6.11 Spine
6.11 Spine

1 Introduction

The management of spinal trauma, either in isolation or as part of the management of the polytraumatized patient, is difficult due to the number of potential pitfalls awaiting the general trauma surgeon faced with such injuries.

The general principles of resuscitation apply. Although the majority of injured patients should be assumed to have an unstable spinal injury until a full evaluation has been completed, certain patient groups are particularly at risk.

- **Patient groups at risk are those who**
  - complain of back or neck pain;
  - have suffered polytrauma;
  - have any head injury;
  - have facial injuries;
  - are unconscious or obtunded;
  - are road traffic accident victims.

In these patients, the cervical spine should be controlled with a firm collar, two sandbags (or infusion packs), and forehead tape (Fig 6.11-1). The thoracolumbar spine should be protected with the use of a spine board and thereafter only by log rolling the supine patient.

- **The orthopedic assessment of the spine should include evaluation of both the skeletal and neurological injuries, and a careful search for associated spinal and nonspinal injuries. Identification of instability and potential instability, classification of the injury, and a complete management plan are essential.**

2 Clinical evaluation

A description of the exact mechanism of injury from the patient, any eyewitnesses, and emergency service personnel is important. In addition, any reported transient or persistent neurological symptoms might indicate significant spinal instability.

![Fig 6.11-1a–c Patient positioned with tape, sandbags, and collar.](image)
Specific fractures

- The spine must be inspected and palpated from occiput to coccyx. The presence of the following signs indicates significant injury:
  - pain with movement;
  - tenderness;
  - gap or step;
  - edema or bruising;
  - spasm of associated muscles.

Neurological assessment must be comprehensive. All muscle groups should be evaluated and graded on a dedicated neurology chart. Weakness should be graded according to the Medical Research Council (MRC) method (Tab 6.11-1) [1]. Sensation should be tested, including light touch, pin-prick, proprioception, and vibration. All dermatomes should be examined bilaterally. Reflexes should be documented. Any sensory and motor level should be recorded.

- Rectal examination is mandatory if there is any suspicion of neurological injury. Anal tone, sensation, and the bulbocavernosus reflex are tested.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Testing parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Total paralysis</td>
</tr>
<tr>
<td>1</td>
<td>Barely detectable contracture</td>
</tr>
<tr>
<td>2</td>
<td>Not enough power to act against gravity</td>
</tr>
<tr>
<td>3</td>
<td>Strong enough to act against gravity</td>
</tr>
<tr>
<td>4</td>
<td>Still stronger but less than normal</td>
</tr>
<tr>
<td>5</td>
<td>Full power</td>
</tr>
</tbody>
</table>

Tab 6.11-1 Standard grades of muscle power.

In the patient with spinal cord injury, vital signs including pulse, blood pressure, respiratory rate, and oxygen saturation should be monitored continuously.

Radiological evaluation

3.1 Cervical spine

All patients with a suspected spinal cord or column injury should be further investigated. The primary survey will include a cross-table lateral film of the cervical spine. The definitive radiological assessment of any patient with spinal injury will include further plain x-rays, as well as CT and MRI scanning.

Fig 6.11-2 Swimmers view to demonstrate the cervicothoracic junction.
In the cervical spine the lateral film should show the spine from the occiput to the C7/T1 disc, and if this has not been achieved, special views, such as the “swimmers view” will be required (Fig 6.11-2). With a lateral film alone the false negative diagnosis rate goes up to 15%. A through-the-mouth odontoid peg view and an AP x-ray of the cervical spine must always be taken.

In the cervical spine the following abnormalities should be specifically sought:
- loss of normal cervical lordosis;
- increased anterior soft-tissue width (normal prevertebral shadow is less than 4 mm at C4 and less than 15 mm at C6) (Fig 6.11-3);
- increased interspinous distance posteriorly (Fig 6.11-4);
- loss of spinous process alignment and/or increased interspinous distance on AP x-ray;
- fractures of the body, lateral mass, pedicle, spinous process;
- fractures of the odontoid peg or the ring of atlas;
- any loss of alignment indicating subluxation or dislocation (Fig 6.11-5a);
- more than 11° angulation or 3 mm translation at any level (Fig 6.11-5b).
3.2 Thoracolumbar spine

In the thoracolumbar spine high-quality AP and lateral x-rays are required. The following abnormalities may be seen:
- loss of vertebral alignment on AP or lateral x-rays (Fig 6.11-6);
- fractures of vertebral body, posterior, spinous, or transverse processes elements;
- widening of interspinous distance;
- abnormal pedicle separation on AP x-ray (Fig 6.11-7);
- loss of vertebral body height, vertebral wedging, and kyphosis.

