128 Subaxial Cervical Spine Injuries

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SUMMARY OF KEY POINTS

- Subaxial cervical spine injuries encompass a broad spectrum of acute traumatic injuries.
- Assessment of spinal stability and injury classification facilitates management.
- Adequate decompression of neural elements and restoration of spinal stability for early mobilization is the basis of treatment.
- Although nonoperative management with external cervical immobilization can be utilized successfully, surgical treatment of these injuries are required, especially in higher injury grades.
- Both anterior and posterior surgical approaches are successful, and neither approach is superior to the other.
- Management strategies must be individualized for each patient based on the patient's injury characteristics.
- Factors to be carefully assessed include neurologic status, degree and type of injury, ligamentous disruption, spinal stability, and spinal cord injury or compression.

Of all trauma admissions in the United States, 2% to 5% will ultimately be diagnosed with a cervical fracture.[1] The subaxial spine accounts for 65% of these fractures and more than 75% of all dislocations.[2] Immediate identification is crucial, as 57% of these injuries are unstable with the potential for increasing neurologic deterioration, progressive deformity, loss of function, and debilitating pain.[1,3,4] Approximately 150,000 cervical spine injuries occur annually in North America.[5]

ANATOMY

The subaxial cervical spine consists of the C3-7 vertebrae. The cervical spinal canal houses the spinal cord and is bound by the vertebral body anteriorly, pedicles laterally, and the laminae posteriorly. The transverse process, which is directed anterolaterally, contains the transverse foramen. The vertebral artery enters the transverse foramen at C6 in 90% of the population and travels up the subaxial cervical spine.[6] Off of the lamina, the inferior and superior articular processes form the facet joints, which are oriented at 45 degrees. The uncovertebral joints are formed by a bony protuberance, known as the uncinate process, on the lateral aspect of the superior vertebral body, which articulates with a convex area in the lateral aspect of the inferior vertebral body.[7] The intervertebral disc is found in the intervertebral disc space and is composed of the gelatinous nucleus pulposus centrally and the fibrocartilaginous annulus fibrosus peripherally. The uncovertebral joint protrudes through an area absent of annulus fibrosus and is believed to be lined by a synovial membrane.[7] The spinous processes project posteriorly and are bifid between C3 and C6. Ligamentous structure is provided on the anterior and posterior aspects of the vertebral bodies by the anterior longitudinal ligament (ALL) and the posterior longitudinal ligament (PLL), respectively. The ligamentum flavum is found connecting adjacent lamina and facet capsules. The interspinous and supraspinous ligaments provide further support between the spinous processes posteriorly.[8,9]

As Bogduk and Mercer noted, the principal movements of the subaxial spine are flexion and extension. This is facilitated by the observation that cervical vertebral bodies are not stacked flatly upon one another but are situated with a sagittal slope.[10] The bony and ligamentous anatomy as well as the intervertebral discs together limit excessive motion of the cervical spine. This prevents injury to the cervical spinal cord while allowing functional motion. The PLL, the facet capsules, the ligamentum flavum, and the interspinous ligaments all resist flexion. Extension is limited by ALL and the annulus fibrosus, as well as the posterior bony anatomy. Excessive movement in these planes of motion can result in injury to these structures.[8,9]

The cervicothoracic junction is of particular interest due to its transitional and variable anatomy. The potential presence of the vertebral artery, tenuous blood supply, and narrow spinal canal make screw placement in this segment difficult and controversial.[11] The cervical vertebrae enlarge moving caudally and are slightly lordotic ending at the cervicothoracic junction where the alignment becomes kyphotic in the thoracic spine. When this transition of curvature occurs, a transition of weight distribution occurs as well complicating intervention.[12] For screw placement, three techniques have been advocated and criticized, including pedicle, laminar, and lateral mass screws. Compared to thoracic pedicles, cervical pedicles are smaller with an increase in height and width and a decrease in angle with the vertebral body moving caudally toward the thoracic spine.[13] Placement of a pedicle screw risks neurovascular compromise with transverse foramen involvement. Translaminar screw use presents the possibility for penetration into the dorsal spinal canal. At C7 the lateral mass is thin and small compared to higher cervical vertebrae presenting screw pullout as a common complication.[13]

CLINICAL ASSESSMENT

In the immediate aftermath of an acute spinal cord injury (SCI), patients frequently develop neurologic dysfunction. These neurologic problems are likely to manifest with functional deficits, and patients often experience pain. The best medical evidence suggests that patients who experience spinal cord injury should undergo serial evaluation and documentation of neurologic and functional deficits, as well as pain severity.[14]

Many classification systems have been developed to document and standardize neurologic evaluation of the patient with acute spinal cord injury.[14] These include the Frankel Scale,[15] the Lucas and Ducker Neurotrauma Motor Index,[16] the Sunnybrook,[17] the Botsford,[18] the Yale scale[19] and the National Acute Spinal Cord Injury scales,[20,21] among others. The ideal scale would have inter-rater reliability, reproducibility, sensitivity to changes in neurologic function, and would provide

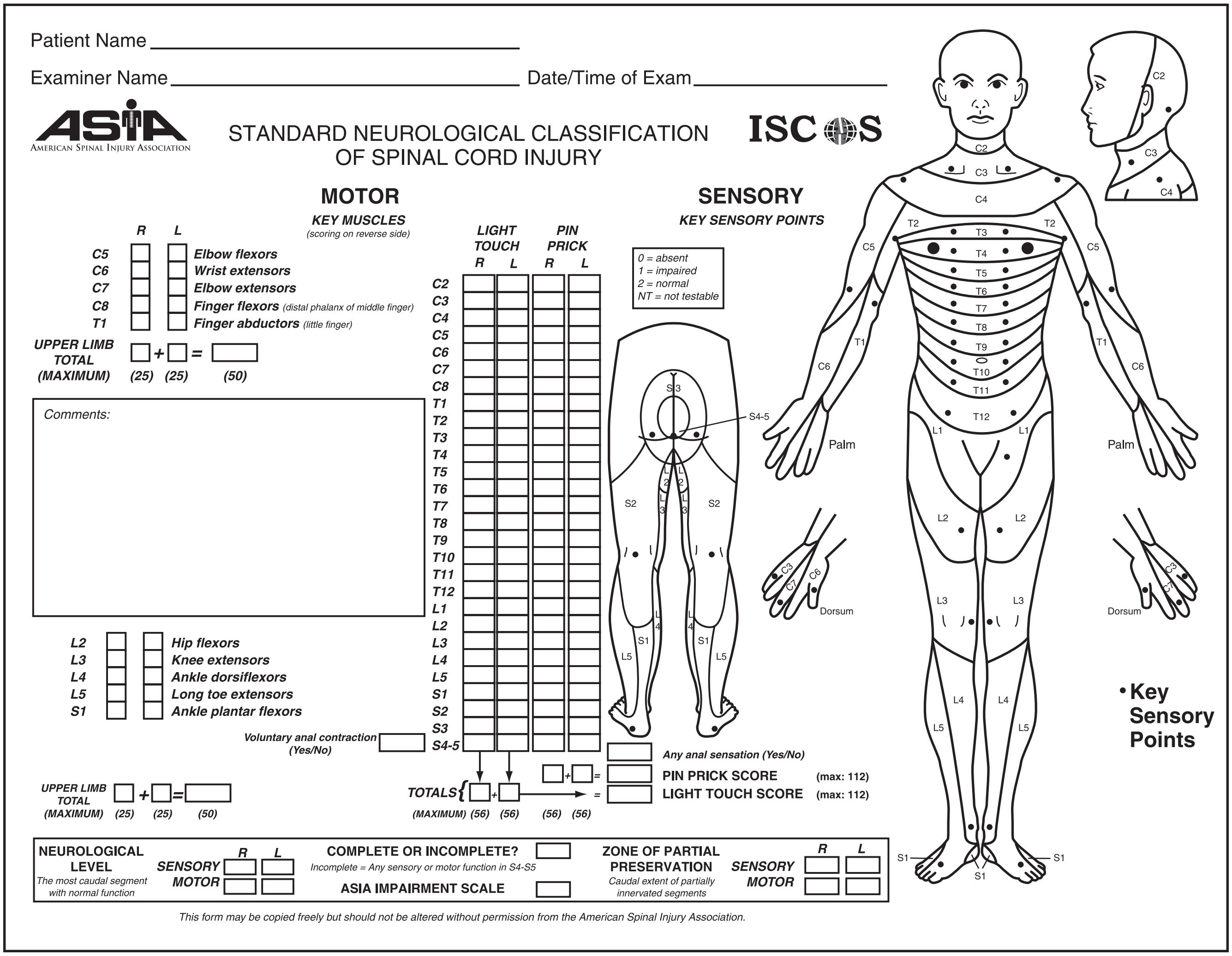

Figure 128-1. American Spinal Injury Association (ASIA) neurologic classification form used to document the physical examination of a patient after cervical trauma.

accurate documentation. The scale would then be sufficiently useful for management and research purposes. Currently, the American Spinal Injury Association (ASIA) scale best meets these criteria and is the preferred neurologic examination tool, as shown in Figure 128-1.[14,22]

This classification system is as follows:[23]

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory incomplete. Sensory but not motor function is preserved below the neurologic level and includes the sacral segments S4-5, *and* no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor incomplete. Motor function is preserved below the neurologic level, and more than half of key muscle functions below the single neurologic level of injury have a muscle grade less than 3 (grades 0 to 2).

D = Motor incomplete. Motor function is preserved below the neurologic level, and at least half (half or more) of key muscle functions below the neurologic level of injury (NLI) have a muscle grade > 3.

E = Normal. If sensation and motor function as tested with the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) are graded as normal in all segments, and the patient had prior deficits, then the ASIA Impairment Scale (AIS) grade is E.

Someone without a SCI does not receive an AIS grade.

