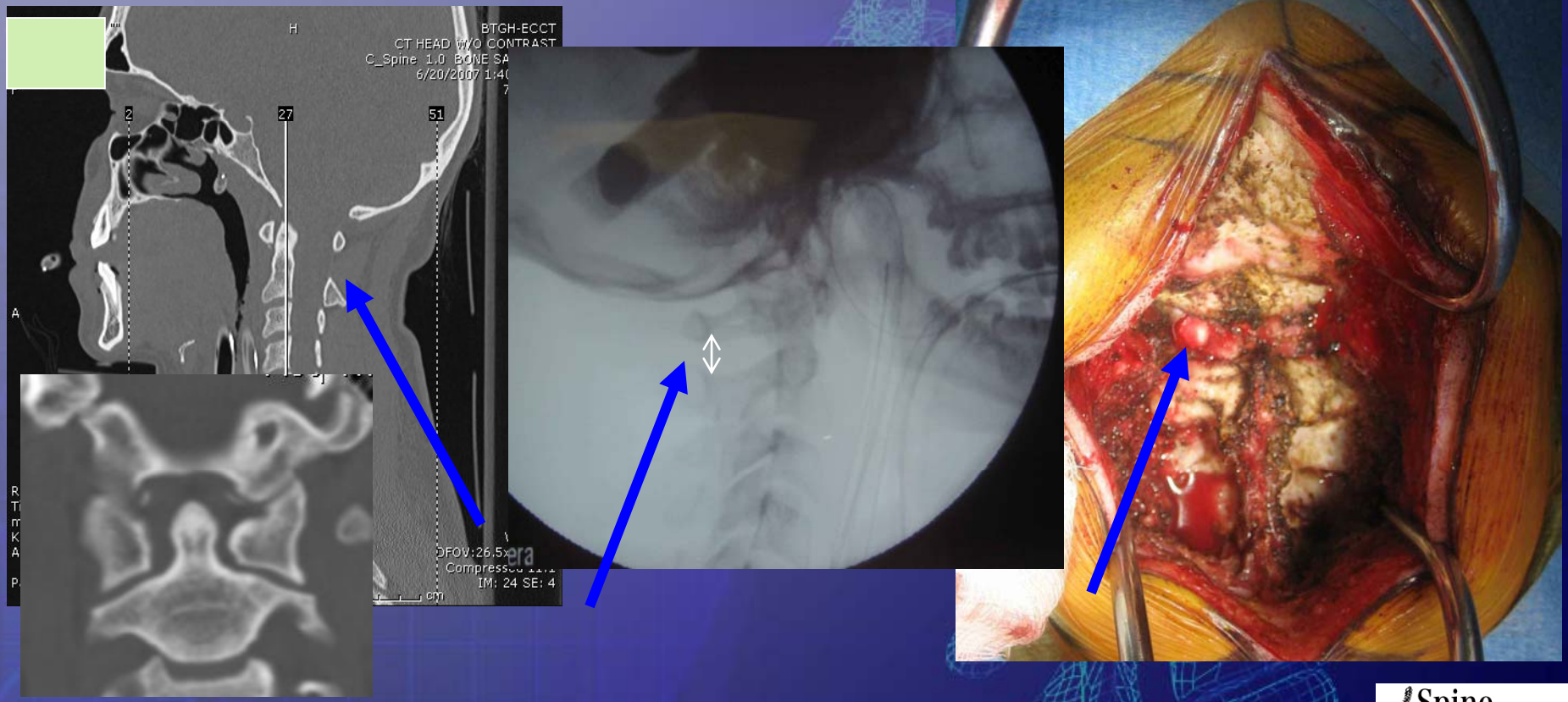
Ben-Taub Clinical experience Case - VII

- 19 y/o female – auto-pedestrian accident



Dissociative injuries

- Soft Tissue Rupture
- Vertical Separation Forces
- Distraction