3.3 Further steps

A standardized approach to further imaging should be adopted.

The incidence of a second spinal injury is up to 20%, so if a significant spinal injury has been identified at one level, the rest of the spine should be reexamined clinically as well as by AP and lateral x-rays of every level.

If any fractures other than minor process fractures are identified on x-ray, cross-sectional imaging with CT scanning should be obtained (Fig 6.11-8). The complete fracture configuration is rarely identified on x-rays alone. 3-D reconstructions aid comprehension and surgical planning, but do not enhance the accuracy of the CT data. CT scans may also be indicated in the following areas if injury is suspected and adequate x-rays cannot be obtained:
- occipitocervical junction;
- C1/2 injuries;
- cervicothoracic junction;
- sacroiliac region.
MRI scanning will demonstrate soft-tissue injury to posterior ligamentous structures and intervertebral discs. If available, its use is mandatory in single or bilateral facet cervical dislocations before reduction, in order to avoid spinal cord injury from the possible concomitant disc protrusion. The precise nature of any spinal cord injury can also be identified on MRI sequences.

3.4 Dynamic radiography

Dynamic radiography, such as flexion/extension, or traction lateral, cervical x-rays, is inappropriate if an unstable spinal injury is diagnosed. Flexion/extension x-rays or image intensification of the cervical spine must be personally supervised by a trauma specialist. It must be recognized that these measures may not be adequate to determine spinal stability and are potentially dangerous. Longitudinal sagittal scanning with MRI, or spiral CT, will provide additional information and the former allows imaging of the entire neuraxis. However, few patients are stable enough for MRI scanning, and MRI compatible anesthetic equipment is not commonly available. The safest policy is to continue to protect the spinal column until the patient can cooperate with dynamic imaging without reporting significant pain.

3.4.1 Conscious patient

In a conscious and cooperative patient with persistent neck pain and no radiographic evidence of fracture or dislocation, supervised flexion/extension x-rays are taken and will exclude significant instability. However, these should be delayed until paravertebral spasm has settled, so that flexion and extension movements actually occur. Until this stage is reached, possibly some weeks after injury, the patient should be treated in a firm orthosis.

3.4.2 Unconscious patient

- In the obtunded patient spinal column assessment must be meticulous.

The standard clinical and radiological investigations are undertaken. The fracture surgeon is often asked to make a judgment on spinal stability when the plain x-rays and, sometimes, CT scans at selected levels appear to be normal. The safest policy is to assume an unstable injury, to log roll the patient and to use a firm cervical orthosis until the protocol in chapter 6.11:3 can be completed.

Spinal cord injury in an unconscious patient should be suspected if any combination of the following is present:
- flaccid areflexia;
- diaphragmatic breathing;
- pain response above, but not below the clavicle;
- bradycardia and hypotension;
- priapism.

4 Spinal instability

The term instability is used to describe a wide variety of spinal conditions, including clinical, radiographical, and biomechanical abnormalities. The most widely used general definition is that of White and Panjabi [2] and states that: “The loss of the ability of the spine under physiological loads to maintain its pattern of displacement so that there is no initial or additional neurological deficit, no major deformity, and no incapacitating pain”.

"Spine"
Instability missed during the initial management phase may produce or exacerbate a spinal cord injury or permit displacement of fractures or dislocations, precipitating the need for more invasive interventions.

In the long term it can lead to chronic instability, pain on movement, and a higher risk of degenerative changes, particularly if overall sagittal alignment is lost. The assessing clinician should make use of all of the clinical and radiological signs which have been described to judge the stability of the spinal column.