The procedure for determining the ASIA grade is outlined in the ISNCSCI.[24] Briefly, the neurologic examination tests two components: sensory and motor. The sensory examination tests light touch and pin prick sensation at 28 points, corresponding to separate dermatomes on the right and left side of the body. The motor examination consists of testing 10 paired myotomes graded with the standard six-point scale. An NLI is then determined for the most caudal aspect of the right and left side, with antigravity motor function and intact sensation. From these four possible NLI, the single NLI is the most rostral and is used in the ASIA classification process.

Burns and coworkers noted decreased reliability of the initial examination in the presence of closed head injury, drug effects, mechanical ventilation, and psychologic disorders.[25] It has also been suggested that impairment following SCI can be better described and predicted with separate upper and lower extremity ASIA motor scores.[26,27]

Although ASIA was designed to measure neurologic deficits, it does not take into account spasticity, pain, or dysesthesias;

therefore, a number of scales have been developed to assess for functional deficits. These scales attempt to document the patient's deficiencies in daily functioning. These include the Functional Independence Measure Scale,[28] the Barthel Index,[29] the Quadriplegic Index of Function,[30] and the Spinal Cord Independence Measure (SCIM),[31] among others. Currently, the third revision of the SCIM scale, SCIM III, is recommended for functional assessment in patients with acute spinal cord injury.[14] This scale was specifically designed for patients with spinal cord injury, in that it derives from assessment of one's ability to perform basic tasks, economic burden of disability, and impact on overall comfort.[31] Additionally, SCIM III provides documentation, which is sensitive to functional changes, has inter-rater reliability, and is reproducible, making it useful for patient care as well as research purposes.[32,33]

SCIM III consists of three complementary subscales: "self-care" (with a score range of 0 to 20) including six tasks, "respiration and sphincter management" (with a score range of 0 to 40) including four tasks, and "mobility" (with a score range of 0 to 40) including nine tasks. The mobility subscale consists of two subscales: one for "room and toilet" and the one for "indoors and outdoors, on even surface." Total score ranges between 0 and 100.[34]

Pain is also a common complication after spinal cord injury and can be severely debilitating.[35] Consequently, numerous methods have been developed to measure the pain in both objective and subjective ways. Ideally, these scales would provide a method to document pain following spinal cord injury and allow assessment of the efficacy of treatment. The most highly recommended of these to date is the International Spinal Cord Injury Basic Pain Data Set (ISCIBPDS).[14,36,37]

RADIOGRAPHIC ASSESSMENT

In patients who present with potential cervical spinal injury, the necessity of imaging must first be determined. A number of criteria have been developed to make this. If imaging is indicated, computed tomography (CT) scanning has been shown to be most effective, though plain films, dynamic films, and magnetic resonance imaging (MRI) may have a role.

The National Emergency X-Radiography Utilization Study Group uses five criteria to determine whether or not patients with potential cervical spine injury require imaging. If all of the five criteria are present, patients require no imaging. These criteria include absence of midline cervical tenderness, absence of focal neurologic deficit, normal alertness, absence of intoxication, and absence of painful, distracting injury.[38] The Canadian C-spine uses three criteria to determine if a patient requires imaging. These include presence of a high-risk factor that mandates radiography, presence of a low-risk factor allowing safe assessment of range of motion, and ability to actively rotate neck 45 degrees to the left and right.[39] Anderson and colleagues found that patients who are alert, asymptomatic, and without neurologic deficit who can complete a functional range of motion examination and are free from other major distracting injury can be released from cervical immobilization without radiographic imaging.[40] The sensitivity of each of these methods for spinal cord injury is high, though best medical evidence supports the use of the criteria of Anderson and colleagues.[41]

For patients who require imaging, CT is more sensitive than three-view cervical plain films for detecting cervical spine injury. The sensitivity of plain films for diagnosing cervical spine injury is thought to be between 35% to 53%, whereas CT can approach 100%.[42-46] If CT is unavailable, three-view cervical plain films can be used, though they are not preferred.[41] In symptomatic or obtunded patients with negative CT or plain radiographs, investigators have studied the utility of MRI and flexion/extension radiographs to further assess for cervical spine injury and determine the need for continued cervical immobilization. Controversy exists in regard to the utility of both. Studies have investigated the usefulness of MRI in these patients and have found it helpful,[47-49] but others have not.[50] More work is needed to determine which patients can benefit from an MRI. Dynamic films are thought to be less sensitive for ligamentous injury than MRI[51] and to be of little use in the setting of a normal CT scan and clinical examination.[52-56] There are also reports of injury to obtunded patients undergoing dynamic imaging, which raises questions as to the safety of the procedure in these patients.[57]

INJURY CLASSIFICATION

Many systems have been proposed to classify injuries from C3-7 in the setting of trauma; a more commonly used system by Magerl and associates had originally been designed for use in the thoracolumbar spine.[58-60] In 2007, publication of the Subaxial Injury and Classification (SLIC) and severity scale by the Spine Trauma Study Group posed a more focused and clinically oriented guideline for management of subaxial cervical spine injuries.[61] Since the publication of SLIC, more recent classification systems have been proposed, but additional literature is needed for their validation.[62,63]

The three parameters evaluated in the SLIC classification are injury morphology, spinal stability, and neurologic status (Fig. 128-2). According to the SLIC grading system, injury morphology is classified as (0) no abnormality, (1) compression fracture, (2) burst fracture, (3) distraction injury, and (4) translation injury. The SLIC scoring system grades discoligamentous complex (DCL) integrity as (0) intact, (1) indeterminate, and (2) disrupted. Finally, neurologic status is defined as (0) intact, (1) nerve root injury, (2) complete spinal cord injury (SCI), (3) incomplete SCI, and (+1) persistent cord compression. Patients with a total score of 1 to 3 are recommended to be treated conservatively with a PMT collar. It is recommended that patients with a score of 4 are treated either

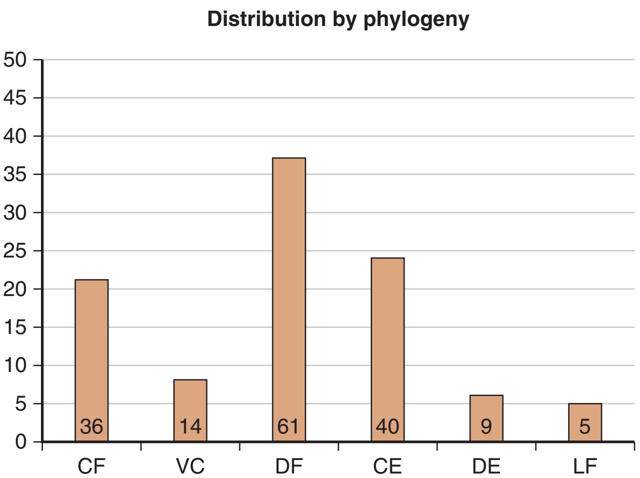

Figure 128-2. Distribution of lower cervical spine injuries among 165 patients. CE, compressive extension; CF, compressive flexion; DE, distractive extension; DF, distractive flexion; LF, lateral flexion; VC, vertical compression. *(Data from Allen BL, Ferguson RL, Lehmann TR, et al: A mechanistic classification of closed indirect fractures and dislocations of the lower cervical spine.* Spine [Phila Pa 1976] *7:1–27, 1982.)*

operatively or nonoperatively based on the patient and surgeon. For example, a patient with a SLIC score of 4 with significant comorbidities may respectably be managed nonoperatively. Lastly, patients with a score of 5 or more are highly recommended for surgical decompression or stabilization.

Studies evaluating the SLIC scoring system demonstrate strong inter- and intraobserver agreement (> 90%) in both the overall injury score and treatment plan chosen.[64] These authors also evaluated the validity of SLIC by performing a retrospective review of 185 patients comparing their management to the recommendations of the SLIC guidelines. Of the 66 patients with a SLIC score of 3 or less, 94% of them were managed nonoperatively; of the 102 patients with a SLIC score of 5 or greater, 95% of them were managed surgically. Of the 17 that had a SLIC score of 4, 65% were conservatively managed.[64] A prospective study also supports the SLIC guidelines as effective in preserving neurologic status after subaxial cervical spine trauma.[65] Despite evidence and support from proponents of the SLIC system, the guidelines do have certain drawbacks, therefore controversy for their use still exists.

One such parameter is evaluating and elaborating upon the morphology of cervical spine injuries. According to SLIC, no abnormality (0) includes isolated spinous process fractures, laminar fractures, or nondisplaced facet or pedicle fractures. A floating lateral mass without significant displacement, for example, would be difficult to classify. Compression fractures (1) are represented as simple anterior compression, comminuted fractures, or the more severe teardrop fractures, the latter of which is highly associated with spinal instability injury. Distraction (3) injuries primarily involve the intervertebral disc and ligamentous structures with anatomic dislocation in the vertical axis. Trauma associated with hyperflexion often results in compression of the anterior column and a distraction injury of the posterior column; trauma associated with hyperextension will have distraction of the anterior column. Often, a component of both are involved in level I traumas. Of note, distraction injuries can also present as injured facets, which may or may not be reliably reflected by the SLIC guidelines. This may be a contributing factor in delayed glacial instability following facet fractures. Lastly, with translational injuries (4), rotation is typically the dominant force. This can present as unilateral or bilateral facet joint or fracture dislocations. Invariably so, both distraction and translational injuries pose a threat to spinal stability.

Special attention should be warranted in patients with previous cervical spondylosis. For example, a patient suffering from a complete spinal cord injury secondary to hyperextension in the setting of cervical spondylosis could be scored a 3 on the SLIC scale, with (0) normal morphology, (0) intact DCL, and (2) complete, (+1) persistent cord injury; but these patients may benefit from surgical decompression.