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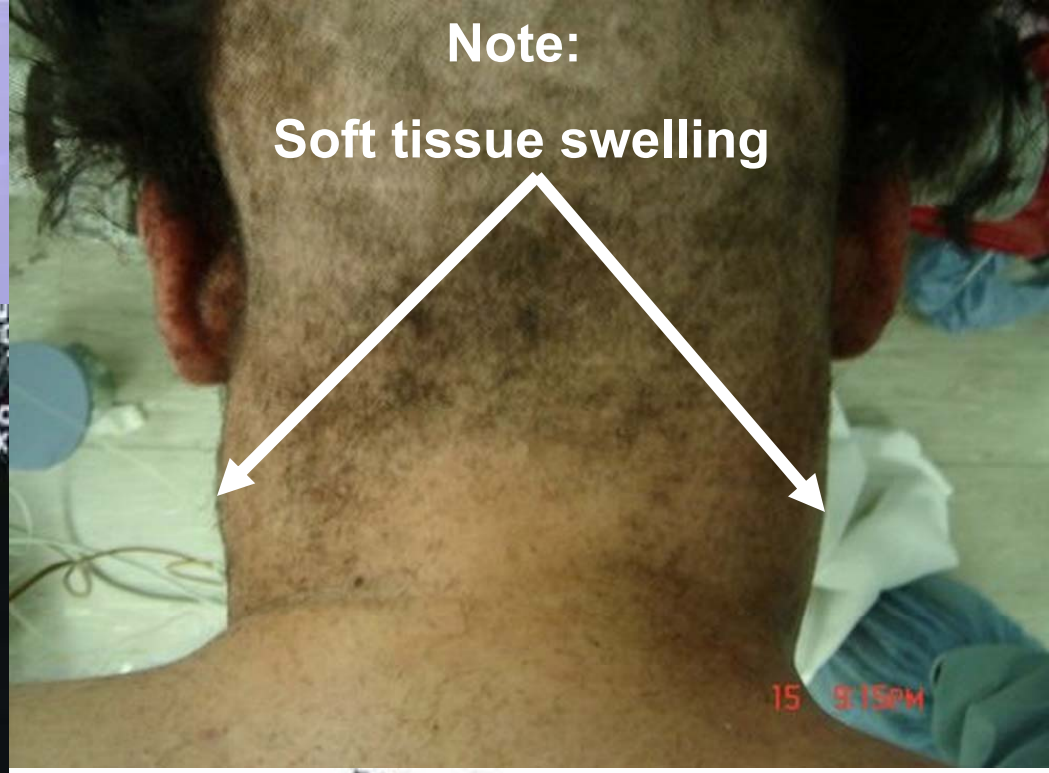
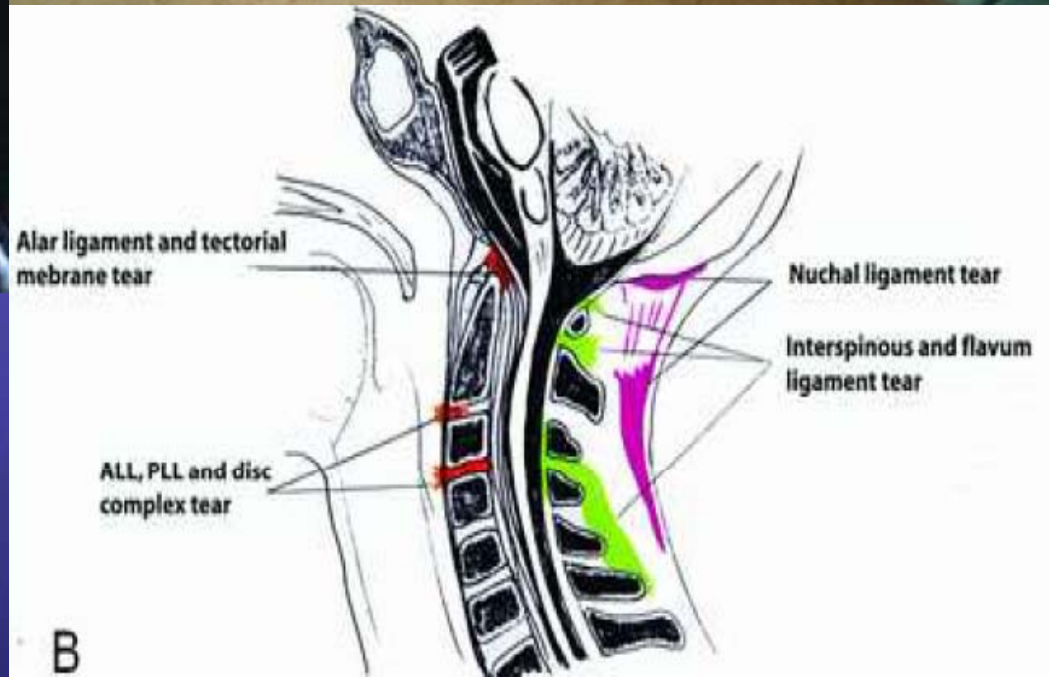
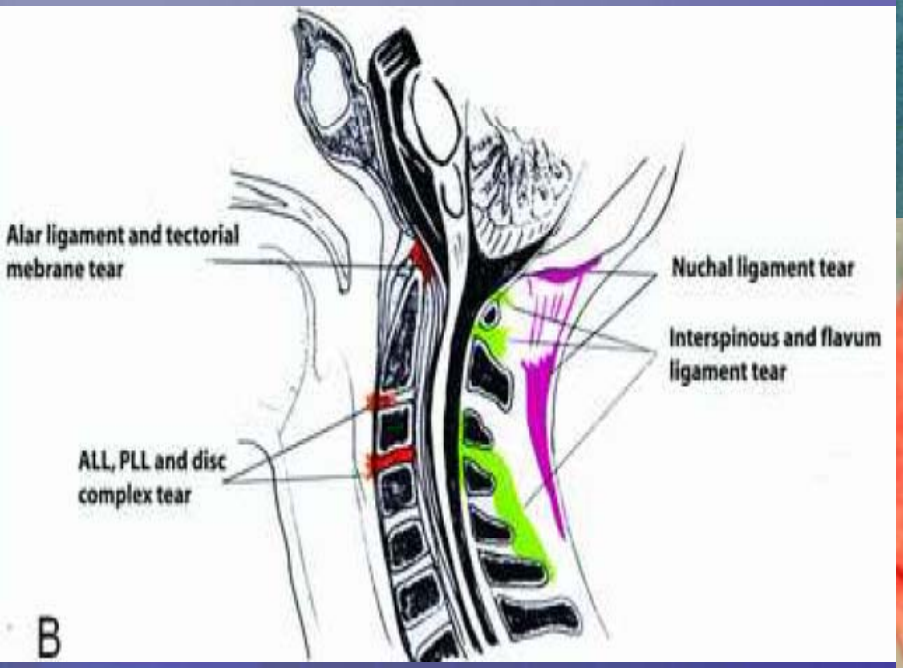
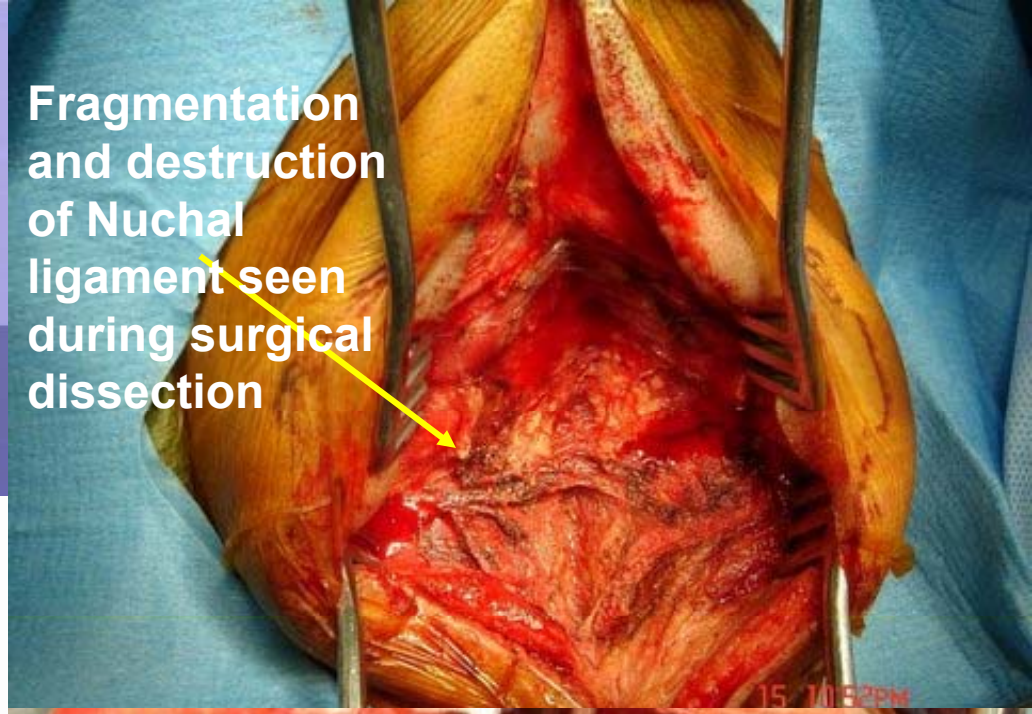
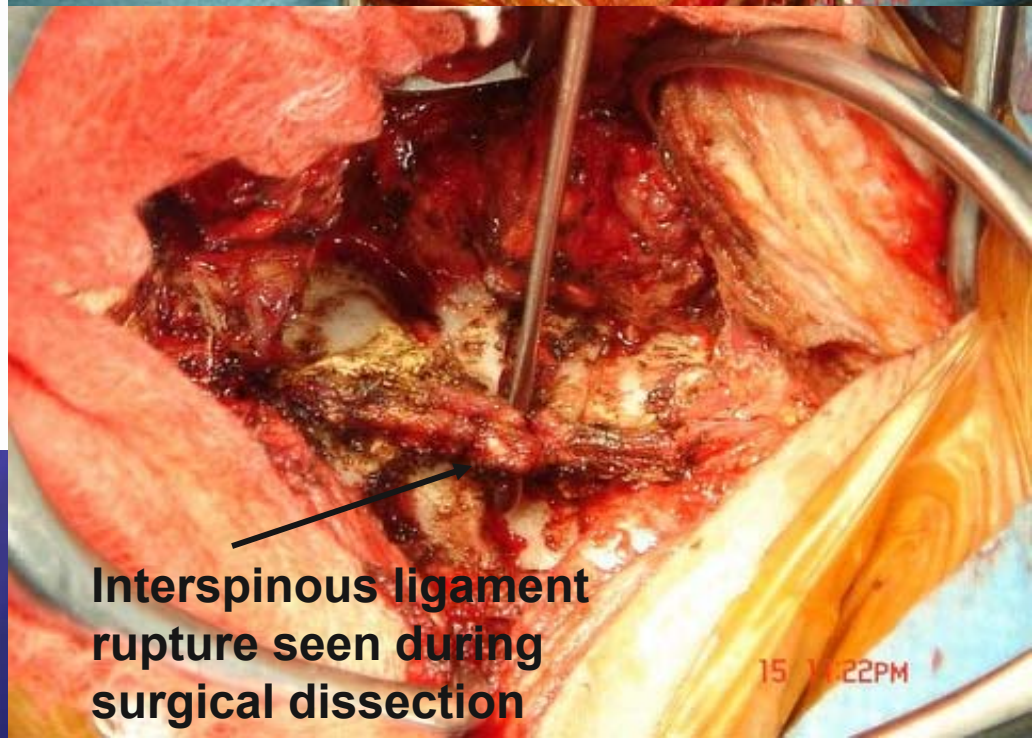




