Upper Cervical Spine Trauma Imaging

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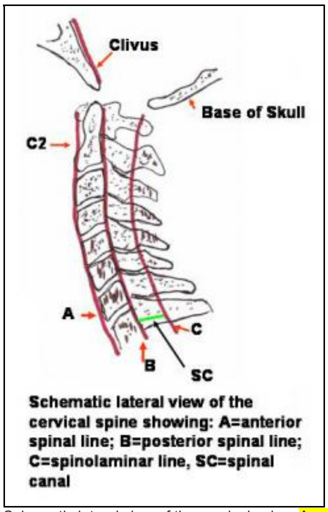
Overview

Preferred examination

All initial evaluations of cervical spine injuries should begin with plain radiographs. A variety of other imaging modalities may also be used, such as conventional tomography, CT, and MRI. An appropriate choice has to be made quickly to make a diagnosis of cervical trauma. When cervical trauma exists, it may be at multiple levels, justifying the fact that if treatment is to be instituted, imaging should include the upper and lower cervical hinges. The quality of the standard radiographs varies greatly; their negative quality and predictive value decreases when the severity of the injury increases.[1, 2, 3, 4, 5, 6, 7]

See the cervical spine illustrations below.



Schematic lateral view of the cervical spine. A=anterior spinal line; B=posterior spinal line; C=spinolaminar line, SC=spinal canal.

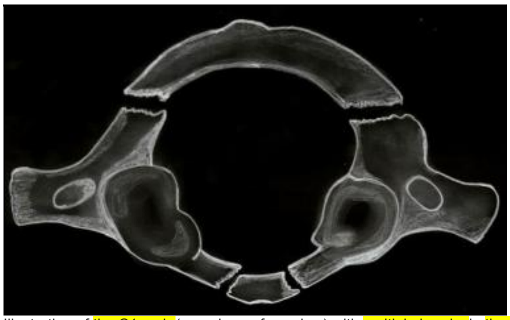


Illustration of the C1 arch (superior surface view) with multiple breaks in the ring, consistent with a Jefferson fracture.

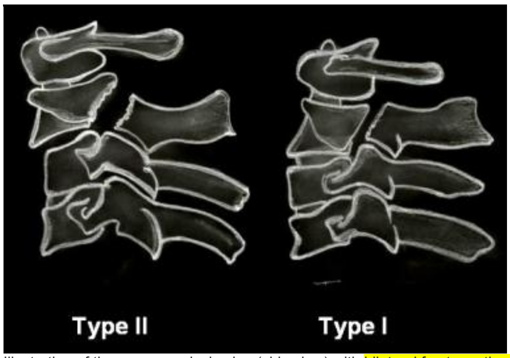


Illustration of the upper cervical spine (side view) with bilateral fractures through the pedicles of C2, consistent with a hangman fracture. When displacement is less than 3 mm, it is classified as type I; when it is greater than 3 mm, it is classified as type II (Levine classification).

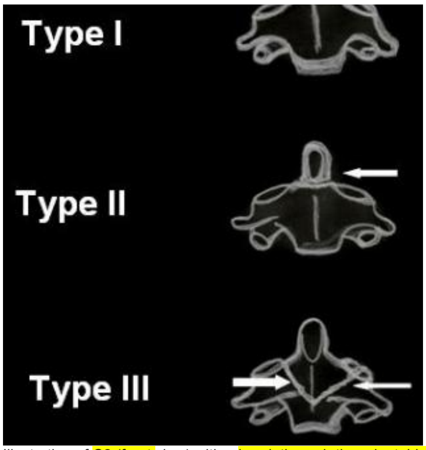


Illustration of C2 (front view) with a break through the odontoid process. Type I fracture is classified as an avulsion of the tip of the dens. Type II fractures occur at the base of the dens. Type III fractures extend from the odontoid into the body of the axis.

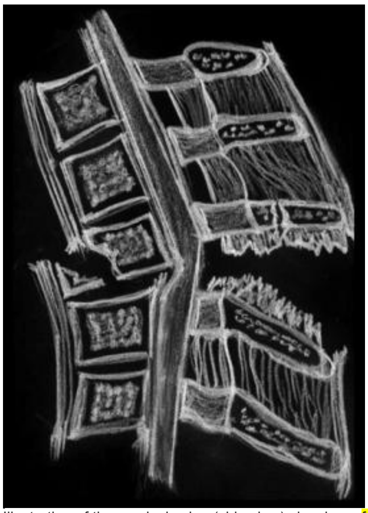


Illustration of the cervical spine (side view) showing a fracture of the anterior inferior corner of the vertebral body and disruption of the interspinous stabilizing ligaments. This type of injury is often called a flexion tear drop fracture due to the resemblance of the vertebral corner fracture to a tear drop.