SPINAL STABILITY

Spinal stability is assessed primarily by the overall alignment of the spine and the integrity of the discoligamentous complex (DLC). The DLC comprises the intervertebral disc, anterior and posterior longitudinal ligaments, interspinous ligaments, facet capsules, and ligamentum flavum. Again, the SLIC scoring system grades DLC integrity as (0) intact, (1) indeterminate, and (2) disrupted. Although spinal alignment is a reflection of ligamentous stability, isolated bony injuries can result in significant spinal instability with an intact DLC such as in the case of a three-column bony chance type fracture.

In the majority of circumstances, disrupted DLC is established by evidence of distraction or translation to the spinal column or significant disruption of the intervertebral disc space or facet joints. Isolated injuries to the ALL, PLL, ligamentum flavum, or interspinous ligaments may not truly represent disruption of the DLC. Identifying and scoring the DLC as indeterminately injured is controversial in this setting and because MRI tends to overestimate true ligamentous injury. An MRI, however, should be considered to assess the intervertebral disc or ligamentous structures in cases of significant neurologic injury.

NEUROLOGIC CLASSIFICATION

The basis of the SLIC neurologic status focuses on the AIS, as shown in Figure 128-1. This classification system is currently the most widely used method to describe SCI. A complete grade A SCI is defined as no sensory or motor function is preserved in sacral segments S4-5.[66] The AIS grading system does not take into account other neurologic findings present in SCI such as spasticity, pain, or dysesthesias all of which contribute to functional recovery and quality of life.

Although widely used and highly reproducible, the AIS interpretation of neurologic status often oversimplifies neurologic symptoms. For example, classification of unilateral spinal cord injury or cauda equina remains difficult and often under represents the true severity of injury. To ameliorate these flaws, other scoring systems have been proposed in an attempt to improve neurologic classification and surgical decision making. Tsou and coworkers in 2012 incorporated neural impairment (scoring range from 2 to 10), pathomorphology (scoring range of 2 to 15), and canal sagittal diameter (millimeters) at the narrowest point of injury as a more detailed form of analysis.[62] Although Tsou and coworkers overcame some surgical management flaws of the SLIC system with more stringent parameters, the large range of scoring and its complexity has limited its widespread use.

MANAGEMENT

Prehospital Immobilization and Transportation

Patients with acute cervical spine injuries should be transferred immediately to a center that specializes in spinal cord injury. This has been linked to better neurologic outcomes, reduced length of stay, fewer complications, and reduced mortality.[67-70] Studies have emphasized the benefits of early transfer after acute injury rather than post procedurally.[69,71] Patients should be immobilized to limit additional injury during transport.[72]

Although prospective studies have not investigated cervical spine immobilization, it is recommend based on anatomic and biomechanical perspectives as well as clinical experience with traumatic spinal injuries.[73] The necessity of cervical immobilization in the field should be assessed by emergency medical services (EMS) personnel using National X-Radiography Utilization Study (NEXUS)–like criteria.[74] These criteria would include midline cervical tenderness, focal neurologic deficit, decreased level of consciousness, intoxication, and other distracting injury.[38] Although many different procedures have been proposed, immobilization should include a cervical collar, a long or short backboard, and straps to immobilize the patient's entire body.[75] This immobilization before prehospital transport will limit spinal motion and thus injury during transport.[76] Immobilization in this way does have complications including pain,[77] increased intracranial pressure,[78] pressure sores,[79] and decreased respiratory function.[80] Immobilization should therefore be removed when it is deemed unnecessary.

In patients with penetrating injuries to the spine, immobilization should not be performed.[73] Typically this type of injury does not cause instability, and immobilization is unlikely to be of benefit. In some cases it may cause further deterioration.[81]

Initial Reduction

Historically, closed reduction has been used to reduce cervical spinal fracture and dislocation injuries until more definitive treatment can be achieved.[82-84] This restores alignment quickly, potentially reducing injury and promoting recovery.[85] The success of this method has been documented and a review of the topic found that of cases in the literature, 1200 have been reduced in this way with an 80% success rate.[86]

Several case reports have documented neurologic deterioration after the application of closed reduction, raising the question of whether a prereduction MRI should be obtained to avoid ventral compression of the cord by displaced disc material.[87] The predictive value of MRI findings of displaced disc material for deterioration with closed reduction is, however, controversial.[85,88,89] A review of this topic found the rate of permanent neurologic deterioration to be 1% and the rate of transient deterioration to be 2% to 4%.[86] It is suggested that, in awake patients, reduction be performed with monitoring to ensure deterioration does not occur.[89] Here, it is not recommended to obtain a prereduction MRI, as this may unnecessarily delay reduction of the injury.[86] For patients in whom a neurologic examination is not possible, a prereduction MRI is recommended.[86]

Acute Cardiopulmonary Management

As early as 1976, Zach and associates noted that acute spinal cord injury patients experienced better neurologic outcomes when they are transferred early into an intensive care unit.[90] Further studies have found lower morbidity and mortality, shorter length of stay, and reduced cost of care when patients are transferred early in the course of care.[91] Transfer to an intensive care unit allows better monitoring and management of complications that can arise after an acute spinal cord injury.[92-94]

Of the complications that follow acute spinal cord injury, pulmonary complications are thought to be the most common.[95] This includes reduction in forced vital capacity (FVC) and expiratory flow rate leading to respiratory failure.[96] Respiratory failure is reported to be the most common cause of mortality.[95] Vigorous pulmonary therapy has been shown to reduce the incidence of pulmonary complications,[97] and Como and coworkers suggested early intubation for patients with complete spinal cord injury, particularly for injuries at C5 and above.[98] For patients with incomplete spinal cord injury, Hassid and colleagues recommended close observation with intubation if pulmonary parameters decline.[99]

Cardiovascular complications are also commonly seen. Increasing cardiovascular instability has been found to correlate with increasing injury severity.[100] Lehmann and colleagues characterized the frequency of cardiovascular complications based on different Frankel levels of injury severity. In their study, up to 71% of patients with severe cervical spinal cord injury (Frankel A or B) experienced marked bradycardia (< 45 beats per minute), whereas this only occurred in 12% of patients with mild cervical spinal cord injury (Frankel C or D). Episodic hypotension unrelated to hypovolemia also occurred in 68% of patients with severe cervical spinal cord injury along with a 16% rate of cardiac arrest. The authors noted that no significant events occurred after 14 days.[101] Neurologic outcomes are improved with hemodynamic monitoring, aggressive volume resuscitation, and blood pressure augmentation.[102,103] Maintenance of a mean arterial pressure between 85 and 90 mm Hg is recommended for 7 days following an acute spinal cord injury.[94]

Pharmacologic Therapy

The administration of methylprednisolone after acute spinal cord injury has been heavily studied, but prospective blind randomized controlled trials have failed to show any benefit.[21,104-107] Retrospective studies have found various improvements in neurologic outcomes, but these have not been reproduced in prospective studies.[21,108-111] Its use after acute spinal cord injury is not recommended.[10] Complications—including infection, hyperglycemia, respiratory compromise, gastrointestinal hemorrhage, and death—have been shown to increase with its use.[105,106,112-114]

GM1 ganglioside had previously shown promise to enhance recovery in patients with acute spinal cord injury,[115] but a subsequent study showed only improved early recovery with improvements lost by the 26-week follow-up.[116] This option requires further study and is not currently recommended for use in acute spinal cord injury.[106]

INJURY TYPES

Spinal Cord Injury without Radiologic Abnormality

Spinal cord injury without radiologic abnormality (SCIWORA) was historically described in a series of children who presented with neurologic signs of myelopathy and transient paresthesias or paralysis with no abnormalities on plain films or computed tomography. Since the advent of MRI, about two thirds of the original SCIWORA cases have been identified as having abnormalities and injuries. Despite true SCIWORA becoming less common, many still use the term *SCIWORA* as historically described. SCIWORA is more common in children. Children are more prone to SCIWORA because the proportional size and weight of their heads are greater when young and decrease into adolescence when the proportions stabilize. Children also have more lax ligaments in the cervical spine, which may contribute to SCI without ligamentous disruption. Spinal cord injury without radiographic evidence of trauma (SCIWORET) is more common in adults. Often this can be associated with cervical spondylosis, ossification of posterior longitudinal ligament, ankylosing spondylitis, disc herniation, and spinal stenosis.

The initial assessment consists of CT imaging and further evaluation of gross instability or ligamentous injury with flexion-extension radiographs or an MRI. CT may miss significant ligamentous, intervertebral disc, or spinal cord injury, therefore an MRI is highly recommended for patients with SCIWORA defined by CT imaging findings. Dynamic films may be considered but only in neurologically stable patients able to participate in the study.

The management of SCIWORA remains controversial. The majority of patients with SCIWORA show a remarkable recovery without surgical or medical intervention. These patients who experience transient symptoms rarely have abnormalities noted on MRI. On the contrary, patients with significant MRI findings such as those with high cervical lesions may require mechanical ventilation, cervical spine decompression or immobilization, and intensive level care for prolonged periods, whereas patients with SCI at the level of the lower cervical spine may require spinal decompression or immobilization and early rehabilitation. Prognosis in SCIWORA is dependent on the initial neurologic status.[117] In one study, 86% of SCIWORA patients with initial complete or severe incomplete cord injury died or maintained the initial disability, whereas 70% with mild/moderate cord injury made a complete recovery.[117]

In regard to surgical management, some authors reported improved outcomes after surgical decompression with expansive laminoplasty,[118,119] whereas others reported similar outcomes with nonoperative management.[120] In a direct comparison study, 70% of patients showed improved ASIA scores with conservative management, whereas only up to 61% of patients had an improvement after surgical intervention.[119] One limitation of the study was that the surgical group had either preexisting cervical spine conditions or a focal disc herniation necessitating decompression. Despite the controversy, some authors believe that neurologic status will improve to some extent regardless of the therapy chosen.[121]

We recommend obtaining an MRI for patients presenting with SCIWORA to rule out spinal instability or a compressive pathology. In patients with mild or resolving symptoms, conservative management with external immobilization and close follow-up may be adequate, whereas surgical decompression and stabilization should be pursued for those presenting with spinal instability or focally compressive lesions.