Dissociative Injury







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Internal Decapitation

- Complete, through and through dissociation from front to back
- Ligament Rupture
- Soft Tissue Rupture

Internal Decapitation

Survival After Head to Neck Dissociation Injuries

Peleg J. Ben-Galim, MD,* Tarek A. Sibai, MD,† John A. Hipp, PhD,
Michael H. Heggeness, MD, PhD,* and Charles A. Reitman, MD*

SPINE Volume 33, Number 16, pp 1744–1749

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- Dissociative injuries are susceptible to traction forces

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Why do these injuries happen ?

Acceleration-deceleration Human Trials

NBDL database

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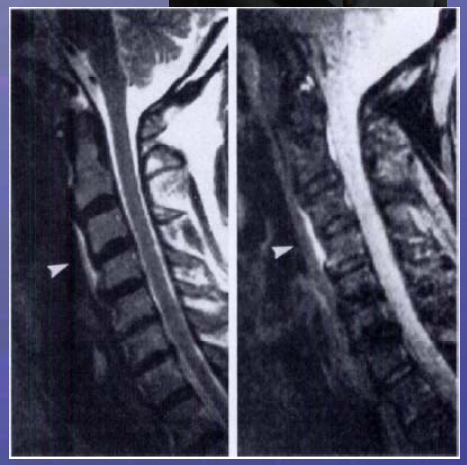
Spectrum of dissociative Injury



Frank separation

Death

Asymptomatic

Neck pain

Fractures and dislocations

Internal decapitation injury

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What pathologies are commonly associated with death from blunt trauma ?


Is There a GOLD standard ?
Forensic studies
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Common pathologies in death from blunt trauma

liver	spleen	aorta	lung	General chest
2.1	0.1	7.1	1.6	1.6
20.8	11.2	10.8	18.1	8.2

Forensic studies – The GOLD standard

Cervical Spinal Injuries:
An Autopsy Study of 109 Blunt Injuries

James R. Taylor
Mary M. Taylor

Cervical Spine: Postmortem Assessment of Accident Injuries—Comparison of Radiographic, MR Imaging, Anatomic, and Pathologic Findings[1]

Axel Stäbler, MD
Jurik Eck, MD
Randolph Penning, MD
Stefan P. Milz, MD
Reiner Bartl, MD
Donald Resnick, MD
Maximilian Reiser, MD

- Bucholz et al. J Bone Joint Surg Am. 1979 Mar;61(2):248-50.
- Bucholz et al. Journal of Trauma-Injury Infection & Critical Care. 19(10):768-71, 1979 Oct.
- Adams et al. Journal of Forensic Sciences. 37(2):556-64, 1992 Mar.

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Forensic studies – The GOLD standard

Radiology 2001; 221:340–346

Emergency Radiology

Cervical Spine: Postmortem Assessment of Accident Injuries—Comparison of Radiographic, MR Imaging, Anatomic, and Pathologic Findings[1]

Cervical Spinal Injuries: An Autopsy Study of 109 Blunt Injuries

James R. Taylor
Mary M. Taylor

Musculoskeletal Pain Emanating from the Head and Neck

Results: Spinal injuries were often secondary to head impacts, or to primary accelerations of the torso without head impact. One hundred and two [94%] of the spines showed injuries, more often to the intervertebral joints than to the vertebrae; the majority of the lesions were not visible on postmortem x-rays. The most frequently in-

CONCLUSION: Soft-tissue and intervertebral disk and ligament injuries account for 89% (25 of 28) of posttraumatic cervical spine lesions detected on postmortem images. Occult lesions, including apophyseal joint injuries, were found in clinically

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Conclusion

Occult dissociative injuries.

Dissociative injuries of the cervical spine are

The Most common pathologies found in trauma fatalities on autopsies

The Association of Occipitocervical Dissociation and Death as a Result of Blunt Trauma

Ran Lador, MD, Peleg Ben-Galim, MD, Bradley K. Weiner, MD, John A. Hipp, PhD

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For decades it was assumed that these patients die at the scene of injury.

Are there ANY survivors ?

Survivors

Survivors of occipitoatlantal dislocation injuries: imaging and clinical correlates

ERIC M. HORN, M.D., PH.D., IMAN FEIZ-ERFAN, M.D., GREGORY P. LEKOVIC, M.D., PH.D., J.D., CURTIS A. DICKMAN, M.D., VOLKER K. H. SONNTAG, M.D., AND NICHOLAS THEODORE, M.D.

J Neurosurg Spine 6:113–120, 2007

Object. Although rare, traumatic occipitoatlantal dislocation (OAD) injuries are associated with a high mortality rate. The authors evaluated the imaging and clinical factors that determined treatment and were predictive of outcomes, respectively, in survivors of this injury.

Methods. The medical records and imaging studies obtained in 33 patients with OAD were reviewed retrospectively. Clinical factors that predicted outcomes, especially neurological injury at presentation and imaging findings, were evaluated.

