Traumatic cervical spine fractures in the adult

This article reviews fractures of the cervical spine, highlighting the pertinent goals of initial management, the indications for different imaging modalities and the different fracture patterns. Basic principles of management of these different fracture patterns are outlined.

The cervical spine is the most mobile, and thus the most vulnerable portion of the spinal construct. Of all traumatic fractures of the spine, 20.8% occur at the cervical region. Owing to the high kinetic forces transmitted in these injuries, 65% of these fractures have significant associated injuries and thus the cervical spine fracture may initially be overlooked (Leucht et al, 2009). Moreover, the risk of neurological deficit is highest with cervical spine fractures because of the proximity to the brainstem. Traumatic fractures of the cervical spine cause considerable mortality and morbidity, with a high economic burden to society, and thus early identification and optimal management is necessary in these patients.

Causes of cervical spine fractures include motor vehicle accidents, falls, sports injuries and other modes of trauma. There is a bimodal distribution, with young adults being at highest risk of injury and another peak in incidence in the elderly population, where more minor falls may cause significant injury (Leucht et al, 2009). This is especially true as elderly patients exhibit pathologies affecting the structural integrity of the column that can predispose to injury, for example osteoporosis, atlantoaxial instability (e.g. rheumatoid arthritis or Down's syndrome), myeloma and pre-existing degenerative disease of the spine.

Emergency management

All trauma patients are presumed to have a cervical spine fracture until proven otherwise and thus the cervical spine is immobilised at the scene of the accident to prevent neurological damage from excessive manipulation during and after transfer. Neck immobilisation is achieved by positioning the patient on a firm surface in a neutral position; this is achieved with a backboard under the spine. Two sandbags or foam blocks are placed on either side of the head and taped together over the patient's forehead and below the chin to provide stabilization. Manual in-line stabilization may be performed before this to achieve stability temporarily. If the patient's neck is not in a neutral position, the patient may, if conscious, be able to re-align it him-/herself. If unconscious, the initial responder should attempt gentle manipulation of the neck into a neutral position. Any signs of resistance, pain or neurological deficit should alert the clinician to stop any intervention and stabilize the spine in its current position.

On arrival at hospital, the patient should be transferred from the spinal board to a firm trolley for resuscitation. If the cervical spine immobilisation devices need to be removed for intubation or examination, manual in-line immobilisation should be reinstated. All patients arriving having suffered major trauma should be treated according to the principles outlined by the Advanced Trauma Life Support (ATLS) and an initial assessment should be performed to treat life-threatening emergencies and reveal underlying injuries.

Fractures of the cervical spine may become apparent during the initial assessment of the patient if neurological deficit is immediately obvious and affects resuscitation, e.g. phrenic nerve palsy or neurogenic shock. They may also become apparent during the secondary survey when examination reveals findings consistent with cervical spine injury, such as spinal tenderness or neurological deficit. However, these fractures are most commonly determined on imaging of the patient by conventional radiography or computed tomography. Indeed, of all patients with fractures of the cervical spine, only 15% have neurological injury. Radiological diagnosis is also much more likely in the unconscious patient or the patient with significant injuries that distract attention from spinal pain.

Imaging

Consensus as to the best method of imaging the potentially injured cervical spine has not yet been reached. The National Institute for Health and Care Excellence (2014) guidelines on head injury state that a patient should have a computed tomography scan within 1 hour if the Glasgow Coma Scale score is <13 on initial assessment, to rule out

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injury before urgent surgery. They also advise computed tomography if there is a dangerous mechanism of injury (*Table 1*), any focal neurological deficit or if the patient is older than 65 years. If the patient is having computed tomography imaging for other injuries, imaging of the vertebral column should be carried out concomitantly. Indeed, in those found to have a fracture of the cervical spine, 15–20% will have a non-contiguous fracture of the vertebral column and thus imaging of the whole spine should be carried out (Torretti and Sengupta, 2007).