Acute Central Cord Syndrome

Acute traumatic central cord syndrome (CCS) typically presents in the setting of cervical trauma as an incomplete spinal cord injury with loss of motor function and sensation in the upper extremities out of proportion to that of the lower extremities. CCS typically occurs with older patients in the setting of preexisting cervical spondylosis, usually from a hyperextension injury. The resulting insult leads to preferential damage to the anteromedial spinal cord classically affecting the anterior horn cells and anterior white commissure of the cervical spine thereby causing loss of motor function and sensory disturbances in the arms and hands.

Management of acute traumatic CCS was historically conservative because neurologic recovery and patient outcomes were generally good. It was not until 1997 when Chen and associates demonstrated improved recovery after surgical decompression in younger acute traumatic CCS patients that surgery even became an option.[122] A retrospective study by Stevens and colleagues compared 66 CCS patients treated with surgery to 59 CCS patients managed nonoperatively.[123] After a mean follow-up of 32 months, an improvement in Frankel grade was noted in the surgical group compared to the nonoperative group. Systematic reviews have also recommended surgical decompression if a focal site of compression is present.[124,125] On the other hand, it must be considered that previous studies debate the benefit of surgery in comparison to conservative management.[126] Conservative management that consists of rigid external cervical orthosis, maintaining adequate systolic blood pressure, and adequate follow-up generally portended favorable outcomes; however, this population often developed neuropathic pain and spasticity, therefore controversy still exists.

The timing of surgical intervention for acute CCS is also a topic of debate. Stevens and colleagues demonstrated no statistically significant difference in outcomes between surgical intervention performed < 24 hours after injury versus > 24 hours after injury in the current hospital stay or compared to delayed surgery after hospital discharge.[127] Other studies also reported a lack of benefit for early decompression.[128] However, a study by Fehlings and coworkers has shown benefit in early decompression (< 24 hours) compared to late decompression (> 24 hours) in regaining motor strength after cervical spinal injury but is not specific to CCS.[129] Earlier studies also advocate for early decompression in favor of better recovery and neurologic outcome but again do not pertain solely to CCS.[130,131] Overall, our recommendation for the management of acute traumatic CCS is to incline toward early decompression for younger patients and those with significant neurologic dysfunction secondary to a focal compression.

Simple Compression Fractures

A compression fracture is the collapse of a vertebra as a result of axial loading forces upon a flexed spine (Fig. 128-3). Compression fractures appear as wedge deformities of the vertebral body. These injuries occur in the setting of trauma but are more common in patients with osteoporosis, lytic lesions, or congenital bone disorders such as osteogenesis imperfecta.[132]

Simple compression fractures involve the anterior superior or inferior end plates and presents with greater vertebral body height loss anteriorly than posteriorly as the anterior column fails in compression. The middle column is uninvolved and the fracture does not affect the posterior vertebral body wall. The posterior column also remains intact and the posterior ligamentous structures retain their integrity.[133] There is no subluxation or significant ligamentous disruption.

Simple compression fractures manifest with neck pain but rarely present with neurologic deficits. Simple compression fractures are stable without significant vertebral body height loss, subluxation, or focal kyphosis. Patients are generally treated conservatively with external immobilization in a cervical orthosis. Upright radiographs are obtained in the cervical orthosis to establish a baseline and to assess for instability prior to discharge. These patients typically heal after 6 to 12 weeks of external immobilization, at which point they are reassessed with flexion-extension radiographs for glacial instability.[133] Patients without evidence of motion or instability on flexion-extension radiographs are gradually weaned from external immobilization.

Burst Compression Fractures

With burst compression fractures, axial loading forces overcome the middle column disrupting the discoligamentous complex resulting in deformity and instability of the cervical spine. Burst fractures are high-energy compression fractures that involve the middle column and disrupt the posterior vertebral body wall (Fig. 128-4). Injury to the posterior cortex seen in burst fractures can result in retropulsion of bone into the spinal canal. Widening between the pedicles is also frequently observed. In these cases, the posterior ligamentous complex is often intact, but instability may ensue from significant kyphosis, vertebral body height loss, and spinal canal compromise. There is no widening of the space between the facet joints or the spinous processes to suggest posterior ligamentous complex injury as is seen in a teardrop fracture, which will be discussed later.

Burst compression fractures may present with neck pain, radiculopathy, or spinal cord injury. Treatment of burst fractures is based on neurologic as well as spinal stability. In neurologically intact patients without significant vertebral body height loss (< 40%) or kyphosis (< 20 degrees), the injury may be amenable to treatment with external immobilization in a semirigid or rigid (Halo or Minerva) cervical orthosis. Baseline upright radiographs are obtained to assess for stability and used for close follow up typically at 4 to 6 week intervals. Severe compression fractures may develop progressive kyphosis and vertebral body collapse, therefore early and close interval follow-up is indicated.

Burst fractures resulting in incomplete spinal cord injury necessitate early closed and open reduction and decompression. Ligamentotaxis from traction can partially reduce retropulsed bone fragments present in the spinal canal but rely on

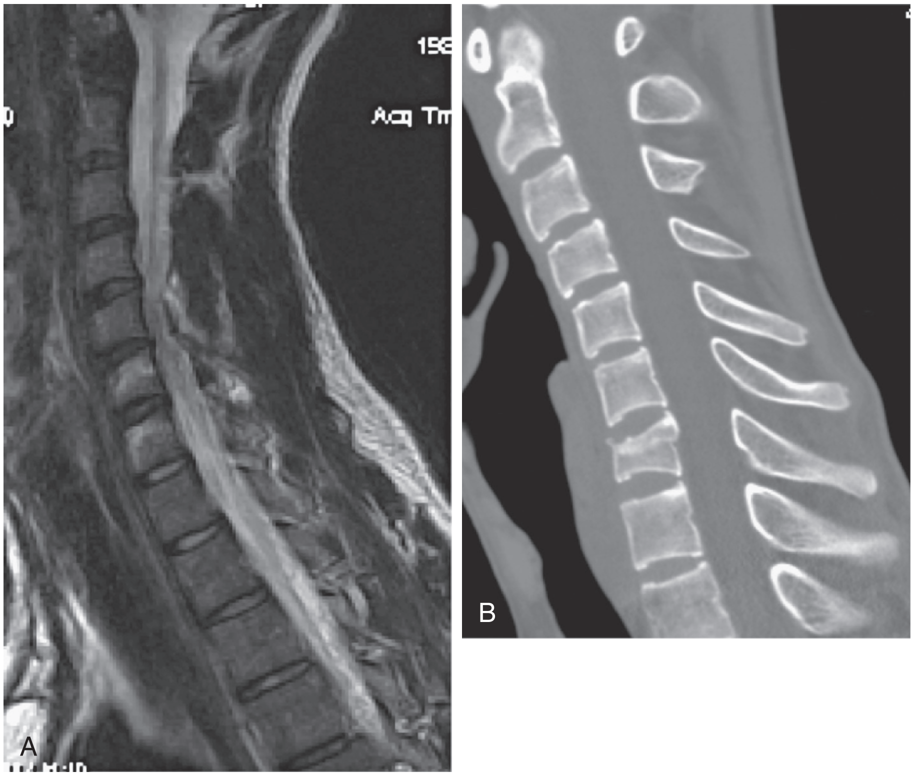

Figure 128-3. A, Midsagittal MRI of a patient with subtle compression fractures at C6 and C7, showing edema in the vertebral bodies. No ligamentous injuries are evident. **B,** Midsagittal CT reconstruction showing a compression fracture of C7. Note that the dorsal elements show no evidence of diastasis.

the competency of the posterior longitudinal ligament.[134] Certain cases of traumatic kyphosis can also be improved with the application of traction.

Data suggest that early decompression in incomplete spinal cord injury facilitates neurologic improvement.[129] The most common surgical technique to decompress the spinal canal is through an anterior approach in order to directly access and remove the intruding fragments.[135] The goal is to decompress the spinal canal by removing the retropulsed bone fragments and to reconstruct the spinal column to provide stability. This is achieved with a corpectomy and subsequent reconstruction and stabilization using ventral instrumentation.[136]

The authors recommend surgical intervention in patients presenting with complete spinal cord injury. Early decompression for complete spinal cord injury does not pertain to improved neurologic outcomes in comparison to delayed decompression, but surgical intervention may result in improvement of one to two root levels below the level of injury compared to conservative management.[135,137] Additionally, surgical decompression and stabilization can prevent delayed neurologic decline from spinal instability in complete spinal cord injury patients such as development or extension of a post-traumatic syrinx. For the aforementioned reason, the authors also recommend surgical stabilization in patients with significant vertebral body height loss (> 40%) or kyphosis (> 20 degrees) as this may result in chronic neck pain or delayed neurologic deficits in initially neurologically intact patients.[9]

Teardrop Fractures

A flexion teardrop fracture is a severe form of compression fracture resulting from a high-energy flexion and axial loading injury to the cervical spine such as in a motor vehicle accident or diving headfirst. Flexion teardrop fractures are most commonly seen at the C5-6 level. In flexion teardrop fractures the anterior, middle, and posterior columns are frequently involved with concomitant disruption of the posterior ligamentous complex (Fig. 128-5).[138,139] This injury pattern has a high rate of neurologic compromise, spinal deformity, and anatomic instability.[138] Unique radiographic findings of a teardrop fracture include injury to the anterior inferior edge of the vertebral body, associated subluxation and kyphosis, and widening of the facet joints or the spinous processes.[139]

An extension teardrop fracture is a less severe form of injury arising secondary to forced extension of the neck resulting in avulsion of the anterior inferior edge of the vertebral body at the attachment of the anterior longitudinal ligament.[139,140] Extension teardrop fractures are typically less severe than flexion teardrop fractures and present more commonly with acute central cord syndrome.[139-141] In comparison, flexion teardrop fracture frequently present with neurologic compromise in the form of anterior cervical cord syndrome or quadriplegia.