Since descriptions of spinal injuries were first reported, authors have considered the spine in conceptual divisions or columns. The work of Denis [3] has popularized the idea of three spinal columns. There is an increasing realization, however, that the use of a two-column description (Fig 6.11-9) simplifies understanding of the injury and has facilitated the process of applying Müller AO Classification principles to the spine. Following an injury, the presence of an intact anterior or posterior column will usually exclude the problems associated with instability. Careful assessment of both columns is essential, as the combination of clinical and radiological investigations may reveal significant injury to both. For example, what may appear to be an isolated compression fracture of the anterior column may have an associated ligamentous posterior column injury diagnosed only by clinical examination or MRI scanning.

5 Classification—skeletal injuries

The AOSpine classification is now widely used for the thoracolumbar and subaxial cervical spine [4]. C1 and C2 level injuries are still classified differently.

Atlantooccipital fracture dislocations are extremely uncommon and usually prove fatal. In the rare survivors they may only be diagnosed on sagittal CT reconstructions.

C1 level

The classical C1 fracture is the Jefferson fracture (Fig 6.11-10a) [5], which is a burst fracture of the ring. Stability is assessed by measuring the atlantodental interval on a lateral x-ray.
6.11 Spine

(normal < 4 mm), and by the lateral mass spread on the AP odontoid peg view (normal < 8 mm) (Fig 6.11-10b). Other injuries of C1 include isolated lateral mass and anterior or posterior arch injuries.

C1/2 level
Atlantoaxial rotary subluxation of C1/2 was described by Fielding and Hawkins [6]. This injury is characterized by fixed rotary subluxation of the joint and is subdivided into four types:

<table>
<thead>
<tr>
<th>Type</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Rotary fixation, no displacement</td>
</tr>
<tr>
<td>Type II</td>
<td>Rotary fixation, unilateral anterior displacement</td>
</tr>
<tr>
<td>Type III</td>
<td>Rotary fixation, bilateral anterior displacement</td>
</tr>
<tr>
<td>Type IV</td>
<td>Rotary fixation, posterior displacement</td>
</tr>
</tbody>
</table>

Diagnosis of atlantoaxial rotary subluxation can be very difficult but should be considered whenever there is unexplained posttraumatic neck pain and torticollis.

Careful inspection of the x-rays and CT scans will normally demonstrate the lesion.

C2/odontoid
Odontoid peg fractures were classified by Anderson and D’Alonzo according to the level of the fracture [7] (Fig 6.11-11).

Type I fractures are at the tip of the odontoid process, and represent ligamentous avulsion which may rarely produce instability. Type II fractures are transverse or oblique fractures through the base of the odontoid process. Type III fractures are through the cancellous bone of the body of C2 close to the base of the odontoid.

Levine and Edwards have classified traumatic spondylolisthesis of C2, the so-called hangman’s fracture [8]. Type I injury is a neural arch fracture of C2, with no angulation and less than 3 mm displacement of C2 on C3. Type II injuries are displaced, with more than 5° of angulation and more than 3 mm of displacement (Fig 6.11-12). Type IIA injuries are characterized by significant angulation, but no displacement, and by the observation that traction causes widening of the C2/3 disc space. Type III injuries have severe angulation and displacement and single or bilateral C2/3 facet dislocation.
Specific fractures

The spine, which is bone group 5, is divided into three sections:
- cervical = 51-
- thoracic = 52-
- lumbar = 53-

There are three basic injury patterns:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>Compression injuries of the vertebral body</td>
</tr>
<tr>
<td>Type B</td>
<td>Distraction injuries of the anterior and/or posterior elements</td>
</tr>
<tr>
<td>Type C</td>
<td>Type A or type B injuries with rotation, complex fractures, and dislocations</td>
</tr>
</tbody>
</table>

Lower cervical, thoracic, and lumbar spine

Subaxial cervical and thoracolumbar fractures are classified according to Magerl et al [9]. The AO group and the Orthopaedic Trauma Association have adopted this classification (Fig 6.11-13) [10].

In the lower cervical spine distraction injuries are more severe than rotational, and are therefore classified as type C. Rotational injuries are classified as type B.
6 Classification—neurological injuries

Cervical cord injury leads to tetraplegia and thoracic and lumbar injuries to paraplegia.

- Neurological injuries are described as complete if there is no recovery of distal neurological function once the stage of spinal shock has passed, for example, when the bulbocavernosus reflex returns.