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Survivors

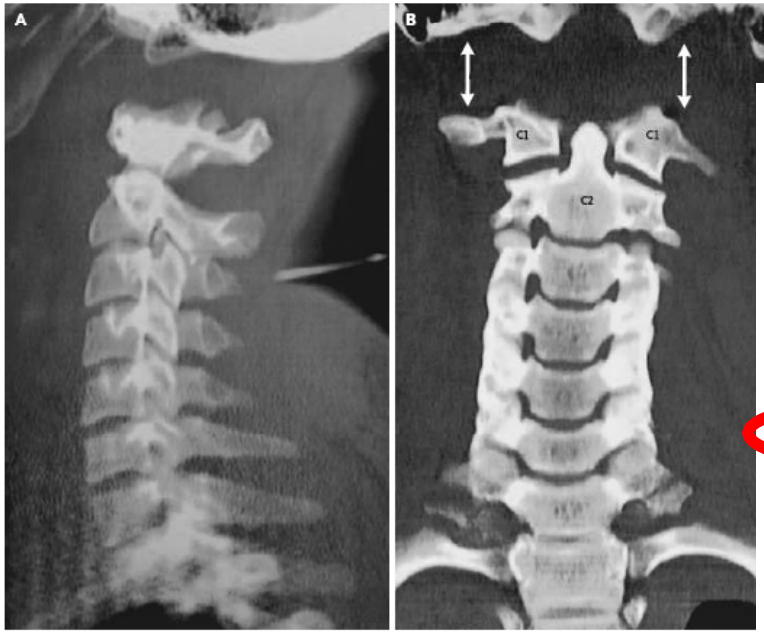
McMonagle,
NEJM 354;4 January 26, 2006

- Blunt trauma
- Emergency laparotomy
- Stabilization in the ICU
- CT in ICU

The NEW ENGLAND JOURNAL of MEDICINE

IMAGES IN CLINICAL MEDICINE

The Importance of Early Cervical-Spine Radiography



A 19-YEAR-OLD MAN WAS BROUGHT TO THE EMERGENCY DEPARTMENT after a high-speed motorbike collision. The patient had a score of 3 on the Glasgow Coma Scale (possible scores range from 3 to 15, with higher scores indicating better function), and his blood pressure was 70/35 mm Hg. He did not respond adequately to advanced resuscitation; results of a subsequent emergency laparotomy were normal. After the patient's condition was further stabilized in the intensive care unit, computed tomography of the cervical spine showed major atlanto-occipital dislocation in the lateral view (Panel A) and anteroposterior view (Panel B, arrows), which proved to be fatal.

Early radiography of the cervical spine may help guide resuscitation efforts. Some trauma surgeons favor performing such radiography as part of the secondary evaluation, rather than as part of the primary evaluation. However, in cases such as this one, early radiography can reveal such serious injury that further resuscitative efforts are futile.

Survivors

Survival After Concurrent Traumatic Dislocation of the Atlanto-Occipital and Atlanto-Axial Joints

A Case Report and Review of the Literature

Conor P. Kleweno, MD, Jay M. Zampini, MD, Andrew P. White, MD, Ekkehard M. Kasper, MD, PhD, and Kevin J. McGuire, MD, MS

Spine 2008;33: E659–E662

Atlanto-occipital dislocation: four case reports of survival in adults and review of the literature

Ludwig Labler
Karim Eid
Andreas Platz
Otmar Trentz
Thomas Kossmann

Eur Spine J (2004) 13 : 172–180

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Survivors

Traumatic atlanto-occipital dislocation with survival: a case report and review of the literature. [Review] [36 refs]

Harmanli O. Koyfman Y.

Surgical Neurology. 39(4):324-30, 1993 Apr.

AB The number of patients who have survived traumatic atlanto-occipital dislocation, the usual outcome of which is death from brain stem transection, has increased in the past two decades due to improvements in on-scene resuscitation and transportation. This case of survival after traumatic atlanto-occipital dislocation is of interest because the patient had a complete neurologic recovery and a magnetic resonance imaging (MRI) study was obtained to confirm the diagnosis and rule out associated injuries. [References: 36]

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Survivors

Traumatic posterior atlantooccipital dislocation with Jefferson fracture and fracture-dislocation of C6-C7: a case report with survival.

Park JB. Ha KY. Chang H.

European Spine Journal. 10(6):524-8, 2001 Dec.

AB Atlantooccipital dislocation (AOD) is a rare and usually fatal injury. In the current study, the authors reported an extremely rare case of posterior AOD with Jefferson fracture and fracture-dislocation of C6-C7. The patient survived the injury and had only incomplete quadriplegia below the C7 segment with anterior cord syndrome. He was successfully managed with in situ occipitocervical fusion using the Cotrel-Dubousset rod system, corpectomy of C6, and anterior interbody fusion of C5-C7 with plating. To our knowledge, this is the first report of posterior AOD with two other non-contiguous cervical spine injuries. A high index of suspicion and careful examination of the upper cervical spine should be considered as the key to the diagnosis of AOD in cases that involve multiple or lower cervical spine injuries.

Radiology in survivors of traumatic atlanto-occipital dislocation.

Ahuja A. Glasauer FE. Alker GJ Jr. Klein DM.

Surgical Neurology. 41(2):112-8, 1994 Feb.

AB Traumatic atlanto-occipital dislocation is fatal, but survivals are reported. Six cases of survival after atlanto-occipital dislocation are presented. Lateral cervical spine radiographs demonstrated retropharyngeal swelling in all patients, and Powers' ratio was abnormal in five of six patients. Reformatted computed tomography (CT) images or three-dimensional CT were useful in confirming the diagnosis. Initial treatment consisted of immobilization with halo or collar, and, in one patient, Crutchfield tongs. Reduction of the dislocation was associated with decreasing Powers' ratio in five long-term survivors. Residual neurologic deficits, however, were seen in these patients. Atlanto-occipital dislocation should be suspected in trauma patients with findings of brain stem injury--especially agonal respirations, irregular heart rate, lower cranial nerve abnormality, and asymmetrical motor deficits.

Survivors

Diagnosis and treatment of craniocervical dislocation in a series of 17 consecutive survivors during an 8-year period

Carlo Bellabarba, M.D., Sohail K. Mirza, M.D., M.P.H., G. Alexander West, M.D., Ph.D., Frederick A. Mann, M.D., Andrew T. Dailey, M.D., David W. Newell, M.D., and Jens R. Chapman, M.D.

J. Neurosurg: Spine / Volume 4 / June, 2006

Object. Craniocervical dissociation (CCD) is a highly unstable and usually fatal injury resulting from osseoligamentous disruption between the occiput and C-2. The purpose of this study was to elucidate systematic factors associated with delays in diagnosing and treating this life-threatening condition and to introduce an injury-severity classification with therapeutic implications.

Methods. In a retrospective evaluation of institutional databases, the authors reviewed medical records and original images obtained in 17 consecutive surviving patients with CCD treated between 1994 and 2002. Images and clinical results of treatment were evaluated, emphasizing the timing of diagnosis, clinical effect of delayed diagnosis, potential clinical or imaging warning signs, and response to treatment.

Craniocervical dissociation was identified or suspected on the initial lateral cervical spine radiograph acquired in two patients (12%) and was diagnosed based on screening computerized tomography findings in two additional patients (12%). A retrospective review of initial lateral x-ray films showed an abnormal dens–basion interval in 16 patients (94%). The 2-day average delay in diagnosis was associated with profound neurological deterioration in five patients (29%). Neurological status declined in one patient after a fixation procedure was performed. There were no cases of craniocervical pseudarthrosis or hardware failure during a mean 26-month follow-up period. The mean American Spinal Injury Association (ASIA) motor score of 50 improved to 79, and the number of patients with useful motor function (ASIA Grade D or E) increased from seven (41%) preoperatively to 13 (76%) postoperatively.

Conclusions. The diagnosis of CCD was frequently delayed, and the delay was associated with an increased likelihood of neurological deterioration. Early diagnosis and spinal stabilization protected against worsening spinal cord injury.

Internal Decapitation

Survival After Head to Neck Dissociation Injuries

Peleg J. Ben-Galim, MD,* Tarek A. Sibai, MD,† John A. Hipp, PhD,
Michael H. Heggeness, MD, PhD,* and Charles A. Reitman, MD*

SPINE Volume 33, Number 16, pp 1744–1749

Study Design. Case series.