Treatment of flexion teardrop fractures is generally surgical as disruption of the posterior ligamentous complex correlates with anatomic instability. In extension teardrop fractures, injury to the anterior longitudinal ligament alone may not account for spinal instability if the disc space and posterior ligamentous complex remain intact.[138]

The goals of treatment are to decompress the spinal canal and stabilize the spine. Although rigid external orthosis may be considered in the treatment of teardrop fractures, these patients must have close follow-up to assess for development of kyphosis or neurologic deficits. A retrospective review by Fisher and associates compared external orthosis (Halo) with anterior cervical fusion for the treatment of

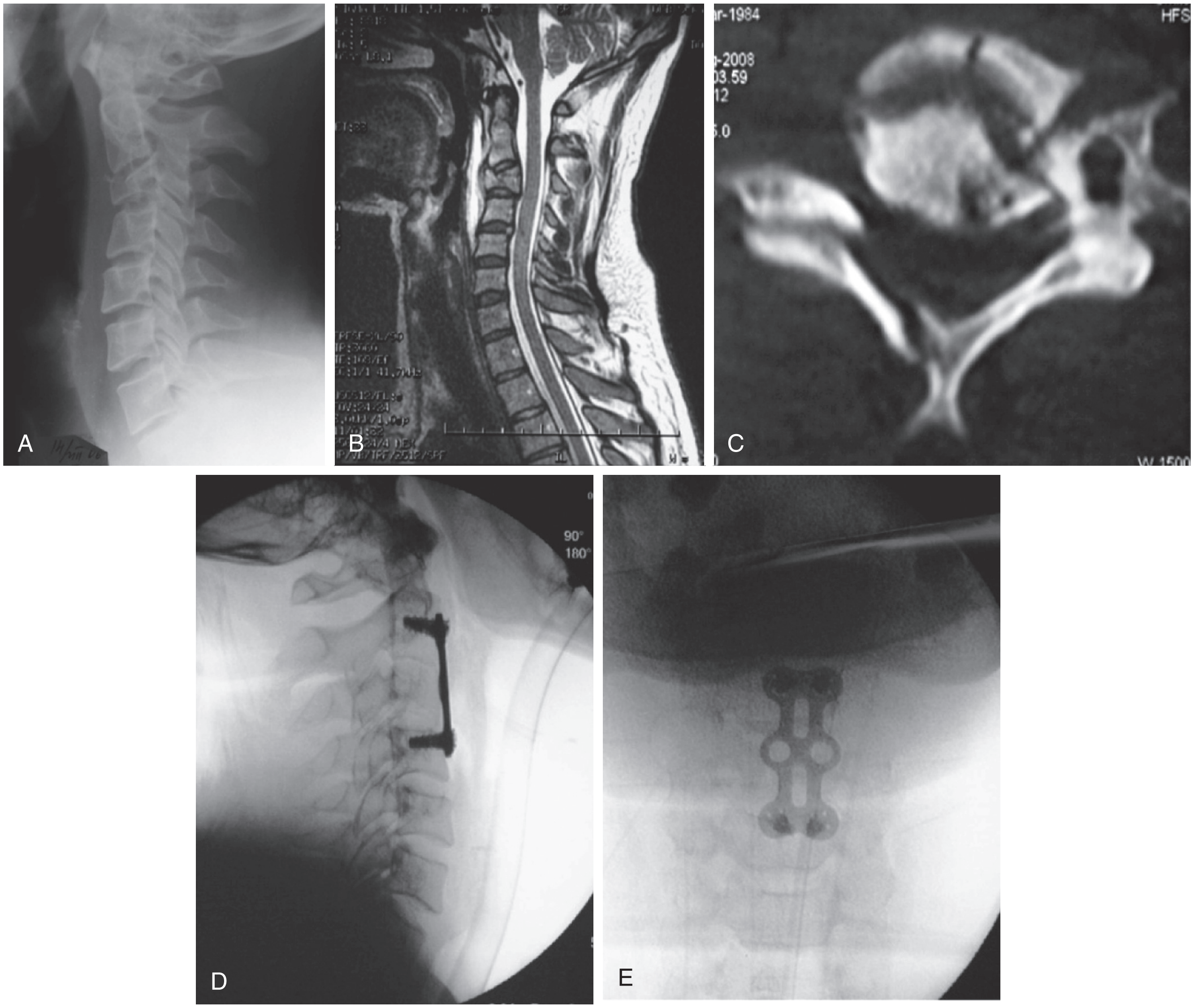

Figure 128-4. Plain radiograph (**A**), sagittal MRI (**B**), and CT scan (**C**) of a burst/axial compression injury at C3. Note retropulsion of the vertebral body on the axial CT (**C**). Although a laminar fracture is present, there is no evidence of widening of the dorsal elements on the plain radiograph or MRI. The injury was treated with a corpectomy of C3 followed by strut grafting and ventral cervical plating (**D** and **E**).

teardrop fractures and found higher rates of kyphosis in the nonoperative group and 15% of patients initially managed nonoperatively subsequently required surgical stabilization.[138] Surgical treatment of teardrop fractures may be performed through an anterior approach with a corpectomy and ventral instrumentation. Toh and colleagues reported higher rates of postoperative spinal canal compromise and longer fusion constructs in patients undergoing posterior instrumentation and fusion for teardrop fractures.[135]

Some authors have recommended the addition of posterior fixation in teardrop fractures with associated subluxation and injury to the disc space or in cases where reduction could not be achieved from an anterior approach alone.[142-144] These authors argue that injury to the posterior ligamentous complex increases the risk of delayed spinal instability and circumferential fusion is indicated in more severe forms of teardrop fractures.[142-144] In circumferential fusion, the ventral approach is performed first for direct decompression of the spinal canal and placement of a graft subsequently followed by posterior stabilization with a long segment instrumentation and fusion.

Simple Posterior Element Fractures

Simple posterior element fractures include fractures of the spinous process, lamina, lateral mass, or pedicle.[145] Although the superior and inferior articulating processes are considered part of the posterior elements, they will be discussed separately. Fractures of the aforementioned posterior elements, albeit a heterogeneous group of injuries, are considered simple because they are stable injuries when occurring in isolation.

Spinous process fractures are most commonly seen at C6 and C7 and is classically known as the "clay shoveler fracture" when occurring at C7. The mechanism of injury is hyperflexion associated avulsion of the spinous process (classic clay shoveler), hyperextension associated compression of the spinous processes, or from direct trauma.[145] Isolated spinous process fractures are considered stable and often do not need treatment in the lumbar spine. In the cervical spine, however, they are often associated with more severe injuries and thus are treated initially with external cervical immobilization.