Canadian C-spine rules (Stiell et al, 2001) stipulate that if the mechanism of action is unlikely to have caused a fracture (*Table 1*), clinical examination of the spine alone can rule out a fracture. A fracture is also less likely if the patient is maintaining a sitting position in the department, is ambulatory at any time, if there is neck pain of delayed onset, or if there is an absence of midline cervical spine tenderness. If the patient does not satisfy these criteria, radiographs are performed. Otherwise the neck immobilisation is removed and the patient is asked to rotate the head 45° to either side. If the patient is unable to do this, he/she requires imaging. If any abnormality is found on plain radiograph studies, a computed tomography scan should be sought to further delineate the injury. Even with optimal radiographic views, a 0.5% false negative value is the reason that in high-risk patients, or if clinical suspicion remains, a computed tomography scan should be performed to ensure an injury is not missed (Besman et al, 2003).

In assessing images of the cervical spine, the clinician should appreciate Denis' three-column model of spinal stability (Denis, 1983). The anterior column includes the anterior longitudinal ligament and the anterior half of the vertebral body, the middle column contains the posterior half of the vertebral body and the posterior longitudinal ligament. The posterior column includes the pedicles, lamina, transverse processes, spinous processes and posterior ligaments of the spinal column. Disruption of one column is usually stable, whereas disruption of two or more columns is an unstable fracture, with implications for management.

Magnetic resonance imaging can be considered as a third-line investigation for cervical spine injuries and can detect certain pathologies not easily seen on the other modalities, including ligamentous or soft tissue injury, vascular injuries, isolated spinal cord contusions or haematomas, and disc herniations. Magnetic resonance imaging is also useful in diagnosing spinal cord injury without radiological abnormalities. Spinal cord injury without radiological abnormalities is defined as neurological abnormalities without evidence of injury on radiographic or computed tomography scanning. It is often the result of soft tissue injuries and is more common in the paediatric population (the less developed paraspinal musculature means the cervical spine is more flexible). Magnetic resonance imaging has a sensitivity of almost 100% for detecting soft tissue injury but as many of 40% of these may be false positives. The clinical significance of these soft tissue injuries has been questioned by experts (Plumb and Morris, 2012). A detailed review of the management of spinal cord injury without radiological abnormalities is beyond the scope of this article, but includes external orthosis until stability is regained and avoidance of 'high risk' activities for 6 months (Rozzelle et al, 2013).

Table 1. Dangerous mechanisms of injury as outlined by the Canadian C-spine rules, applicable to National Institute for Health and Care Excellence guidelines for head injury

Fall from 1 m (3 feet) or five stairs
Axial load to the head
Motor vehicle crash at high speed (>100 km/h or >62 mph)
Motorized recreational vehicle accident
Ejection from a vehicle
Bicycle collision with an immovable object

From National Institute for Health and Care Excellence (2014)

Following initial resuscitation, immobilisation of the neck should be continued until a spinal surgeon is available to implement definitive management. However, the patient is at risk of developing pressure ulcers if left immobilised and so should be carefully log-rolled every 2 hours to prevent this complication.

Types of fractures and mechanisms of injury

Atlanto-occipital dislocation

This rare injury pattern carries an 80% risk of neurological deficit, as a result of the great force necessary for disruption at the cranio-cervical junction; it is often fatal but, with improving pre-hospital care, more and more cases are being reported (Hall et al, 2015). Magnetic resonance imaging is indicated in these patients to determine the extent of injury; indeed, temporary normalisation of alignment may provide false negative results of bony alignment on initial computed tomography imaging (Stiell et al, 2001). Horn et al (2007) proposed that those with bony alignment on computed tomography and minor soft tissue changes on magnetic resonance imaging should be treated with a halo vest. However, other experts maintain that the halo vest should only be used for initial stabilization before definitive surgical fixation, arguing that the halo vest does not sufficiently stabilize the cranio-cervical junction, that the immobilised ligamentous injury may not heal with sufficient strength and that the morbidity associated with the halo vest is unacceptable (Hall et al, 2015).

Occipital condyle fractures

These often occur as isolated injuries and may be missed on plain radiography, the only sign may be a retropharyngeal haematoma (Noble and Smoker, 1996). Increased use of computed tomography scanning has shown that these

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Figure 1. Jefferson classification of atlas fractures. **a.** Normal anatomy of the C1 vertebra. **b.** Patterns of fractures as defined by the Jefferson classification system. Type I fractures involve the posterior ring only. Type II fractures involve the anterior ring only. Type III fractures involve both anterior and posterior rings. Type IV fractures are crush injuries of the lateral mass of the C1 vertebral ring, with or without disruption of the transverse atlantal ligament.