A portable cross-table lateral radiograph in the emergency department is frequently inadequate and needs to be abandoned, as it is often insufficient, needs several repeats, and often cannot exclude a fracture. Once a clinical decision is made to evaluate the patient with radiography, adequate views must be obtained in the radiology department. The patient's neck should remain immobilized until a full cervical spine series can be obtained, although initial films may be taken through the cervical collar.

The most common reason for a missed cervical spine injury is a cervical spine radiographic series that is technically inadequate.

CT scanning is the most efficient technique for not only detecting but also formally eliminating an injury. Its indications should therefore be extended but also limited to a selected population. MRI is indicated in patients with a neurologic deficit. MRI is also indicated in symptomatic patients with normal radiographs when a bone bruise is suspected. Ligamentous injuries are often missed on conventional radiographs and CT, which is an indication for dynamic MRI.[8, 9, 10, 11]

Johansson described 3 severely injured patients who had been extensively examined without any findings of structural lesions but were diagnosed by functional MRI to have injuries in the CCJ region.[12] These injuries were confirmed at surgery, and after surgical stabilization, the medical condition was highly improved.

Ovadia et al conducted a retrospective study on 860 patients seeking compensation following whiplash injury and concluded that the initial radiograph taken in the emergency room was the best imaging modality and probably the only one needed routinely following whiplash injury.[13]

Platzer et al looked at the frequency and reasons for delayed or missed diagnosis at a level 1 trauma unit with a view to provide recommendations for optimal examination of patients with suspected cervical spine injuries. The authors suggested that for optimal examination of patients with suspected cervical spine injuries, specific diagnostic algorithms are needed, including complete sets of proper radiographs with functional flexion/extension views, secondary evaluation of the radiographs by experienced staff, and further radiologic examinations (CT, MRI) if evaluation of standard views is difficult.[14] In this study, the diagnostic failure rate was 4.9%. In 44% patients, radiologic misinterpretation was responsible for delay in diagnosis; in 28%, incomplete sets of radiographs were responsible; in 22%, the injury was missed because inadequate radiographs did not show the level of injury.

Nontraumatic upper cervical spine instability can result from abnormal development of osseous or ligamentous structures or from gradually increasing ligamentous laxity associated with connective tissue disorders. Such instability can lead to compression of the spinal cord during movement of the cervical spine. Establishing a correct diagnosis includes performing a thorough physical examination as well as evaluating radiographic relationships and measurements.[15]

Types and classifications of cervical spinal injuries

Cervical spine injuries are the most feared of all spinal injuries because of the potential for serious neurologic sequelae. Morbidity and mortality related to cervical spine injuries depend on the mechanism of injury and the level of traumatic insult. Greater morbidity results from higher levels of cervical spine injury, with craniocervical junction injuries being associated with the highest mortality. A third of injuries are sustained at the C2 level, and one half of injuries occur at the level of C6 or C7. Most fatal cervical spine injuries affect the upper cervical levels: the craniocervical junction, C1, or C2.

Cervical spine injuries are best classified according to the mechanisms of injury, which include flexion, flexion-rotation, extension, extension-rotation, vertical compression, lateral flexion, and imprecisely understood mechanisms that may result in odontoid fractures and atlanto-occipital dislocation. Inaccurate assessment and diagnosis of cervical spine injuries is still a common problem in trauma medicine. The incidence of delayed diagnosis is said to be 5-20%.

For more information on cervical spine injuries, see the Medscape Reference articles Cervical Spine Anatomy, Cervical Spine Fracture in Emergency Medicine, and Cervical Spine Injuries in Sports.

Radiography

Plain radiographs can identify most cervical spine fractures and ligamentous injuries (see the image below). Plain radiographs are cheap, readily available, and noninvasive; do not involve the administration of intravenous contrast; and can be performed on virtually any patient. Approximately 85-90% of cervical spine injuries are evident in lateral view radiographs. The lateral cervical spine radiograph has a sensitivity of 82%, which, when combined with AP and odontoid views, rises to 93%. They remain the mainstay of assessing cervical trauma. Any views that require manipulation of an acutely injured patient are difficult to justify in view of the ready availability of cross-sectional imaging.