The American Spinal Injury Association (ASIA) and the International Medical Society of Paraplegia have refined the original Frankel [11] functional classification.

<table>
<thead>
<tr>
<th>ASIA Impairment Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Complete lesion</td>
</tr>
<tr>
<td>B</td>
<td>Incomplete sensory preservation</td>
</tr>
<tr>
<td>C</td>
<td>Incomplete motor preservation &lt; MRC grade 3</td>
</tr>
<tr>
<td>D</td>
<td>Incomplete motor preservation &gt; MRC grade 3</td>
</tr>
<tr>
<td>E</td>
<td>Normal neurological function</td>
</tr>
</tbody>
</table>

Incomplete lesions can fit into the following clinical syndromes:

- **Brown Squeard syndrome:** Ipsilateral motor and proprioceptive loss, and contralateral loss of temperature and pin-prick sensation.

- **Central cord syndrome:** Cervical cord lesion with severe tetraparesis, upper limbs worse than lower limbs, and sacral sparing.

- **Anterior cord syndrome:** Most of the spinal cord affected with dorsal column sparing only.

- **Conus lesion:** This will produce a mixed picture of sacral cord and lumbar root injuries, with areflexic bowel and bladder.

- **Cauda equina lesion:** This produces nerve root injury with areflexic bowel and bladder.

7 Initial management

- Protecting the spine and preventing further injury are the guiding principles during the evaluation period.

The patient with a spinal cord injury may be considered for a high dosage methylprednisolone protocol as soon as diagnosis is made. The second National Acute Spinal Injury Study [1], a randomized, multicenter, double-blind trial of methylprednisolone, established that early administration of very high doses led to better motor and sensory scores 6 months after injury. The initial dose is a bolus of 30 mg/kg, followed by 5.4 mg/kg/hour for 23 hours. The proven improvement in recovery is, however, marginal and many of the patients in the original study also had early surgery, which is a confounding factor. Although systemic complications were not reported from this protocol, there was a delay in wound healing in the surgical patients. A thorough study and understanding of these results is suggested before a patient can be advised that this protocol is functionally effective and without major complications.

**Nondisplaced cervical injuries**

- Nondisplaced cervical injuries, whether stable or potentially unstable, can be controlled with a firm orthosis during the initial phase.
Displaced and unstable injuries to the cervical spine should be managed with the use of halo traction. The admitting trauma surgeon or musculoskeletal specialist should apply this device under local anesthesia. A halo is preferable to tongs or calipers, because of superior head and neck control, and because modern haloes are both MRI compatible and can be attached to a molded jacket as definitive treatment.

The anterior pins are placed in the supraorbital ridge, lateral to the supraorbital notch, with the patient’s eyes tightly closed during insertion. The halo ring should lie so that it is 1 cm higher than the superior tip of the pinna. Local anesthetic is inserted, the pins are positioned and gently tightened, following which diagonally opposite screws are tightened simultaneously. A torque wrench should be used so that all screws are tightened to 6 in-lbs (= 2.1 Nm) (Fig 6.11-14).

Fig 6.11-14a–d Application of a halo.
Initially, 24–44 N longitudinal traction is applied and a lateral check x-ray is obtained. In a type IIA hangman’s fracture, traction may cause segmental distraction, and should this occur, the traction should be removed, a halo jacket applied in the best obtainable position, and the patient urgently transferred to a specialist spinal unit.

**Other displaced cervical injuries**

All other displaced cervical injuries should reduce with traction increasing incrementally every 15 minutes or so, and monitored by neurological examination and lateral x-ray. As a rule of thumb, the weight should be about 24 N plus 24 N for each level from C1/2 down. Displaced Jefferson fractures, hangman’s fractures, odontoid fractures (types II and III), displaced subaxial fractures, and dislocations can all be treated in this fashion in the first instance. Reduction can also be maintained by traction until a definitive management program is determined.

Some authors describe the necessity for traction forces over 490 N for facet dislocations, although usually much less weight is required. Reduction of cervical spine injuries in the presence of spinal cord injury is equally urgent.

**Thoracolumbar fractures**

Patients with nondisplaced stable or potentially unstable thoracolumbar fractures should be nursed supine with intensive pressure area care during this phase. Most of those with significant spinal injuries will require urethral catheterization.