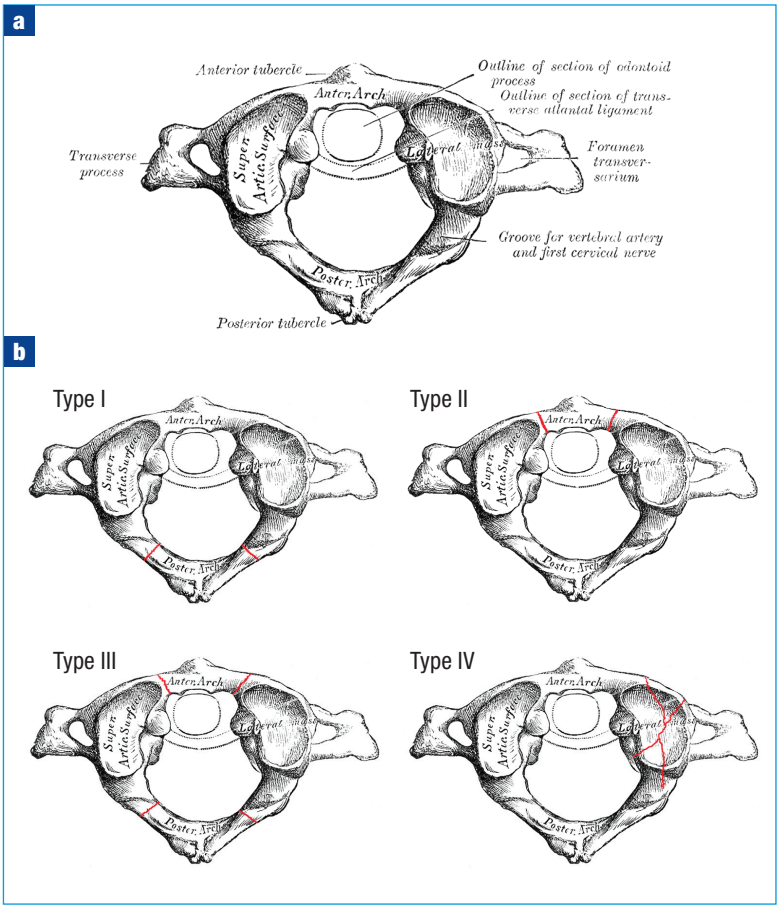
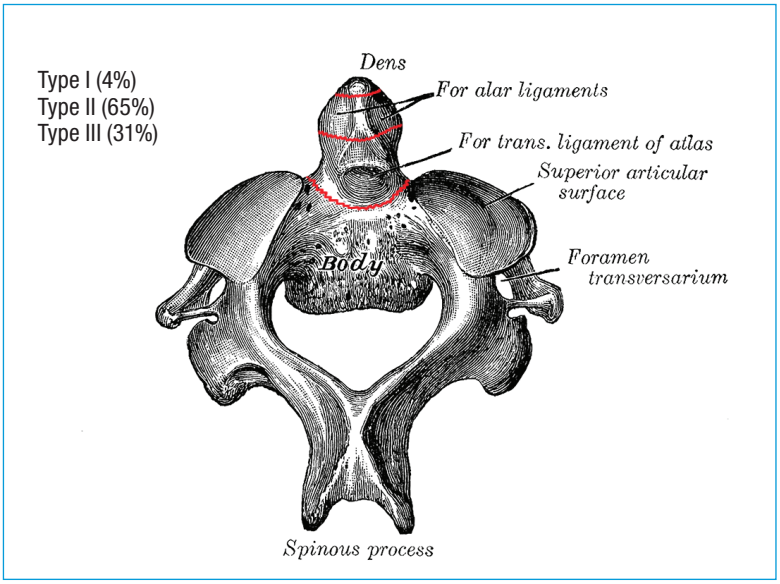


Figure 2. Anderson–D'Alonzo classification of odontoid peg fractures and their relative frequency. Type I fractures involve the odontoid tip (also known as the 'dens'). Type II involve the base of the odontoid peg/dens. Type III extend to involve part of the body of the C2 vertebra.



injuries are more common than initially appreciated. The Anderson and Montesano system (1988) classifies these fractures based on mechanism of injury:

- Type I (axial load and comminuted)
- Type II (extension of a skull base fracture)
- Type III (avulsion of the condylar fragment by disruption of the alar ligament).