Lateral cervical spine conventional radiograph in the flexed position, showing an unstable injury at C4/5 where there is anterior spondylolisthesis at C4/5 of approximately 3 mm and vertical distraction at the same level by 2-3 mm as evidenced by the increased gap of the C4/5 facet joints. In addition there is increased distance between the odontoid process and the anterior arch of C1 that is suspicious for an additional injury at that level.

Ligamentous injuries are often associated with cervical vertebral body malalignment. Some ligamentous injuries are elusive to plain radiography. If there is a high index of clinical suspicion of ligamentous injury, as evidenced by focal neck pain and minimal malalignment of the lateral cervical radiograph, and if the radiographs show no evidence of instability or fracture, flexion-extension views are indicated. These radiographs can only be undertaken in the conscious patient, however, where the patient is allowed to move the neck, with the patient limiting the motion of the neck based on the occurrence of pain. The neck should not be forced into flexion or extension by the physician or technologist, since force may result in cord injury.

If difficulty is encountered visualizing all 7 cervical vertebrae and the C7-T1 disc space on a lateral cervical radiograph, traction of the arm is a useful maneuver, providing no arm injury is present. A swimmer's view is particularly effective in visualizing all 7 vertebrae and the C7-T1 disc space. While attempts are being made to obtain adequate plain radiographs, the patient should be maintained in cervical immobilization. If adequate plain films cannot be taken, CT scans should be substituted. It should be borne in mind that most false-negative results occur because of an inadequate plain film series.

Not all patients arriving in an emergency room following multiple injuries need cervical radiographs even if they arrive with a cervical collar. Criteria for low-risk patients have been defined and can be used clinically to exclude cervical spine fractures. Clinically significant cervical spine injury is not likely in a patient with a normal mental status with no neck pain, tenderness on neck palpation, neurologic deficit, other distracting injury and no history of loss of consciousness.

Views required to radiographically exclude a cervical spine fracture include a PA view, a lateral view, and an odontoid view. The lateral view must include the whole cervical spine, including the C7-T1 disc space. The "SCIWORA" syndrome (spinal cord injury without radiographic abnormality) is common in children. It is important to diagnose SCIWORA, as these patients respond to steroids, which limits the neurologic sequelae. Currently, these criteria apply only to adults because of concerns of a reliable history from young children.

Some concern has been raised about case reports suggesting that "occult" cervical spine fractures will be missed if asymptomatic trauma patients do not undergo radiography of the cervical spine. A review of these reported cases does not meet the low-risk criteria in cervical spine radiographs.[16] For alert patients with trauma who are in stable condition, the Canadian C-Spine (CCR) rule is superior to the National Emergency X-Radiography Utilization Study (NEXUS) with respect to sensitivity and specificity for cervical spine injury, and its use would result in reduced rates of radiography.[17]

False-negatives and false-positives

Conventional radiographs are generally considered adequate to rule out a fracture, but there are significant false-negative rates (approximately 20%). This could be countered by proceeding to a CT when the plain radiographs are negative in the face of a patient who has neck pain disproportionate to the findings on plain radiographs. A CT scan is a sensitive means of identifying cervical fractures, but its ability to identify ligamentous injuries is limited. There may still be an indication for conventional tomography if a type II dens fracture is suspected, although with the advent of multidetector CT (MDCT), the need for conventional tomography would be limited.

False-positive results may occur when one fails to identify the many congenital anomalies that are prevalent in the upper cervical spine. Three major anomalies of the odontoid process are identified: aplasia, hypoplasia, or the most common anomaly of os odontoideum. Hypoplasia is diagnosed if the apical segment of the peg does not form. If it does not unite, this apical piece is called an ossiculum terminale. The radiologic appearance of os odontoideum is that of a round ossicle with a smooth border located in the position of the normal odontoid or closer to the base of the occipital bone. A wide radiolucent zone separates the os odontoideum from the base of the remaining odontoid process. It has been postulated that an os odontoideum represents an old nonunion of an occult odontoid fracture. An os odontoideum is associated with Down syndrome, spondyloepiphyseal dysplasia, Morquio's syndrome, and upper respiratory infections.