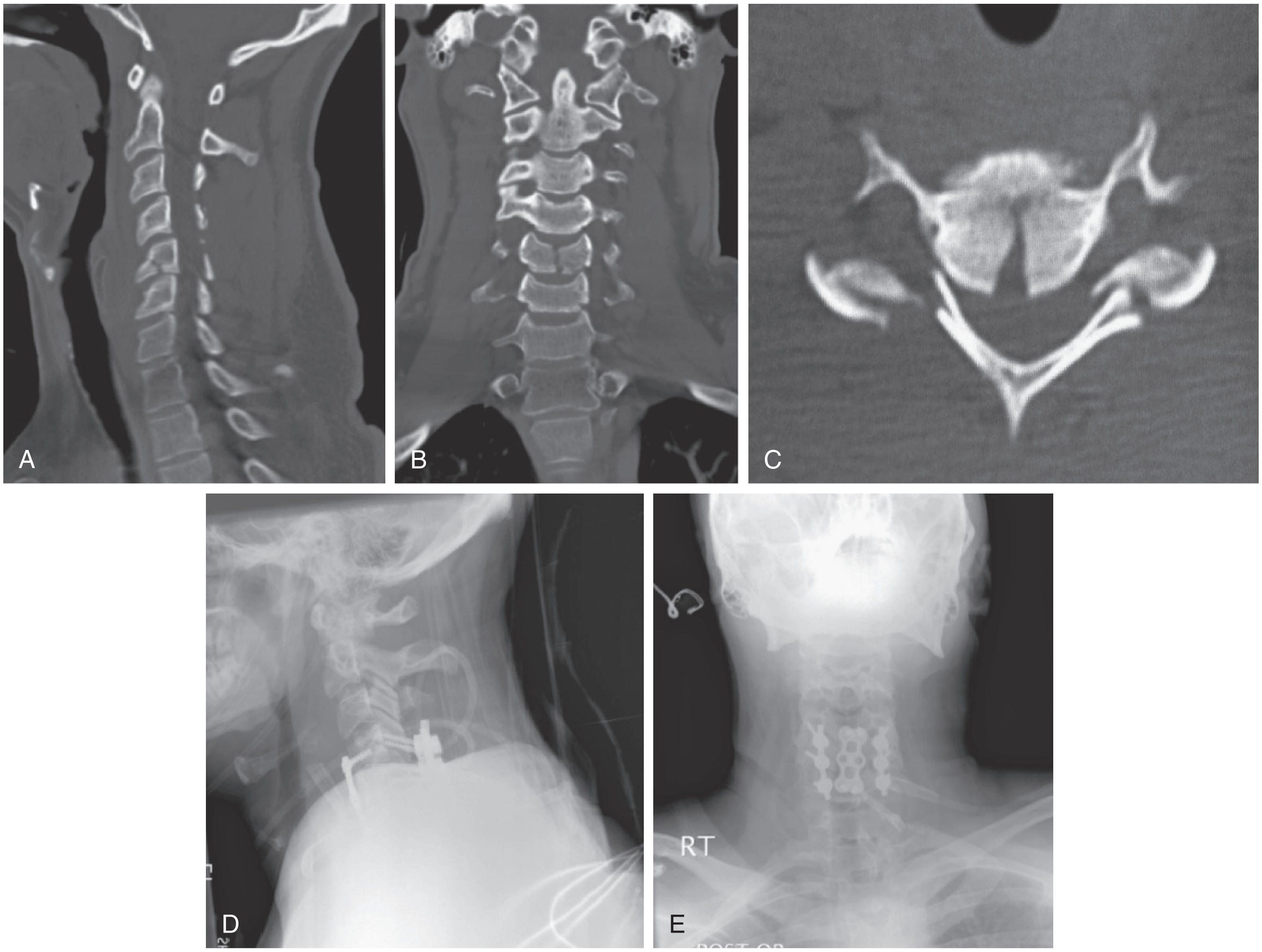

Figure 128-5. C5 teardrop fracture. A, Note the fracture of the ventral/caudal corner of the vertebral body on the sagittal CT reconstruction and the widening of the dorsal elements. **B** and **C,** Also note the sagittal plane vertebral body split on the coronal CT reconstruction and axial CT. The dorsal elements show significant comminution and displacement. **D** and **E,** The injury was stabilized by corpectomy of the C5 vertebral body with strut grafting and ventral plating, followed by dorsal stabilization with lateral mass fixation.

Flexion-extension radiographs can be used to assess for glacial instability during follow-up. Despite development of pseudarthrosis, old spinous process fractures do not need further treatment if there is no accompanying instability.[133,145]

Similar to spinous process fractures, laminar, pedicle, and lateral mass fractures are also considered stable fractures; however, they too are frequently associated with more severe injuries.[133] Fractures of the lamina, pedicle, or lateral mass are often secondary to a hyperextension or rotational injury.[140] When occurring in isolation, without evidence of posterior ligamentous complex disruption, severe comminution, or involvement of the articulating facets, these fractures may be treated with close follow-up in an external cervical orthosis.[133] Flexion-extension radiographs can be used to assess for development of kyphosis or subluxation during follow-up.

Significant evidence of motion or kyphosis is an indication for surgical stabilization.[146] This occurs more commonly in comminuted lateral mass fractures, especially if the articular facet is involved or in cases with coexistent fractures through the ipsilateral lamina and pedicle.[147] Fractures through the ipsilateral pedicle and lamina create a “floating lateral mass” (Fig. 128-6). This isolated fragment no longer allows the zygapophyseal articulations to contribute to overall cervical stability, therefore these fractures are often considered unstable.[147]

For nondisplaced fractures involving a floating lateral mass, external immobilization may be attempted. If there is evidence of subluxation or instability, surgical intervention is indicated.[146,147]

Surgical stabilization is generally performed via an anterior approach, which is the most commonly performed technique. Anterior cervical approaches have lower rates of infection and they postoperative pain, and they require fusion of only the affected levels whereas posterior approaches often require longer exposures and fusions.[133]

Facet Fractures

Facet fractures without dislocation constitute a heterogeneous group of injuries of which there remains controversy regarding the optimal management. Facet fractures are thought to arise secondary to rotational injuries in combination with either flexion or extension (Fig. 128-7).[140] Most fractures of the articulating facets are minimally displaced involving only a small component of the zygapophyseal articulation, whereas other cases can compromise a large portion of the facet. Small and minimally displaced facet fractures are often considered stable and most are adequately treated with an external cervical orthosis for 6 to 12 weeks.[133]

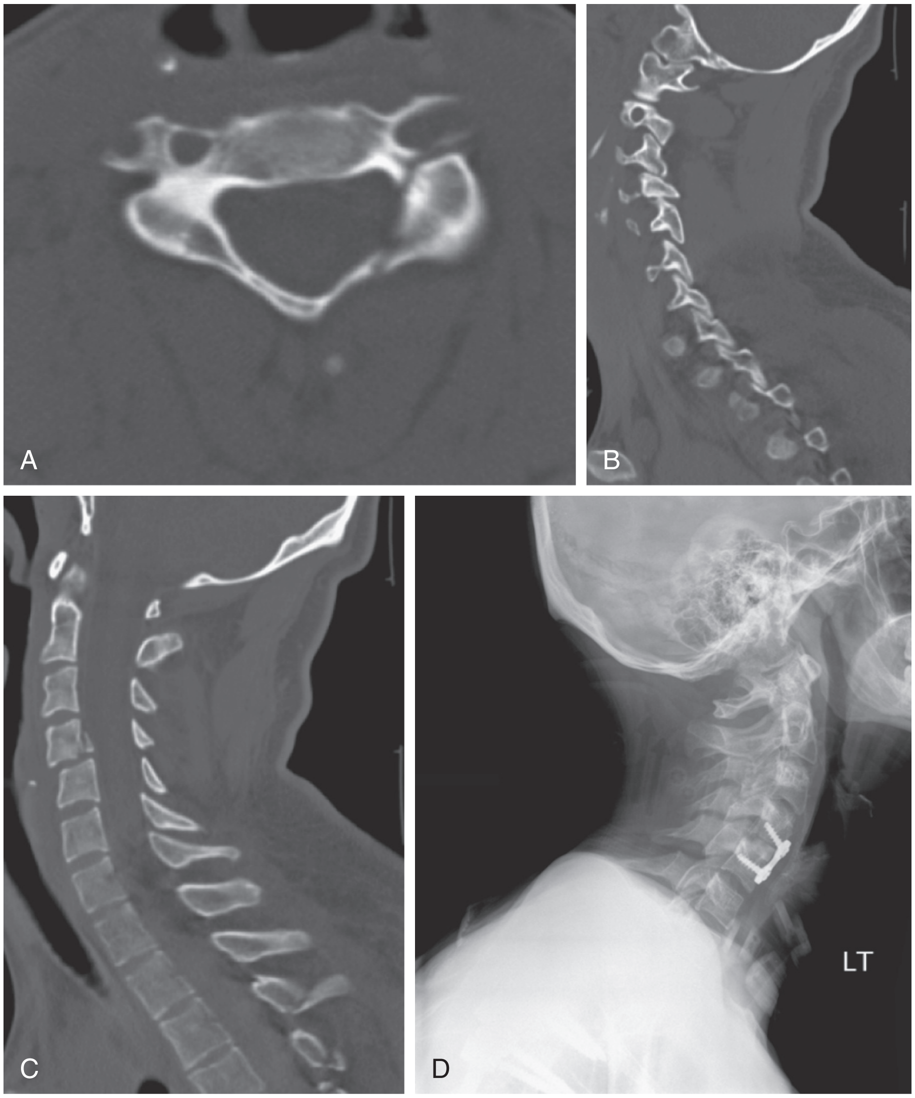

Figure 128-6. C4 fracture-subluxation with fracture of the lamina and pedicle creating a floating lateral mass (**A**). Note the disruption of the facet relationship on parasagittal CT reconstruction (**B**) and the slight kyphosis and anterior subluxation on sagittal CT reconstruction (**C**). The injury was stabilized by ventral cervical discectomy and fusion with anterior cervical plating (**D**). Use of the anterior approach allows the fusion to be limited to the C4-5 level.

In some cases, however, occult ligamentous disruption to the anterior longitudinal ligament, disc space, or posterior ligamentous complex can exist. In this scenario patients present late with evidence of kyphosis or subluxation despite lack of initial translational deformity on presentation.[148,149] It is important to closely follow patients suffering facet fractures with frequent upright radiographs (often at 2 to 4 week intervals). Although initial neurologic injury is uncommon in minimally displaced facet fractures without dislocation, radiculopathy may be present but is often self-limiting. Flexion extension radiographs should be obtained upon completion of a trial of external immobilization to ensure stability. Unrecognized ligamentous injury can result in the development of delayed neurologic decline.[148,149]

As in the case of a "floating lateral mass," there is reduced stability of the cervical spine when the zygapophyseal articulations fail. In cases of displaced facet fractures or fractures compromising a large portion of the articular facet, there is increased frequency of anatomic instability as well as neurologic compromise. Spector and colleagues studied 24 unilateral facet fractures and found that fractures involving greater than 40% of the facet or an absolute height of 1 cm were associated with increased risk of nonoperative treatment failure requiring surgical stabilization.[150,151]

MRI can be used to evaluate injury to the anterior longitudinal ligament, posterior longitudinal ligament, facet capsule, and inter-spinous ligament; however, the predictive value of MRI on failure of nonoperative therapy has yet to be published, thus the authors currently do not recommend routine MRI for neurologically intact patients with unilateral facet fractures without evidence of overt instability.