- **Patients with complete spinal cord injuries will need physiological optimization in an intensive care unit to maintain spinal cord perfusion and oxygenation.**

---

**Definitive management**

The definitive treatment of spinal injuries may be surgical or nonsurgical.

- **In the age of surgical subspecialization, much of the decision making and surgical intervention should be performed in dedicated spinal surgical units, by a team consisting of an orthopedic surgeon, neurosurgeon, and, if appropriate, a spinal cord injury rehabilitation physician.**

Many believe that the only indication for early surgical intervention is a deteriorating neurological situation persisting despite appropriate nonsurgical management, together with a demonstrable bony or disc-compressive lesion on imaging. This combination often requires an anterior vertebrectomy and decompression, a dangerous undertaking in the acute situation, especially when there is concomitant visceral trauma. Such patients must always be transferred to a specialist unit.

**Unstable spinal column injuries**

Unstable spinal column injuries, with or without neurological injury, will often need surgical stabilization after reduction. However, in the absence of spinal cord injury some injuries may be managed in a halo jacket or rigid orthosis. Displaced Jefferson fractures, hangman’s fractures, type III odontoid fractures, and subaxial fractures may all be treated in a halo jacket for 6–8 weeks after reduction, with frequent x-ray monitoring. Such injuries should then be treated in a rigid orthosis until 3 months postinjury.
Specific fractures

Odontoid fractures—type II
Type II odontoid fractures, which are displaced more than 25% on original x-ray (Fig 6.11-15) even after reduction, or undergoing recurrent displacement, have a high risk of proceeding to nonunion and will need surgical fixation. These patients should also be transferred to a specialist spinal unit.

Subaxial cervical soft-tissue disruptions
Significant disruptions of subaxial cervical soft tissues, particularly after reduction of facet dislocations, will need surgical stabilization with an anterior plate system. Irreducible facet dislocations will need posterior open reduction, stabilization, and fusion. Cord compression from either bone or disc mandates an anterior approach, decompression, often including vertebrectomy, and fusion with plate stabilization (Video 6.11-1).

Nondisplaced and stable cervical injuries
Nondisplaced and stable cervical injuries should be treated in an appropriate firm orthosis.

Thoracolumbar dislocations
Thoracolumbar dislocations, with or without neurological compression, need open reduction and stabilization through a posterior approach and, with partial or complete neurological injuries where spinal shock is still present, this should be performed as soon as the patient’s general condition allows.

Thoracolumbar burst fractures
Thoracolumbar burst fractures where there is partial, deteriorating, or complete neurological loss with persistent spinal shock should be considered for emergency decompression and stabilization (Fig 6.11-16). There is some evidence that cord...
recovery is enhanced by such early intervention, but to minimize the mortality and morbidity the procedure should only be performed by a spinal surgeon with experience of this approach.

**Unstable injuries**

Unstable injuries where there is significant two-column disruption need surgical stabilization, using posterior stabilization systems (Video 6.11-2).

**Type A fractures in the thoracolumbar region**

Type A fractures in the thoracolumbar region, with more than 50% loss of anterior body height and significant regional kyphosis, or wedging (> 30° at the thoracolumbar junction, or > 10° in lumbar spine), are best treated by posterior indirect reduction and posterior fusion (Fig 6.11-17). Surgeons with experience of pedicle screw insertion in the thoracolumbar region should be able to manage most type A fractures requiring surgery using this method.

Most thoracolumbar fractures do not meet these indications and can be treated nonoperatively. A thoracolumbosacral orthosis will aid pain control, but most stable injuries are sufficiently pain free after the first 2 weeks to not require this. In addition, the predominant injuring force is axial compression, and external bracing will not control this.

Fig 6.11-16  CT scan of thoracolumbar burst fracture.

Video 6.11-2  Universal spine system for thoracolumbar fractures.
Specific fractures

Fig 6.11-17a–e

a–b  Displaced thoracolumbar compression fracture without neurological deficit.

c  CT scan.

d–e  Reconstruction within hours and stabilization with universal spine system (USS).
6.11 Spine

9 Bibliography


10 Suggestions for further reading