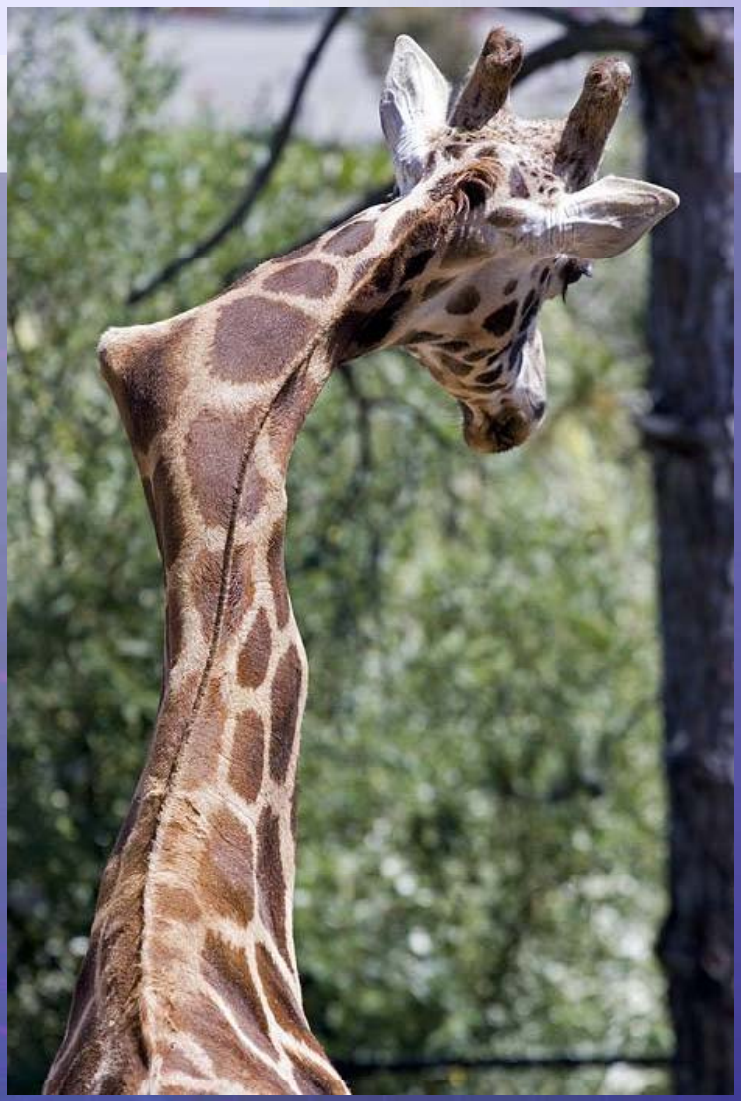
Objective. To describe survival and outcomes after occipitocervical dissociation injuries.

Summary of Background Data. Historically, occipitocervical dissociation injuries have a high rate of associated neurologic deficit with a relatively high incidence of mortality.

Methods. Six patients with occipitocervical dissociation injuries are reported and their management and imaging findings reviewed. Possible contributory factors for survival are discussed.

Results. All patients had upper neck and head dissociation injuries. The pattern of injury in all of these cases included a distraction type mechanism. All cases demonstrated soft tissue disruption in the zone of injury, which was consistent and apparent on all imaging studies. In these patients, the extent and severity of injury was more apparent on magnetic resonance imaging (MRI) than on radiograph or computed tomography scan. Management of these injuries included immobilization followed by surgery with particular care taken to avoid application of distraction forces to the neck.

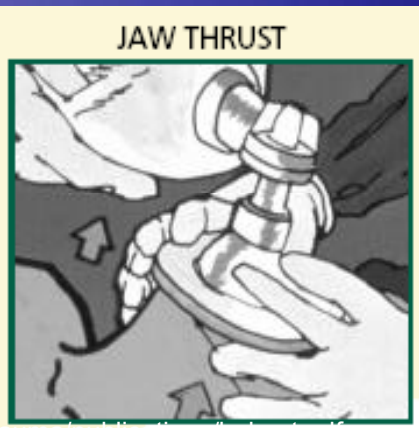
Conclusion. Patients with occipitocervical dissociation injuries may survive their injury and even retain neurologic integrity. Initial in-line head stabilization is emphasized to prevent catastrophic neurologic injury. The resting osseous relationships and vertebral alignment at the time of imaging evaluation may be deceivingly normal, and the damage often primarily or exclusively involves disruption of the perivertebral soft tissue structures. Prevertebral soft tissue swelling was apparent in all cases. For these injuries that involve primarily damage to the ligamentous structures, MRI seems to be the optimal test for revealing the magnitude of the injury.



It is possible to survive severe neck injuries

What do we currently do to protect the neck?

Pull - Traction reality of Airway and C-Spine protection



www.facs.org/trauma/public

ttp://www.facs.org/trauma/publications/airway.pdf

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http://anesthesia.

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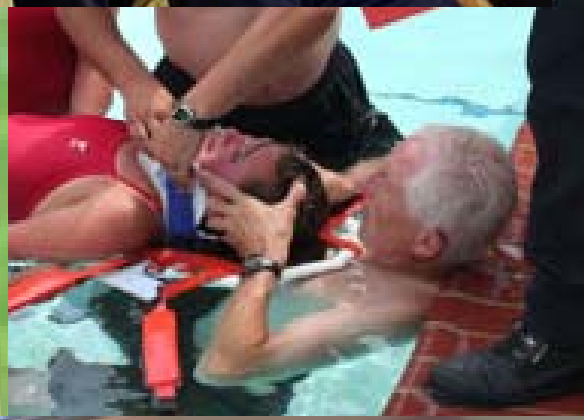
The Reality of it all

the so called

"in line

stabilization"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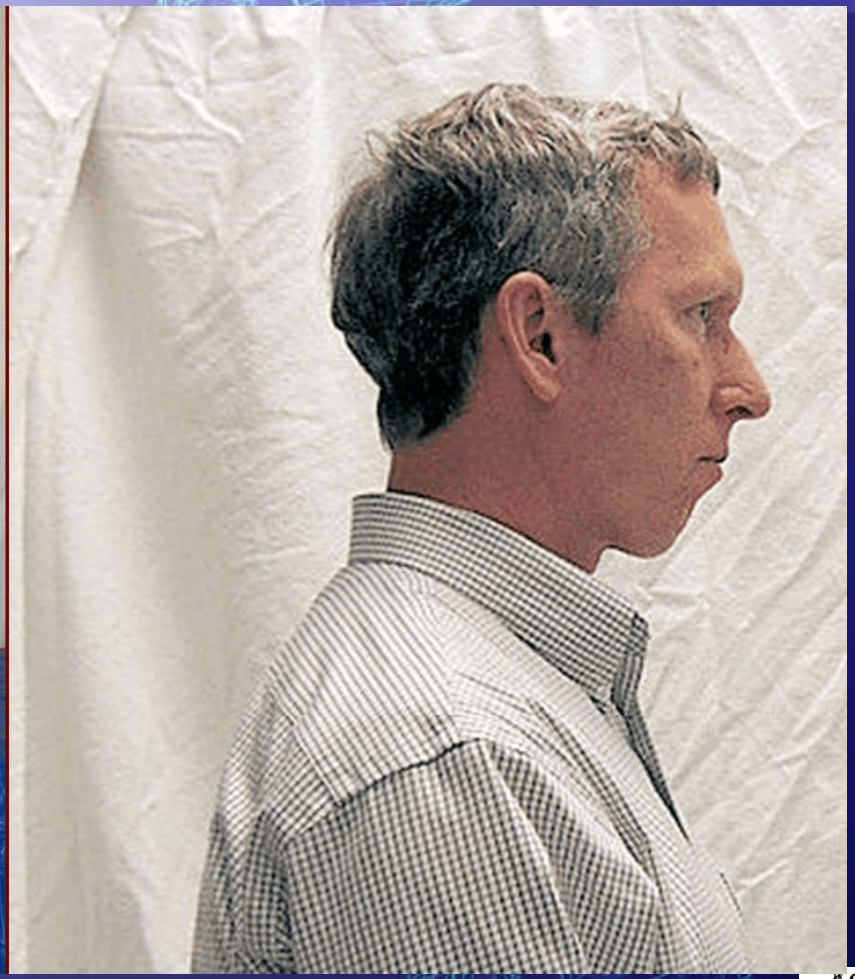
Hypothesis: Collars stabilize the spine in part through the use of distractive forces