Type I and II are stable if isolated, whereas type III are not and require external or internal fixation.

Fractures of the atlas (C1)

These can occur in isolation or with associated axis (C2) fractures in 40–44% of cases (Kakarla et al, 2010). As the spinal foramen is wide at this level, neurological deficit is less likely. The Jefferson classification system divides these fractures by anatomical location (*Figure 1*). Type I involve the posterior arch, type II the anterior arch and type III both the anterior and posterior arch (the classical burst fracture of C1). This classic burst fracture is the more common pattern and is caused by axial loading. Type IV fractures involve the lateral mass, and are caused by a crushing mechanism. The transverse atlantal ligament may or may not be disrupted by the fracture; if so the stability of the fracture is further compromised (Dickman et al, 1996). Jefferson fractures are treated with external fixation using the halo vest or rigid cervical orthoses. If the transverse atlantal ligament is intact, immobilisation of the neck alone is sufficient, whereas a disrupted transverse atlantal ligament often requires immobilisation plus internal fixation (Dickman et al, 1996).

Fractures of the axis (C2)

These fractures account for nearly 20% of all cervical spine fractures (Hadley et al, 1989). Of these, 60% are of the odontoid peg. Rates of neurological deficit in these patients are 8.5% for non-odontoid peg and 2.4% for odontoid peg fractures. The Anderson–D'Alonzo classification (1974) splits odontoid peg fractures into three types: odontoid tip fracture (type I), base of odontoid tip fracture (type II) and a fracture extending through the body of C2 and disrupting the odontoid from its base (type III) (*Figure 2*). Treatment is with the halo vest if type I or III as these are relatively stable. Type II fractures are treated in the same way if the dens is displaced less than 5 mm. If it is more displaced, surgical intervention is necessary, either by odontoid screw fixation or fusion of the atlantoaxial joint. Lennarson et al (2000) found that patients with type II fractures over 50 years old had a 21-fold increase in rate of non-union and so advised initial surgical treatment despite the distance of displacement.

Hangman's fractures are bilateral fractures of the pars interarticularis of C2. These are so-called for the forced hyperextension and longitudinal distraction that occur during hangings. This injury is also seen in hyperextension of the neck when the head hits the dashboard or windshield in road traffic accidents. The rate of neurological injury

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Table 2. Levine and Edwards (1985) classification of hangman's fractures and their management

Type	Displacement	Treatment
I	Vertical fracture with minimal angulation and <3 mm antero-posterior translation of C2 on C3	Relatively stable and so treated by external immobilisation
II	Vertical fracture with >11° angulation and >3 mm antero-posterior translation with disruption of posterior longitudinal ligament	Relatively stable and so treated by external immobilisation
IIA	Horizontal fracture with less antero-posterior translation than type II fractures but a greater degree of angulation	Operative intervention as unstable
III	Rupture of C2–C3 facet joint capsules, fracture of pedicles and disruption of anterior and posterior longitudinal ligaments	Often fatal or associated with severe neurological deficit, this pattern of fracture is unstable and treated by operative intervention

in these fractures is low, with neck pain being the most common symptom. They were classified into four types by Levine and Edwards (1985) – these determine their stability and therefore their management (*Table 2*) (Schleicher et al, 2015).

Fractures of C3–7

Injury to C3 is uncommon, accounting for <1% cervical spine injuries. In contrast, 75% of all cervical spine injuries affect C4–T1, C5–6 being most vulnerable as it comprises one of the two areas of greatest extension and flexion in the spinous unit (the other being C1–2) (Bohlman, 1979). Types of injury include vertebral body fractures, subluxations, dislocation of facet joints and fractures of the laminar, pedicular or spinous processes. The mechanism of injury explains the fracture or dislocation pattern.