Lateral view

Approximately 85-90% of cervical spine injuries are evident in lateral view, making it the most useful view from a clinical standpoint. The first observation to be made on a lateral cervical spine radiograph is the alignment of the vertebral bodies. The anterior and posterior margins of the vertebral bodies, the spinolaminar line, and the tips of the spinous processes need all to be aligned. Any "step" in the alignment is considered abnormal and should be regarded as evidence of ligamentous injury or an occult fracture; thus, cervical spine immobilization should be maintained until a definitive diagnosis is made.

Here a point should be made about "pseudosubluxation," which is a physiologic misalignment that is due to ligamentous laxity, which can occur at the C2-C3 level and, less commonly, at the C3-C4. If the degree of subluxation is within the normal limits listed and the neck is not tender at that level, flexion-extension views may clarify the situation. Pseudosubluxation is more common in children than in adults. Pseudosubluxation should disappear with an extension view. Flexion-extension views, however, should only be taken once fracture/dislocation has been ruled out.

Once alignment has been checked and found to be normal, the spinous processes are examined for widening of the interspinous space. If widening is present, a ligamentous injury or fracture is suspected. Next, spinal angulation should be assessed. An angulation greater than 11 degrees at any level of the cervical spine is regarded as abnormal, and in the context of cervical spine injury, it should be regarded as being secondary to a ligamentous injury or fracture until proved otherwise. The spinal canal should measure more than 13 mm in width on the lateral radiograph; a measurement less than 13 mm may be a sign of impending spinal cord compromise.

The predental space, which is the space between the odontoid process and the anterior portion of the ring of C1, should be less than 3 mm in adults.

There is a significant overlap of normal and abnormal range in the depth of the retropharyngeal space. A retropharyngeal soft tissue space depth greater than 6 mm at C2 and greater than 22 mm at C6 is highly specific for a fracture but is not very sensitive. An increase in soft tissue depth in a traumatized patient is an indication for CT if the plain radiographs do not reveal a fracture.

Odontoid view

The odontoid view is used to evaluate an area that is difficult to visualize in the cross-table lateral view because of shadow superimposition. There are many artifacts that may give the appearance of a fracture through the odontoid process. These artifacts are often radiographic lines caused by the teeth overlying the odontoid process. However, fractures of the odontoid process are unlikely to be longitudinally oriented. If there is any doubt, the view should be repeated to try to get the teeth out of the way. If it is not possible to exclude a fracture, thin-section CT scans or conventional plain film tomography is indicated.

The lateral processes of C1 should be symmetrically placed equidistant from the odontoid peg. Any asymmetry is suggestive of a fracture. The lateral aspects of C1 should align with the lateral aspects of C2. If they do not line up, there may be a fracture of C1.

Anteroposterior view

The AP view is the least useful view from a clinical standpoint. The spinous processes should all align and lie in the midline. If one of the spinous processes is offset to one side, consider a rotation injury, such as a facet dislocation. Also consider a clay shoveler's fracture if a spinous process appears vertically split.

Oblique views

It has been suggested that additional lateral oblique views also be obtained, but these are best left to the discretion of the radiologist who would be reading the films. Oblique views are considered laminar views, because most pathologies depicted on these views are due to the disruption in the normal overlapping appearance of the vertebral laminae. The appearance of the normal laminae has been likened to shingles on a roof, forming regular elliptical curves with equal interlaminar spaces. A posterior laminar fracture is usually evident as a break within the body of a single shingle.

Simple wedge fracture

A simple wedge fracture shows a diminished height of the vertebral body anteriorly, associated with increased concavity and increased density due to bony impaction. The prevertebral soft tissue space is increased. The posterior column remains intact, making this a stable fracture.

Anterior subluxation

In anterior subluxation, the lateral cervical radiograph shows widening of interspinous processes, and anterior and posterior contour lines are disrupted in flexion views.

Bilateral facet dislocation

At the point of injury, the upper vertebrae, inferior articulating facets pass superior and anterior to the superior articulating facets of the lower involved vertebrae because of extreme flexion of the spine. Lateral cervical spine radiographs show an anterior displacement of more than half of the anteroposterior diameter of the vertebral body. This is an extreme form of injury, is highly unstable, and is often associated with spinal cord injuries. It often is associated with disc herniation. Further neurologic deficit may accrue if the injured disc retropulses into the canal during the application of cervical traction.

Clay shoveler's fracture

A clay shoveler's fracture is best seen on a lateral radiograph as an avulsion/separation of the spinous process of a lower cervical vertebra. Thus visualization of the C7-T1 junction in the lateral view is imperative. The fracture is seen in the anteroposterior view as a vertically split appearance of the involved spinous process. This is a stable injury and is usually not associated with a neurologic deficit.