Although some authors recommend aggressive operative treatment for nearly all facet fractures, we propose judicious follow-up with upright and flexion-extension radiographs. Facet fractures with significant displacement or evidence of neurologic or anatomic instability are indications for surgical intervention.[148,149] Surgery may be performed through either an anterior or posterior approach. Anterior procedures usually consist of a single level interbody fusion with arthrodesis, whereas posterior constructs can be achieved with bilateral lateral mass screws stabilized by rods.[152] Large facet fractures may preclude the use of a lateral mass screw at the level of

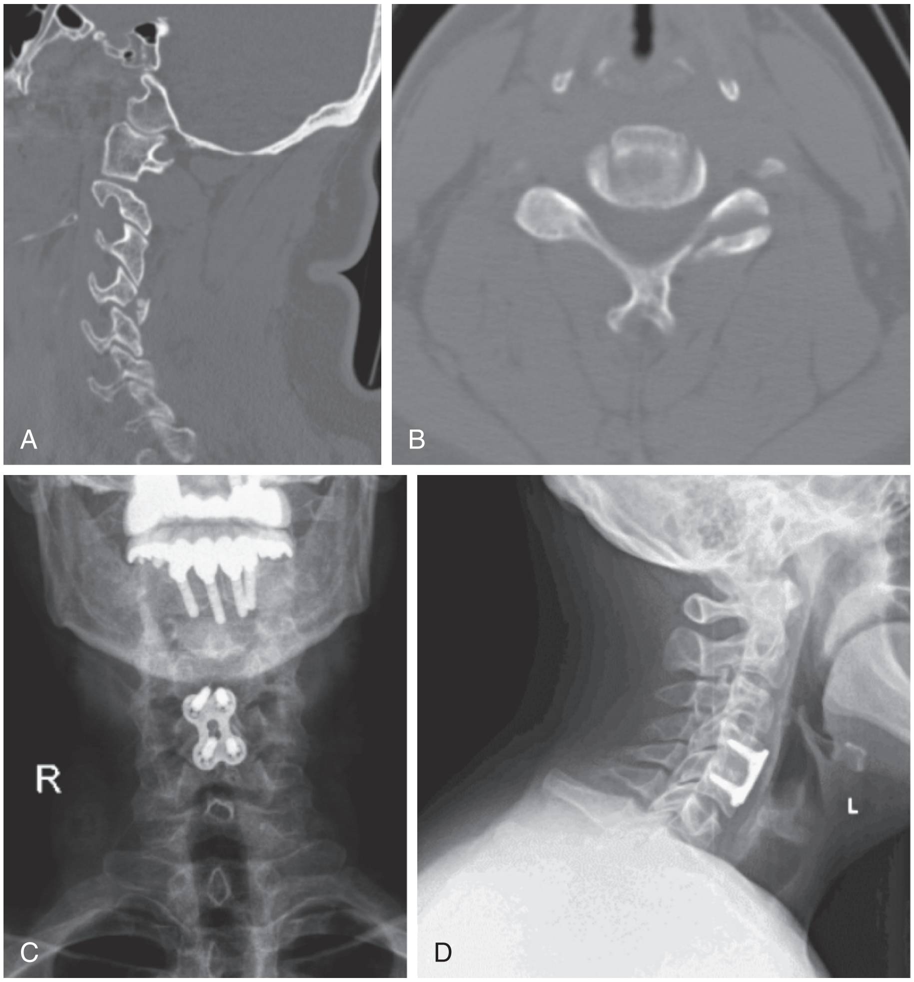

Figure 128-7. **C4 facet fracture involving a significant percentage of the inferior articular process. A** and **B,** Note that the fractured facet joint is widened and the fracture is angulated and displaced. **C** and **D,** The injury has been stabilized by ventral fusion with anterior plating.

injury in which case the screw is placed in the adjacent nonfractured lateral mass. Posterior wiring techniques may also be used but have higher rates of failure due to poor rotational control.[133,152]

The advantages of an anterior approach are higher rates of fusion, lower rates of infection, and postoperative pain; however, biomechanical studies suggest anterior fusion constructs may be less stable when there is severe dorsal disruption.[133,142,153] Despite this concern, after a 2-year follow-up, Lifeso and associates reported no postoperative pseudarthrosis using an anterior approach for the surgical treatment of facet fractures.[152] In cases of severe dorsal disruption, circumferential fusion may be indicated, but this is uncommon with facet fractures without dislocation.[142]

Facet Dislocations/Severe Flexion Distraction Injuries

Facet dislocations and flexion distraction injuries result from a severe hyper flexion injury with or without a rotational component leading to disruption of the posterior ligamentous complex.[144] Facet dislocations and flexion distraction injuries represent stages along a continuum. In lower energy injuries, a unilateral facet subluxation may be observed secondary to disruption of the facet capsule.[140] This can occur with or without associated catastrophic posterior ligamentous complex disruption and presents with less than 25% of vertebral body subluxation. Higher energy injuries produce bilateral facet subluxation, which is invariably associated with severe posterior ligamentous disruption and may result in perched or jumped facets. In contrast to unilateral facet dislocations, bilateral facet dislocations present with 50% or greater vertebral body subluxation (Fig. 128-8).[140] Although unilateral facet subluxation may produce a radiculopathy, neurologic injury is significantly more likely in bilateral facet subluxations or dislocations. High-energy flexion rotation injuries to the bony structures produce fracture dislocations, which will be discussed later.

The long-term management of flexion distraction injuries is generally distinguished between unilateral and bilateral involvement, as unilateral subluxations can occur without significant instability whereas bilateral dislocations are invariably unstable.[133] The initial management of facet dislocations is irrespective of unilateral or bilateral injury. Traction and closed reduction may be indicated for initial stabilization and early reduction in both cases when the facets are jumped.[154] As previously discussed, traction can facilitate temporary immobilization during transport as well as provide realignment and reduction of the cervical spine. This technique is commonly used in facet dislocations and fracture dislocations for early stabilization and decompression of the spinal canal but is unnecessary in mild facet subluxations.[154] Traction is contraindicated in occipital cervical dissociation or severely angulated traumatic spondylolisthesis of the axis.

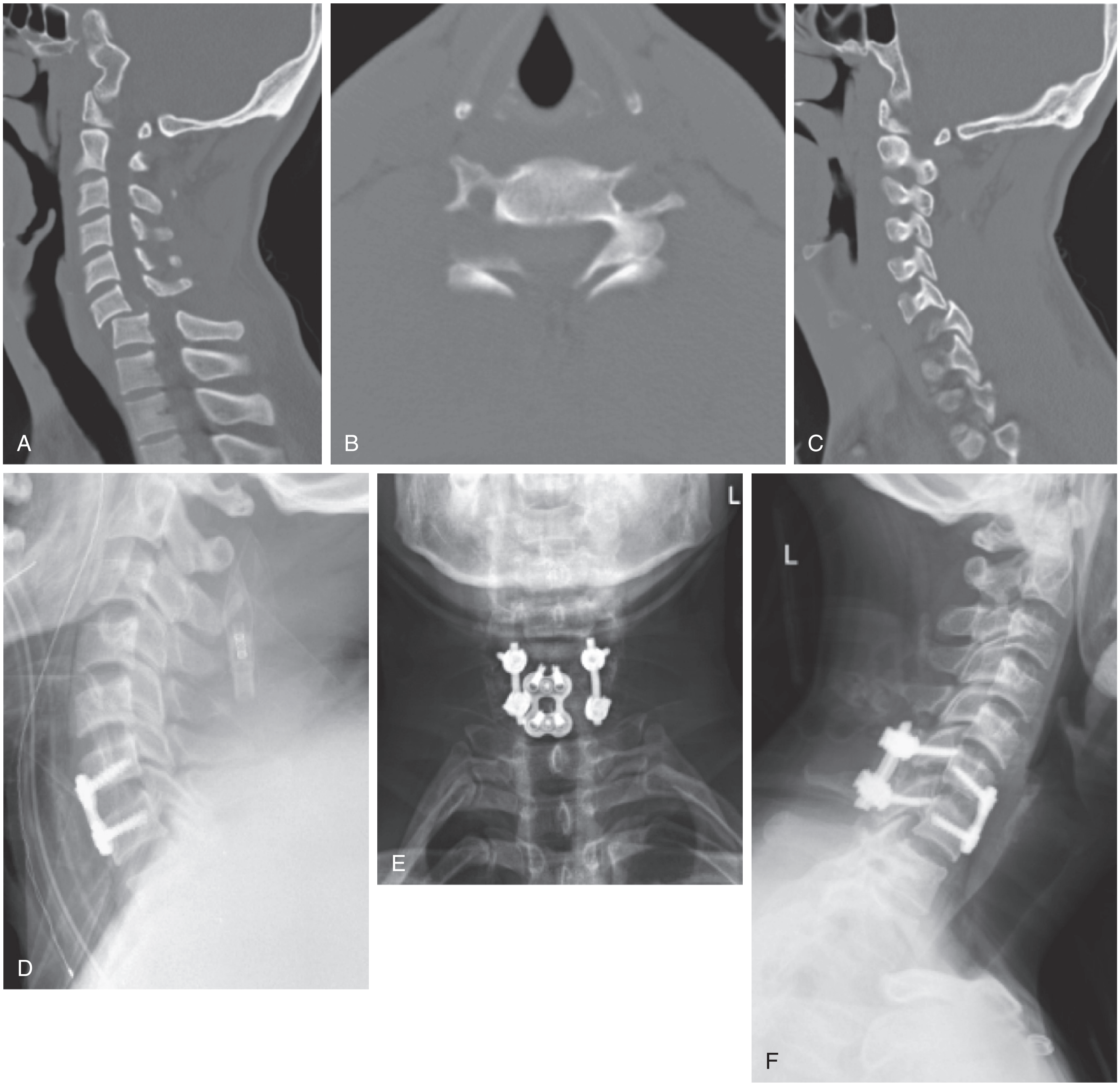

Figure 128-8. CT scans of a patient who sustained a bilateral facet dislocation (**A–C**). Note the ventral subluxation of the rostral vertebral body and the caudal articular process, which is ventral to the rostral articular process. MRI (not shown) demonstrated a large traumatic disc herniation dorsal to the C6 vertebral body. Therefore, a ventral approach was performed first to achieve decompression of the spinal cord. Next, a reduction of the facet dislocation was achieved through a ventral approach, followed by interbody grafting and ventral cervical plating (**D**). Finally, the posterior column was stabilized using lateral mass fixation (**E** and **F**).