Hypothesis:
collar creates distraction ?



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Can the Hypothesis be proven ?
- Whole Human Cadaver studies

- Whole human cadavers
- Intact head, torso, limbs
- Fresh / non-embalmed
- Post-rigor mortis

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Cadaver studies

- **Simulated OCI:**

  - C1-C2 flexion distraction injury was simulated
  - Complete ligamentous disruption. (Muscle sparing)

Cadaver studies

- Standard EMS maneuvers
  - Rigid collar application process
  - Patient tilting
- Fluoroscopic imaging
  - Baseline
  - During maneuver

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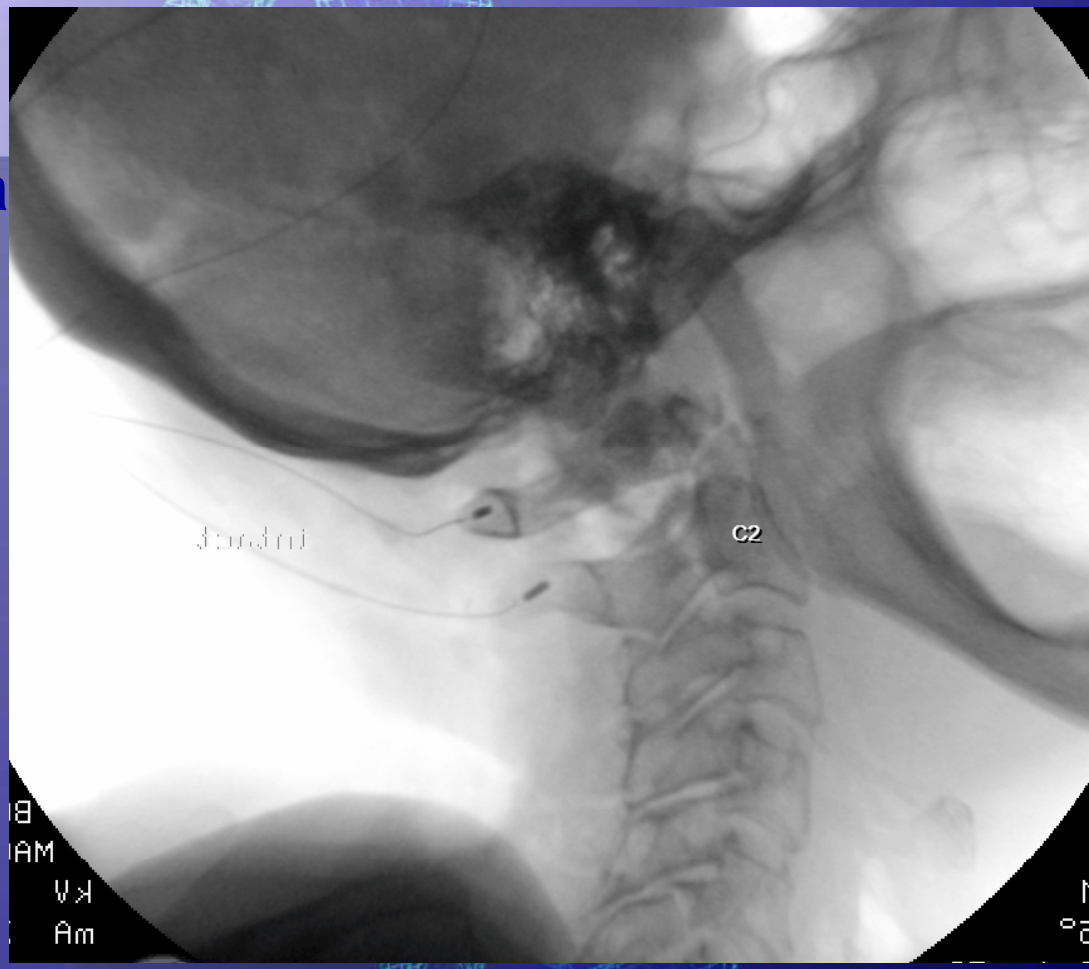
Intervertebral Motion in the Unstable Cervical Spine