Unilateral facet dislocation

The lateral cervical spine radiograph shows an anterior displacement of the spine, at the involved level, of less than one half the diameter of the vertebral body. This is in contrast to the greater displacement seen with a bilateral facet dislocation. The AP view shows a disruption in the line connecting the spinous processes at the level of the dislocation. An oblique view shows disruption of the typical shingles appearance at the level of the involved vertebra. The dislocated superior articulating facet of the lower vertebra is seen projecting within the neural foramina.

Rotary atlantoaxial dislocation

An AP cervical radiograph of the odontoid generally shows asymmetry of the lateral masses of C1 with respect to the dens, along with unilateral magnification of a lateral mass of C1, which has been dubbed the "wink sign." Despite injury, full-range movement is allowed at the atlantoaxial joint, but radiographic asymmetry is produced when the head is tilted laterally or rotated or if a slightly oblique odontoid view is obtained despite perfect head positioning. To confirm a true dislocation, basilar skull structures such as the jugular foramina should appear symmetrical in the presence of the findings seen on the cervical spine radiographs.

Hangman fracture

A hangman fracture appears as a fracture line extending through the pedicles of C2, associated with an obvious disruption of the spinolaminar contour line.

Fracture of the posterior arch of C1 fracture

A fracture of the posterior arch of C1 appears as radiolucent line through the posterior neural arch on a lateral projection. The odontoid is not displaced in terms of the lateral masses of C1 with respect to the articular pillars of C2, a finding that distinguishes this fracture from a Jefferson fracture. As the transverse ligament and the anterior arch of C1 are not involved, this is a stable fracture. It is important to differentiate this benign fracture from a Jefferson fracture.

Jefferson fracture

Jefferson fracture is characterized by bilateral lateral displacement of the articular masses of C1. The AP odontoid view shows unilateral or bilateral displacement of the lateral masses of C1 in relation to the articular pillars of C2. The lateral cervical spine radiograph reveals considerable prevertebral soft tissue edema. A lateral mass displacement of more than 6.9 mm indicates a complete disruption of the transverse ligament and warrants an urgent referral for cervical traction. When displacement is less than 6.9 mm, it can be assumed that the transverse ligament is still intact, and neurologic injury is unlikely.

Burst fracture of the vertebral body

A burst fracture of the vertebral body is characterized by a vertical fracture line in the AP projection, associated with comminution and protrusion of the vertebral body both anteriorly and posteriorly in relation to the contiguous vertebrae in the lateral view. Posterior protrusion of the middle column may extend into the spinal canal and can be associated with anterior cord syndrome. A burst fracture always requires an axial CT scan or an MRI to document the degree of middle column retropulsion. A burst fracture with a loss in height of more than 25%, retropulsion, or neurologic deficit is treated by applying traction. A fracture is considered stable if none of the aforementioned features exist.

Atlantoaxial subluxation

An atlantoaxial subluxation is suspected if the predental space is more than 3.5 mm (5 mm in children); axial CT is used to confirm the diagnosis.

Atlanto-occipital dislocation

Atlanto-occipital dislocation is seen radiographically as a disassociation between the base of the occiput and the arch of C1.

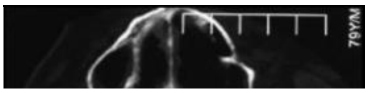
Occipital condyle fracture

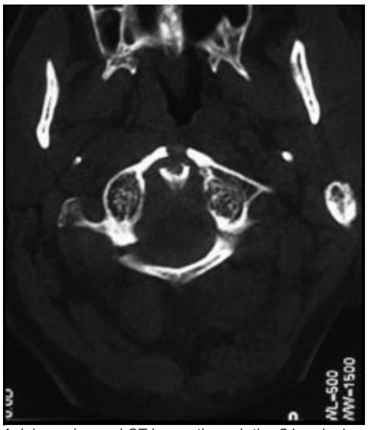
Occipital condyle fractures may be difficult to delineate radiographically. Axial CT may be required to identify them.

Computed Tomography

CT scanning is the most efficient technique for not only detecting but also formally eliminating an injury. Its indications should therefore be extended but also limited to a selected population. CT examination is particularly good in the diagnosis of traumatic C1-C2 rotatory subluxation.[18, 1, 2, 3]

See the cervical CT images below.