Facet joint dislocation

Traumatic flexion of the spinal column causes unilateral or bilateral dislocation of the facet joints. Pure flexion injury causes bilateral dislocation, whereas flexion plus rotation causes unilateral dislocation. Bilateral dislocation is almost always associated with damage to the spinal cord, 80% complete and 15% incomplete (Sahoo et al, 2012), and requires operative fixation. Neurological deficits are also seen in a high proportion of unilateral facet dislocations and 34% of these are radiculopathies (Kalayci et al, 2004). Unilateral facet fractures or dislocations without ligamentous damage have historically been treated non-operatively but there is a move toward operative intervention as a high proportion of these patients fail to spontaneously fuse (Kalayci et al, 2004). Moreover, Dvorak et al (2007) compared quality of life indices in 90 patients treated either operatively or non-operatively, and found increased levels of pain and disability over long-term follow up in those treated non-operatively. Nevertheless, operative management is required if non-operative reduction is unsuccessful, if there is neurological deficit or if there is associated ligamentous injury that will hamper stability if left untreated, as determined by magnetic resonance imaging.

Wedge fractures of the vertebral body

Flexion and axial loading causes pressure on the anterior vertebral body and may cause wedge fractures. A 'teardrop' fracture may occur, whereby a fragment of the antero-inferior vertebral body splits from the main body with the characteristic teardrop appearance on imaging. Associated displacement of the posterior body causes pressure on the spinal cord with neurological deficit, particularly anterior cord syndrome. Patients with this fracture are treated operatively as a result of this instability, often by anterior decompression and plate stabilization.

Burst fracture of the vertebral body

Pure axial compression causes a burst fracture pattern. The superior intervertebral disc is compressed into the centre of its inferior vertebral body and causes a burst fracture, with retropulsion of bony fragments into the spinal cord. The stability and clinical picture is highly variable, depending on the compression exerted by these retropulsed fragments (Harris et al, 1986).

Fractures of the spinous processes or lamina

Pure extension causes relatively stable fractures of the spinous process or lamina that may be amenable to non-operative management. These injuries do not present with neurological symptoms. A caveat to this is that in older patients with degenerative changes of the spinal column causing stenosis, extension injury has the propensity to cause central cord syndrome without bony injury. Here, it is believed that forces exerted on the intervertebral discs cause subluxation posteriorly into the spinal cord and cause compression that acutely worsens the existing stenosis (Collignon et al, 2002). Significant traumatic extension plus axial loading may also result in a teardrop fracture, as described above, with fracture of the antero-inferior aspect of the vertebral body. In comparison to those caused by flexion injuries, these are less severe. They are stable in flexion but unstable on extension. These are managed conservatively using a Philadelphia neck brace for 12 weeks to allow bony union (Kim et al, 2009).

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KEY POINTS

- Initial stabilization of the cervical spine and early identification of injury is vital in achieving a good outcome.
- Canadian C-spine rules should be followed with regard to imaging and clearing the cervical spine but any clinical suspicion of injury mandates further assessment by computed tomography.
- Magnetic resonance imaging may be used to further delineate injury and is important in identifying ligamentous damage, which can guide whether a patient requires external or internal fixation.
- Associated spinal cord injury often requires intensive care management for cardiorespiratory monitoring and support.
- Once the patient has overcome the initial phase of the injury, rehabilitation and psychological support is of paramount importance.

General principles of management

Management of cervical spine injuries depends on patient factors, mechanism of injury and subsequent effects of the injury on the cord or roots. If there are symptoms of cord compression, decompression may be performed. Fractures or subluxations require reduction and realignment to anatomical position. This can be performed by open or closed reduction. Generally, if a fracture is minimally displaced and stable, it can be treated conservatively with external fixation, such as the hard collar or halo vest. If the fracture is displaced and unstable, operative management may be necessary. Operative techniques include use of screws, plates, grafting and bony fusion (arthrodesis) to achieve open reduction. As with all fractures, principles of management are to reduce, immobilise and rehabilitate. Immobilisation may be necessary for 6–12 weeks in order to achieve bony union at the fracture site. Rehabilitation, an often overlooked facet in the management of fractures, is vital in the goal of achieving return to 'normal' or baseline function for the patient.

Management of subsequent spinal cord injury

Cervical fractures affecting the spinal cord itself may manifest clinically as a resultant neurological deficit. This is largely dependent on the level, mechanism of injury and subsequent stability of the injury.

Timing of surgery in traumatic spinal cord injury has been a controversial debate for many years with a paucity of level 1 evidence. While theoretical and experimental animal studies suggest early intervention would be of benefit for those with spinal cord injury secondary to cervical spine fracture, clinical studies have yet to show this. Through the Delphi process, expert opinion is that the optimal timeframe for operative intervention is 8–24 hours (Furlan et al, 2011). Such early intervention allows shorter periods of hospitalisation and earlier mobilisation, which may reduce the morbidity associated with prolonged bed rest and hasten the start of post-injury rehabilitation.