Caused by Application of a Conventional Collar

Laboratory Test 3



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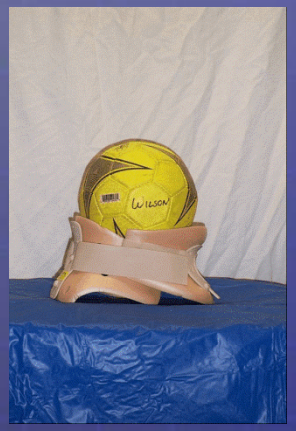
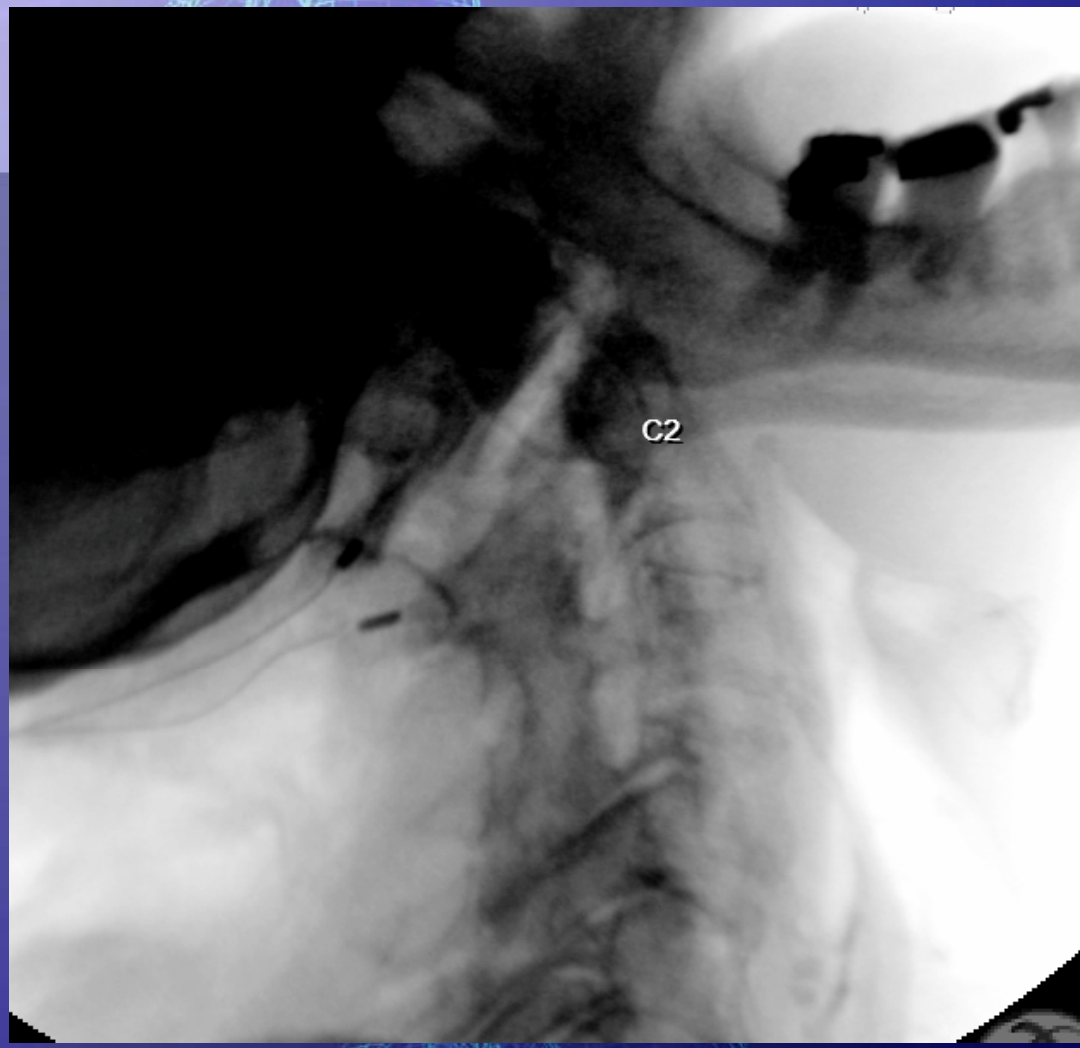
Intervertebral Motion in the Unstable Cervical Spine

Caused by Application of a Conventional Collar

Laboratory Test 4





Lying Supine injured ->Collar on->Intubate

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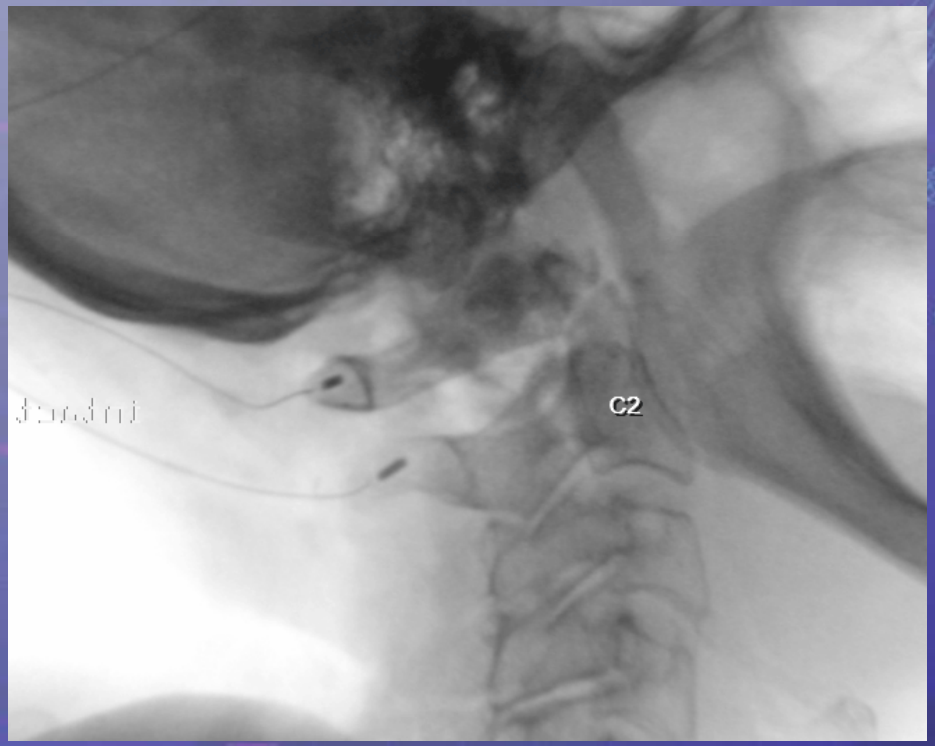
J Neurosurg (Spine 1) 3:273–280, 2004

Vertical atlantoaxial distraction injuries: radiological criteria and clinical implications

L. Fernando Gonzalez, M.D., David Fiorella, M.D., Ph.D., Neil R. Crawford, Ph.D., Robert C. Wallace, M.D., Iman Feiz-Erfan, M.D., Denise Drumm, Ph.D., Stephen M. Papadopoulos, M.D., and Volker K. H. Sonntag, M.D.



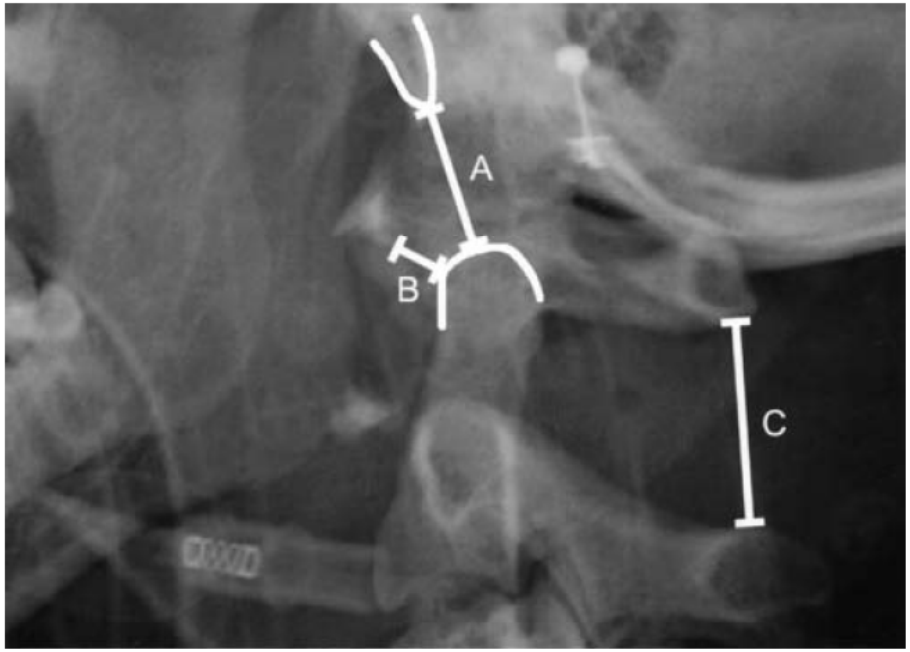


FIG. 2. Cross-table lateral cervical radiograph revealing a vertical distraction injury in a patient who died soon after the radiographs were obtained. The C-1 ring and skull base are markedly displaced cephalad with respect to C-2. The BDI is widened (Line A), and the atlantodens distance is increased (Line B). The distance between the posterior elements of C-1 and C-2 is grossly increased (Line C).