The role of a prereduction MRI remains controversial in the literature. Although an MRI could be obtained to rule out a traumatic herniated disc, which might contribute to the risk of neurologic decline during closed reduction, it may not be necessary in an examinable patient. Grant and colleagues suggested that closed reduction can be performed safely in patients whose neurologic examination can be followed closely during the procedure.[155] Some authors have proposed performing an anterior cervical discectomy and fusion with findings of a traumatic disc; however, the advantages and disadvantages over closed reduction and decompression are not clearly established.[156]

For patients too sick to undergo surgical stabilization or for those without neurologic compromise, nonoperative treatment of mild unilateral facet subluxations or dislocations may be attempted. Although effective for milder subluxations, external immobilization is often considered inadequate for jumped or dislocated facets, therefore surgical stabilization is the basis of management especially for bilateral injury.[149,157]

In the presence of a herniated disc in association with facet dislocations, surgical reduction and decompression may be performed through an anterior approach.[158] After discectomy, a lamina spreader or Caspar pins may be used to distract the injured segments and unlock the dislocation. Irreducible injuries should be attempted with a posterior approach where resection of the superior articulating facet may be required for reduction.[159] In general, posterior instrumentation has been shown by Jenkins and associates to be more biomechanically stable than anterior constructs with restoration to the disrupted posterior tension band.[133]

The authors recommend augmentation of posterior stabilization even with successful decompression and stabilization through a ventral technique. The authors also recommend posterior reduction and stabilization over anterior approaches alone in the absence of a traumatic herniated disc. Despite the biomechanical advantage of posterior techniques, in severe cases the development of segmental kyphosis is common; therefore, circumferential fusion must be carefully considered especially in bilateral facet injuries.[142-144] A lateral intraoperative radiograph should always be obtained to confirm reduction. Care must also be taken to avoid over distraction that can exacerbate neurologic injury.

Severe Hyperextension Injuries

Severe hyperextension injuries are diagnosed when there is significant disruption to the anterior tension band resulting in significant anatomic instability. The anterior longitudinal ligament and intervertebral disc make up the anterior tension band.[133,140] When there is widening of the disc space, one should have high suspicion that the anterior tension band has been disrupted. This can occur alone or in conjunction with posterior element fractures and in rare cases may also involve the posterior ligamentous complex in which case coronal and sagittal displacement may be seen.

An avulsion of the anterior inferior edge of the vertebral body at the attachment of the anterior longitudinal ligament can be seen in extension teardrop fractures. In mild cases, extension teardrop fractures are stable; however, one should be highly suspicious of spinal instability.[160,161] An MRI may be indicated to rule out significant disruption of the intervertebral disc as these injuries are highly unstable (Fig. 128-9).

Nonoperative treatment is rarely considered in anterior tension band injuries unless the injury is across the vertebral body or the patient is too high risk to undergo surgical intervention. Severe bony hyperextension injuries occur more commonly in the elderly or in those with diffuse idiopathic skeletal hyperostosis or ankylosing spondylitis.[133,162] Surgical approaches for the treatment of anterior tension band injuries are generally performed through an anterior approach to restore stability to the anterior segment. The most common procedure performed is an anterior discectomy with instrumented fusion. Dorsal decompression and fixation can be performed to augment the surgical construct as well as decompress the spinal cord in cases of cervical stenosis or spinal cord compression.

Fracture Dislocations

Fracture dislocations are high-energy injuries associated with a very high rate of complete neurologic injury resulting in an exceedingly unstable cervical spine. Fracture dislocations develop from a combination of flexion or extension with shearing, compression, or rotational forces.[140] There is often a significant translational deformity across the site of bony injury resulting in dislocation of the bony surfaces and encroachment of the spinal canal.[163]

Fracture dislocations occur more commonly in the elderly or in those with diffuse idiopathic hyperostosis or ankylosing spondylitis. Cervical spines that are effectively fused should be considered as long bones in the setting of trauma. As in true long bone fractures, the extent of injury generally extends through the entire column. Therefore, fractures in patients with diffuse idiopathic skeletal hyperostosis or ankylosing spondylitis result in three column injuries and are highly unstable.[164]

The initial management is with immediate traction immobilization to prevent neurologic decline and early reduction in incomplete spinal cord injury.[163] Patients who have suffered complete cord injuries may not benefit from immediate

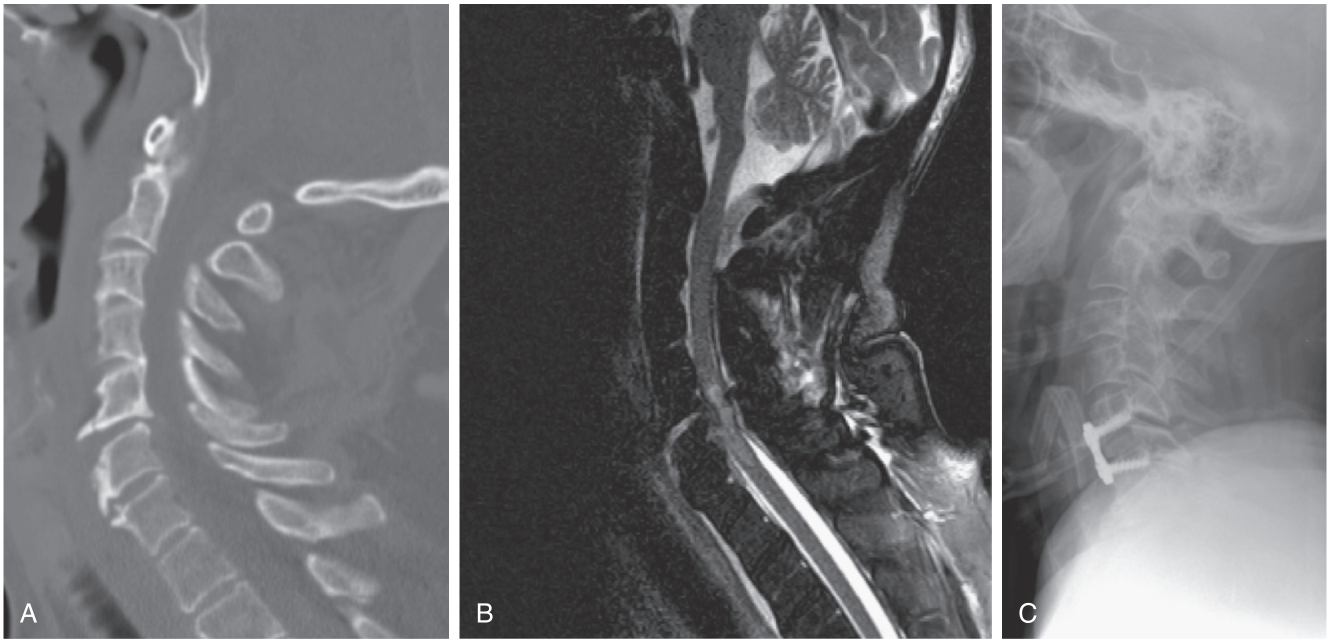

Figure 128-9. Extension-distraction injury to the C5-6 interval. Note the underlying spondylosis, creating a stiff cervical spine. Also note that the injury is less evident on the CT scan (**A**) compared with the MRI, where the abnormal signal in the disc space is evident (**B**). The injury pattern was stabilized by ventral fusion and plating of the C5-6 level (**C**).

decompression but require strict stabilization to prevent delayed neurologic decline from spinal instability.

Most patients require surgical stabilization for the treatment of fracture dislocations, although there are rare occasions when patients are medically unable to undergo a surgical procedure. In these cases nonoperative treatment requires an extended period of rigid cervical immobilization and bed rest.

Surgical indications and approaches mirror the considerations discussed in severe facet dislocations. Stabilization is most commonly performed through a posterior approach to achieve reduction and stabilization. Subluxations can be realigned under direct manipulation of the vertebra using bone clamps or elevators, but we recommend restoration of anatomic stability by delivering the appropriate forces using instrumentation hardware. Circumferential fusion must be carefully considered to prevent delayed postoperative subluxation and kyphosis.

Associated Vertebral Artery Injury

Vertebral artery injuries (VAI) were first associated with blunt traumatic injuries of the cervical spine when Suechting and coworkers described a patient who developed Wallenberg syndrome after a cervical fracture dislocation injury.[165] Fractures through the foramen transversarium, fracture dislocations, or severe subluxations are highly correlative with VAI. There is level 1 evidence to suggest patients who meet the parameters set by the modified Denver Screening Criteria should have a screening computed tomographic angiography to screen for suspected vertebral artery injury.[166]

Although the incidence of VAI is high after significant (based on Denver Criteria) cervical trauma, the clinical significant of these injuries may not be as imperative as previously thought. Many patients with VAI remain asymptomatic and most of the symptomatic strokes occur at the initial onset of injury, thus the question is raised as to whether performing routine imaging is indicated in asymptomatic patients.[167]

Traumatic VAI has the potential to cause posterior circulation stroke, although many patients remain asymptomatic despite VAI. Antiplatelet and anticoagulants to reduce the risk of stroke from VAI may be indicated in certain patient populations and must be individualized based on associated injuries, comorbidities, and their related risks. Because many patients remain asymptomatic despite VAI as well as VAI-associated strokes, there is no consensus on its treatment.[168,169] There is no class I or II evidence to support conservative management over antiplatelet or anticoagulant medications. One review noted a 31% incidence of complications associated with heparin therapy.[170] Conservative management and aspirin antiplatelet therapy appear to be comparable options for the treatment of asymptomatic patients with VAI.[171] For symptomatic patients, aspirin antiplatelet therapy appears to be safer than anticoagulation and should be considered to reduce future stroke risk.

CONCLUSION

Subaxial cervical spine fractures are common injuries following major trauma. Anatomic differences of the subaxial cervical spine differentiate it from injuries to the upper cervical or thoracolumbar spine. This heterogenous group of injuries has varying levels of spinal stability and neurologic risks; therefore, mastering the biomechanics of the spine and treatment constructs is key for optimizing treatment.

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