The American Association of Neurological Surgeons (Walters et al, 2013) advise intensive care management after spinal cord injury for cardiac, respiratory and haemodynamic monitoring and support. The patients often have multiple injuries requiring management alongside the haemodynamic instability, cardiovascular instability and compromised respiration secondary to their spinal cord injury. Mean arterial pressure should be kept at 85–90 mmHg to maintain adequate perfusion to the spinal cord. Low molecular weight heparin and pneumatic compression stockings are used to prevent venous thromboembolic disease in these high-risk patients. Vena cava filters are of use if these measures fail or if anticoagulation is not appropriate because of comorbidities. The use of high dose steroids was once commonplace for spinal cord injury secondary to trauma, but this dogma has since been challenged. Their use is discouraged by experts because of a lack of consistent high-level evidence, and because of associated side effects (particularly sepsis and gastrointestinal haemorrhage), with a demonstrable increase in mortality rates (Hurlbert et al, 2013). Early commencement of enteral feeding and physiotherapy are also important to combat catabolism and muscle wasting. Once the patient has overcome the initial phase of the injury, the focus is on rehabilitation and psychological support as he/she becomes accustomed to the sequelae of the injury.

Conclusions

The cervical spine is the most vulnerable and hence the most damaged portion of the vertebral column. Owing to its proximal position in relation to the brain, injury can have catastrophic consequences. Treatment is highly individualized based on the damage done and the other injuries sustained. The aims in management of cervical spine trauma are to identify the injury or instability, to promptly treat and reverse neurological deficits, and to prevent long-term disability by stabilization of the fracture. BJHM

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Anderson LD, D'Alonzo RT (1974) Fractures of the odontoid process of the axis. *J Bone Joint Surg Am* **56**(8): 1663–74
Anderson PA, Montesano PX (1988) Morphology and treatment of occipital condyle fractures. *Spine* **13**(7): 731–6 (doi: 10.1097/00007632-198807000-00004)
Besman A, Kaban J, Jacobs L, Jacobs LM (2003) False-negative plain cervical spine x-rays in blunt trauma. *Am Surg* **69**(11): 1010–14
Bohlman H (1979) Acute fractures and dislocations of the cervical spine. An analysis of three hundred hospitalized patients and review of the literature. *J Bone Joint Surg Am* **61**(8): 1119–42
Collignon F, Martin D, Lénelle J, Stevenaert A (2002) Acute traumatic central cord syndrome: magnetic resonance imaging and clinical observations. *J Neurosurg* **96**(1 Suppl): 29–33 (doi: 10.3171/spi.2002.96.1.0029)
Denis F (1983) The three column spine and its significance in the classification of acute thoracolumbar spine injuries. *Spine* **8**(8): 817–31 (doi: 10.1097/00007632-198311000-00003)
Dickman CA, Greene KA, Sonntag VK (1996) Injuries involving the transverse atlantal ligament: classification and treatment guidelines based upon experience with 39 injuries. *Neurosurgery* **38**(1): 44–50 (doi: 10.1097/00006123-199601000-00012)
Dvorak MF, Fisher CG, Aarabi B et al (2007) Clinical outcomes of