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Cadaver studies

- Standard EMS maneuvers
  - Rigid collar application process
  - Patient tilting
- CT imaging
  - Baseline
  - During maneuver

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ORIGINAL ARTICLE

Extrication Collars Can Result in Abnormal Separation Between Vertebrae in the Presence of a Dissociative Injury

Peleg Ben-Galim, MD, Niv Dreiangel, MD, Kenneth L. Mattox, MD, Charles A. Reitman, MD, S. Babak Kalantar, MD, and John A. Hipp, PhD

The Journal of TRAUMA® Injury, Infection, and Critical Care

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Should we be surprised ?

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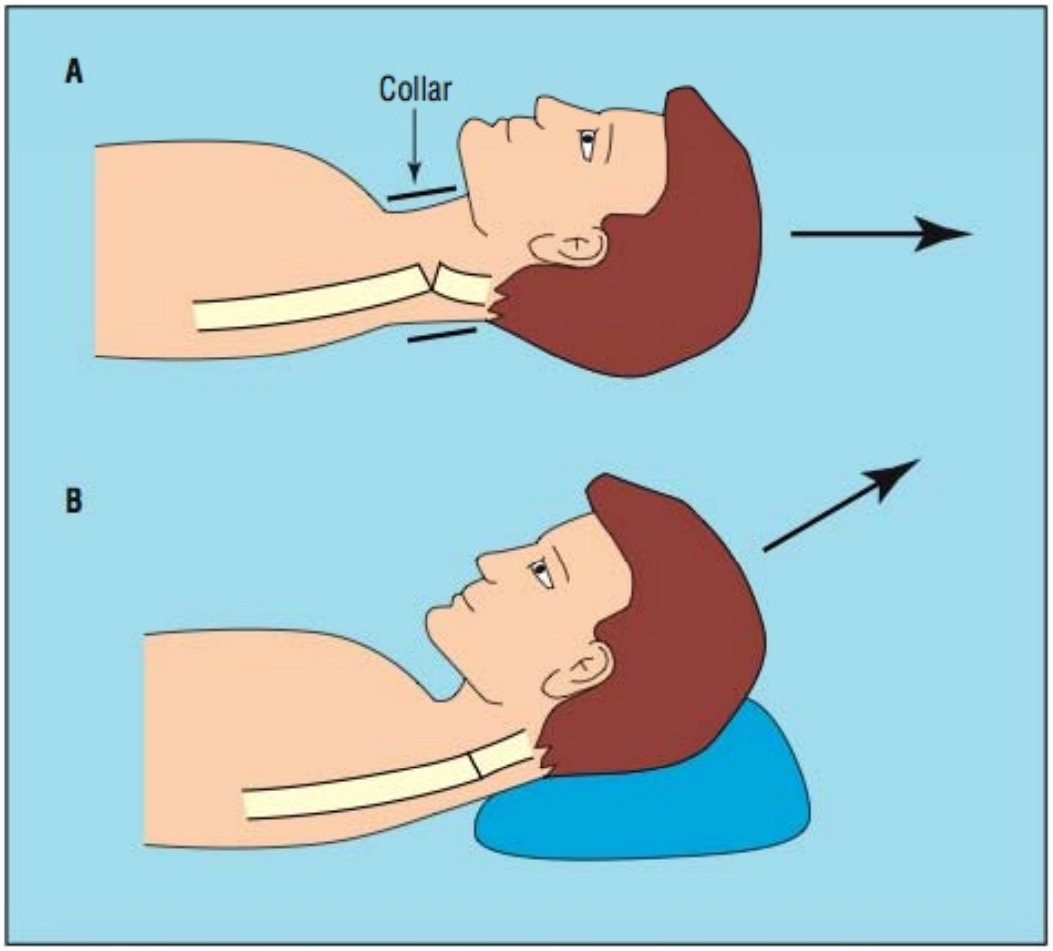

Fig 3 Applying a hard collar to a patient with major cervical kyphosis and a fracture of the cervical spine (above) angulates the fracture and causes cord injury; immobilisation in flexion by placing sandbags under the occiput (below) reduces the fracture and prevents cord damage

Papadopoulos et al. Lesson of the week: exacerbating cervical spine injury by applying a hard collar. BMJ (1999) vol. 319 (7203) pp. 171-2

Ongoing neurological deterioration

Ongoing neurological deterioration during transfer and initial workup

- **Deterioration during transit or early management**

Cervical Spine Immobilization before Admission to the Hospital

Neurosurgery, Vol. 50, No. 3, March 2002 Supplement

vertebrae. It is estimated that 3 to 25% of spinal cord injuries occur after the initial traumatic insult, either during transit or early in the course of management (14, 15, 42, 48, 81, 97).

Ongoing neurological deterioration during transfer and initial workup

Secondary Neurologic Deficit Due to Unrecognized Spine Instability in Multitrauma Casualties

*Yoram Folman, MD, and †Reuven Gepstein, MD

(*J Orthop Trauma* 2004;18:450–454)

Ten to twenty-nine percent of multitrauma casualties with delayed/missed diagnosis of CSI sustain secondary injury to the spinal cord/cauda equina, with neurologic sequelae, while undergoing urgent life-saving treatment or while the diagnosis is being made.[6,7]

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Spinal immobilisation for trauma patients (Review)

Kwan I, Bunn F, Roberts I, on behalf of the WHO Pre-Hospital Trauma Care Steering Committee

Lunsford 1994	The effectiveness of four contemporary cervical orthosis in restricting cervical motion	Randomised controlled trial	10 healthy volunteers	No collar vs Philadelphia collar vs Miami J collar vs Malibu collar vs Newport collar	Degree of cervical motion measured with video frames	Significant reduced motion with each orthosis than 'no orthosis' ($P<0.05$). Significant more restriction in mobility with the Malibu collar ($P<0.05$).

Main results

We found no randomised controlled trials of spinal immobilisation strategies in trauma patients.

Authors' conclusions

We did not find any randomised controlled trials that met the inclusion criteria. The effect of spinal immobilisation on mortality, neurological injury, spinal stability and adverse effects in trauma patients remains uncertain. Because airway obstruction is a major cause of preventable death in trauma patients, and spinal immobilisation, particularly of the cervical spine, can contribute to airway compromise, the possibility that immobilisation may increase mortality and morbidity cannot be excluded. Large prospective studies are needed to validate the decision criteria for spinal immobilisation in trauma patients with high risk of spinal injury. Randomised controlled trials in trauma patients are required to establish the relative effectiveness of alternative strategies for spinal immobilisation.

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Take Home message

- Cervical collars are applied to millions of trauma patients with a good intent to protect against further injury in the rare event of an unstable cervical injury.

- Ironically, it is in these patients that this good intent may be harmful.

Take Home message

- Increased Vigilance for the potential that severe blunt trauma patients may have dissociative cervical spine injuries.

- Current stabilization paradigms do not address this issue.