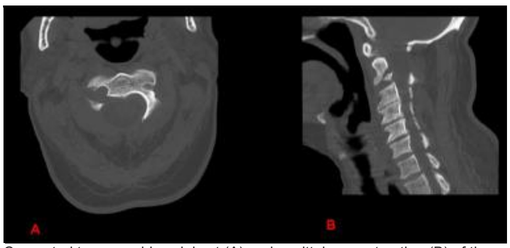




Axial unenhanced CT image through the C1 arch showing midline disruption (congenital nonfusion can mimic this appearance; look for disruption of the compact bone of cortical bone to avoid this pitfall) of the anterior arch and a break of the right and a questionably left lamina just posterior to the pedicle.

Axial unenhanced computed tomography image through the occipital condyles showing lucent fracture lines in the condyles consistent with a burst fracture following a vertical loading force. The C1 arch often has an associated injury with this occipital condyle injury (C1 is not well seen on this image).

Computed tomography coronal reconstruction of the cervical spine illustrating a burst fracture of the bodies of C4 and C5 as evidenced by a vertical fracture line through the bodies of these vertebrae and some loss of height.



Computed tomographic axial cut (A) and sagittal reconstruction (B) of the cervical spine illustrating a C2 body fracture with extension into the right vertebral canal.

The advent of multidetector CT (MDCT) supplements or, in many centers, has supplanted plain radiography.[19, 20] CT appears more sensitive, with lower rates of missed primary and secondary injury. One series found 36% of patients with one injury on plain radiography had a second injury seen on CT only. Of these patients, 27% had a noncontiguous, anatomically distinct second injury. The same views generated by plain radiography (AP, lateral, open mouth) are generated via CT. If plain radiograph findings are negative but clinical suspicion for fracture is high, films should be followed by CT.

CT can be falsely negative in bony injuries even when these injuries present with paraplegia. This occurs using a helical scanner with 2-mm slice thickness and multiplanar reconstruction. It remains to be seen whether the newer multidetector scanners can reliably diagnose bony injuries of the cervical spine. It should be emphasized, however, that CT can miss significant injuries of the cervical spine, including fractures seen on radiographs. CT is not suitable for the assessment of soft tissue trauma to the spine or spinal cord.

Hu et al conducted a retrospective study in a series of patients with teardrop fracture of the axis. While most patients with an extension teardrop fracture of the axis can be treated conservatively, based on this case series, the authors suggest that large fragment size, displacement or angulation, intervertebral disk injury, neurologic deficit, or signs of instability are reasonable indications for surgical treatment. Thus, CT and MRI guide further management of these patients.[21]

Fractures of the atlas

Fractures of the atlas are not uncommon and actually constitute 10% of all cervical spine injuries in adults. However, in the pediatric population, fractures of the atlas are extremely rare, and only a few cases have been described. On plain radiographs, fractures of the atlas, and the anterior aspect in particular, may remain occult. Accurate diagnosis of atlas fractures depends on further radiologic investigations, including CT and MRI.[22]

Occipital condyle fractures

Occipital condyle fractures are better imaged by CT and MRI. CT is the primary diagnostic modality following head injury and usually depicts occipital condyle fracture well, determining its size and location by multiplanar and 3-D reconstructions. With complex associated injuries (eg, cerebral and cord and soft tissue hematomas of the neck) or for the detection of brainstem contusion, MRI has significant advantages.[23]

Scout film

A lateral scout view of the head is always obtained when performing head CT. It is common knowledge that viewing the lateral scout view may provide additional information. For a variety of reasons, however, a careful review may not be performed routinely. Careful evaluation of the scout view of the head CT, including the skull and neck, may yield valuable information, which may not be visualized on the axial CT images.[24]

Jefferson fractures

Spence's rule applies to Jefferson fractures, which states that if, on plain films, the distance of excursion of lateral masses is 7 mm or more, there is a transverse ligament rupture. A lateral mass fracture raises the suspicion of injury to transverse ligament. Thin-cut axial CT with sagittal reconstruction is the imaging technique of choice.

Magnetic Resonance Imaging

Magnetic resonance imaging now has an established role in the assessment of spinal injuries, because there is often associated spinal cord and nerve root compromise and a relatively common association of unsuspected disc herniation with vertebral fractures.