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90 isolated unilateral facet fractures, subluxations, and dislocations treated surgically and nonoperatively. *Spine* **32**(26): 3007–13 (doi: 10.1097/BRS.0b013e31815cd439)
Furlan JC, Noonan V, Cadotte DW, Fehlings MG (2011) Timing of decompressive surgery of spinal cord after traumatic spinal cord injury: an evidence-based examination of pre-clinical and clinical studies. *J Neurotrauma* **28**(8): 1371–99 (doi: 10.1089/neu.2009.1147)
Hadley MN, Dickman CA, Browner CM, Sonntag VK (1989) Acute axis fractures: a review of 229 cases. *J Neurosurg* **71**(5 Pt 1): 642–7 (doi: 10.3171/jns.1989.71.5.0642)
Hall G, Kinsman M, Nazar R et al (2015) Atlanto-occipital dislocation. *World J Orthop* **6**(2): 236–43 (doi: 10.5312/wjo.v6.i2.236)
Harris JH Jr, Edeiken-Monroe B, Kopaniky DR (1986) A practical classification of acute cervical spine injuries. *Orthop Clin North Am* **17**(1): 15–30
Horn EM, Feiz-Erfan I, Lekovic GP, Dickman CA, Sonntag VK, Theodore N (2007) Survivors of occipitoatlantal dislocation injuries: imaging and clinical correlates. *J Neurosurg Spine* **6**(2): 113–20 (doi: 10.3171/spi.2007.6.2.113)
Hurlbert RJ, Hadley MN, Walters BC et al (2013) Pharmacological therapy for acute spinal cord injury. *Neurosurgery* **72** (Suppl 2): 93–105 (doi: 10.1227/NEU.0b013e31827765c6)
Kakarla UK, Valdivia JV, Sonntag VK, Bambakidis NC (2010) Intracranial hemorrhage and spinal cord injury from a fractured C1-C2 sublaminar cable: case report. *Neurosurgery* **66**(6): E1203–4 (doi: 10.1227/01.NEU.0000369198.70959.E1)
Kalayci M, Çagavi F, Açikgöz B (2004) Unilateral cervical facet fracture: presentation of two cases and literature review. *Spinal Cord* **42**: 466–72 (doi: 10.1038/sj.sc.3101623)
Kim HJ, Lee KY, Kim WC (2009) Treatment outcome of cervical tear drop fracture. *Asian Spine J* **3**(2): 73–9 (doi: 10.4184/asj.2009.3.2.73)
Lennarson PJ, Mostafavi H, Traynelis VC, Walters BC (2000) Management of type II dens fractures: a case-control study. *Spine* **25**(10): 1234–7
Leucht P, Fischer K, Muhr G, Mueller EJ (2009) Epidemiology of traumatic spine fractures. *Injury* **40**(2): 166–72 (doi: 10.1016/j.injury.2008.06.040)
Levine AM, Edwards CC (1985) The management of traumatic spondylolisthesis of the axis. *J Bone Joint Surg Am* **67**(2): 217–26
National Institute for Health and Care Excellence (2014) *Head injury: Triage, assessment, investigation and early management of head injury in children, young people and adults.* Clinical guidance 176. National Institute for Health and Care Excellence, London
Noble ER, Smoker WR (1996) The forgotten condyle: the appearance, morphology, and classification of occipital condyle fractures. *AJNR Am J Neuroradiol* **17**(3): 507–13
Plumb JO, Morris CG (2012) Clinical review: Spinal imaging for the adult obtunded blunt trauma patient: update from 2004. *Intensive Care Med* **38**: 752 (doi: 10.1007/s00134-012-2485-4)
Rozzelle CJ, Aarabi B, Dhall SS et al (2013) Spinal cord injury without radiographic abnormality (SCIWORA). In: Guidelines for the management of acute cervical spine and spinal cord injuries. *Neurosurgery* **72**(Suppl 2): 227–33 (doi:10.1227/NEU.0b013e3182770ebc)
Sahoo SS, Gupta D, Mahapatra AK (2012) Cervical spine injury with bilateral facet dislocation, surgical treatment and outcome analysis: A prospective study of 19 cases. *Indian J Neurotrauma* **9**(1):40–4 (doi: 10.1016/j.ijnt.2012.04.002)
Schleicher P, Scholz M, Pingel A, Kandziora F (2015) Traumatic spondylolisthesis of the axis vertebra in adults. *Global Spine J* **5**(4): 346–58 (doi: 10.1055/s-0035-1550343)
Sekhon LH, Fehlings MG (2001) Epidemiology, demographics and pathophysiology of acute spinal cord injury. *Spine* **26**: S2–12
Stiell IG, Wells GA, Vandemheen KL et al (2001) The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA* **286**(15): 1841–8 (doi:10.1001/jama.286.15.1841)
Torretti JA, Sengupta DK (2007) Cervical spine trauma. *Indian J Orthop* **41**(4): 255–67 (doi: 10.4103/0019-5413.36985)
Walters BC, Hadley MN, Hurlbert RJ et al; American Association of Neurological Surgeons; Congress of Neurological Surgeons (2013) Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update. *Neurosurgery* **60**(Suppl 1): 82–91 (doi: 10.1227/01.neu.0000430319.32247.7f)

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