The craniocervical junction is seen well on MRI. The anterior aspect of the foramen magnum is delineated, but the posterior margin is less constant in appearance. Compression and distortion of the medulla and upper cervical cord by bony and extramedullary lesions are seen easily.[25] Vertebral artery injury associated with craniocervical junction trauma can be detected by MR angiography.

Unstable ligamentous injury has traditionally been evaluated by flexion-extension views. MR is less dangerous and more sensitive for soft tissue injury than conventional radiography. MRI is useful in differentiating between pathologic vertebral fractures related to metastatic malignancy and benign osteopenic insufficiency fractures.

Vaccaro et al determined that MRI is neither useful nor cost-effective in patients presenting with a fracture of the upper cervical spine without neurologic deficit. They conducted a prospective analysis of patients admitted with isolated upper cervical spine fractures who had MRI performed within 48 hours after the traumatic event.[26] In patients with an identified neurologic deficit, MR findings changed the treatment of 25% of the patients, whereas MR findings did not change the treatment of patients without a neurologic deficit.

MRI is particularly useful in the following situations:

- Trauma at the craniocervical junction
- Evaluation of spinal cord injuries associated with cervical spine fractures
- Follow-up of SCIWORA
- Neurologic deficit with negative radiography
- When neurologic deficit does not correlate with the level of trauma
- Prior to surgical decompression or stabilization
- Evaluation of patients with persistent pain and negative radiographs
- Imaging long-term sequelae of spinal trauma, particularly when new deficit develops in patients with past history of trauma

MRI scanning is being increasingly used as an adjunct to plain films, but the lack of wide availability and the relatively prolonged scanning time required limits its usefulness in the acute setting. Another major drawback is limitation regarding the resuscitation equipment and stabilizing devices that can be used near MRI scanners. MRI is considerably weaker than plain films or CT for posterior element fractures, but some fractures are better detected with MRI, such as intramedullary fractures and fractures in the axial plane (eg, Chance fracture).

Another disadvantage with MRI for acute trauma is motion artifact, because MRI is particularly sensitive to patient motion. However, this may not be such an issue with modern scanners.

Ultrasonography

Intraoperative ultrasonography is a useful noninvasive technique to monitor, and reduce the potential for, spinal cord compromise when a posterior surgical approach is used for complex spinal fractures. Intraoperative ultrasonography has also been found to be useful in localizing posttraumatic subarachnoid and spinal cord cysts. Ultrasound imaging needs dedicated training and remains an operator-dependent technique.

Nuclear Imaging

In patients with spinal injuries that are occult on conventional radiographs, bone scintigraphy often demonstrates previously unrecognized injuries and may help target specific areas for further evaluation with cross-sectional imaging. Radionuclide scanning is particularly useful in elderly females with osteoporosis, which may be difficult to image with routine radiographs.

Radionuclide scans add a functional element to conventional radiography and cross sectional imaging. However it is not the imaging of choice in emergent situations. The sensitivity of radionuclide scans is high, but its specificity is low. In patients with osteoporosis, occult fractures may take 2-3 days following injury to demonstrate increased tracer uptake on bone scans.

Whiplash-associated injuries are a major medicolegal problem and remain controversial. Otte et al designed a study to evaluate perfusion and glucose metabolism in whiplash syndrome.[27] Using technetium-99m-bicisate single-photon emission computed tomography (SPECT) and fluorodeoxyglucose (FDG) PET, 6 patients with whiplash syndrome were compared with controls and were found to have significant hypometabolism and hypoperfusion in the parieto-occipital regions. In some patients there was hypometabolism in regions other than the parieto-occipital region. It was hypothesized that parieto-occipital hypometabolism may be caused by activation of afferent nerves from the upper cervical spine.

Angiography

Four-vessel cerebrovascular angiography remains the standard screening test for patients at risk for blunt cerebrovascular injury, but it is being challenged by less invasive techniques such as CTA and MRA. Digital subtraction angiography is the most sensitive imaging study for assessing carotid and vertebral circulation, but because of invasiveness, its role as a screening study remains questionable.

Two-dimensional time-of-flight MRA is an effective diagnostic method for blunt vertebral artery injury. It may, however, have difficulty differentiating spasm and small disruption of the intima under certain conditions.[28]

Although the reported sensitivity of CTA for the diagnosis of blunt cervical vascular injury has been inadequate, the advances in CT technology have improved the diagnostic sensitivity of CTA. CTA with a 16-channel detector can be used to accurately screen at-risk patients for blunt cervical vascular injury.[29]

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