Chapter 4
Cervical Spine Injuries

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1 Introduction

Ten percent of the roughly 10,000 new spinal cord injuries (SCIs) sustained annually in the United States are sports related. The five most frequent sports responsible for SCI in descending order of incidence and total percentage of all SCIs are: diving (3.9%), snow skiing (0.9%), football (0.5%), surfing (0.5%), and horseback riding (0.5%). Sports-related injuries are the second most common cause, following motor vehicle accidents (MVAs), for neck-related emergency room visits. Most sports-related injuries involve soft tissue trauma such as ligament sprains, muscle strains, and soft tissue contusions. Fortunately severe cervical spine injuries are rare. However, physicians who treat sports medicine injuries are often responsible for the emergency care of such injured athletes and must know the spectrum of injuries that can occur. They must also know how to assess and manage these injuries on the field.

2 Anatomy of Cervical Spine

Compared with the relatively rigid thoracic spine and moderately flexible lumbar spine, the cervical spine is the most flexible of the three allowing significant range of motion (ROM) in all planes at the cost of relative stability, especially when the structures of the neck are stressed. The region relies heavily on ligaments and other soft tissue structures to maintain physiological ROM. The cervical spine is composed of seven vertebrae. The occipital-atlantal and C1-C2 joints together account for 34% of the available cervical flexion and extension, whereas 54% of the total cervical rotation takes place at C1-C2. Motion at this these joints, however, accounts for only 10% of lateral bending. The greatest cervical flexion and extension takes place at C5-C6 and C6-C7, whereas the greatest side bending occurs at C2-C3 and C3-C4 with relatively less motion in all planes occurring at the lowest cervical levels. Excessive pathological neck mobility is kept in check by both static and dynamic stabilizers. Static stabilizers include the following structures: the anterior longitudinal ligament (ALL), posterior longitudinal ligament (PLL), intervertebral disc, ligamentum flavum, facet capsules, interspinous ligaments, and...
supraspinous ligament. Of these, the posterior structures, PLL, ligamentum flavum, facet capsules, interspinous ligaments, and supraspinous ligament contribute more to stability in flexion; whereas the anterior ligaments, ALL, and discs contribute more to stability on extension. The major muscles that act as dynamic stabilizers of the cervical spine controlling the degree and speed of movement of the spine are the paraspinals, trapezius, sternocleidomastoid, and lateral strap muscles.

3 Stable Cervical Spine Injuries

3.1 Acute Cervical Strain Syndrome

3.1.1 Mechanism of Injury

Acute cervical strains are muscular stretch injuries that occur most commonly at the musculotendinous junction and less commonly within the muscle body itself. They are induced by mechanical overloading of the musculotendinous tissue and can often result in a tearing of the muscle or tendon. The most common muscles affected are the trapezius, sternocleidomastoids, erector spine, scalenes, levator scapulae, and rhomboids. The strained muscle overstretches while eccentrically contracting. Cervical facet mechanoreceptors provide proprioceptive feedback to neck stabilizer muscles and are thought to help instigate protective contraction of these structures at the time of strain.

3.1.2 Clinical Presentation and Diagnosis

The athlete’s first complaint after experiencing a cervical strain is local pain, tenderness, and/or weakness in the neck. The athlete is able to maintain full ROM of the cervical spine immediately after injury. The athlete complains of muscle pain that peaks several hours postinjury. However, mild strains may not manifest symptomatically until the following morning, at which time muscle soreness, swelling, and mild limitation in ROM may occur. Pain is typically exacerbated by muscle stretch. The extent of tissue damage correlates roughly with the relative limitation in ROM, swelling, and discomfort experienced 24–48 hours postinjury. This condition often accompanies a brachial plexus injury. Athletes with painful ROM of the neck should undergo flexion/extension radiographs of the cervical spine to rule out instability and fracture.

3.1.3 Treatment

Treatment is symptomatic and includes anti-inflammatory medications, rest, ice, and heat after 24 hours. For more severe strains, a soft foam cervical orthosis may be prescribed for use until the initial muscle spasm has passed, most often 7–10 days.
At this time the soft cervical orthosis can be removed and gentle active ROM initiated. Cervical isometric neck strengthening exercises may also be started. With continued clinical improvement, functional and sports-specific exercises are introduced. Although commonly prescribed, the use of a soft foam cervical orthosis is controversial. In 2000 and 2003, Rosenfeld et al. published two articles that compared active neck exercises without cervical orthosis with a protocol involving rest, soft collar use, and self-mobilization; these studies were performed in persons who had suffered whiplash injuries. The authors found that the patients whose clinical course did not involve orthosis use had less pain and fewer lost days from work.

3.1.4 Return to Play

The athlete may return to play after he or she has regained preinjury neck muscle strength, full cervical ROM, and is asymptomatic. Returning early may result in repeated cervical strains and the risk of more serious future cervical spine injury. After returning to sport, performance of a regular cervical exercise program may help prevent further injury.

3.2 Acute Cervical Sprain

3.2.1 Mechanism of Injury

Acute cervical sprains are ligamentous stretch injuries resulting from distraction injuries to the cervical spine’s ligaments and capsular structures. Hyperextension of neck with concomitant compression can produce facet joint and peri-facet joint soft tissue trauma. Numerous tears in the fascia can occur with rupture of small vessels within the soft tissues of the neck, which may ultimately result in fibrous tissue contraction and possible limitation in neck ROM. The joints of Luschka and their capsular ligaments are extremely susceptible to sprain. Acute cervical sprains may be accompanied by traumatic compression neuropathies.

3.2.2 Clinical Presentation and Diagnosis

Pain is generally limited to the neck, upper arm, or area between the scapulae. Hyperesthesia may be present from a concomitant compression neuropathy. Cervical extension ROM is often decreased. Athletes with persistent painful ROM of the neck should undergo static and flexion/extension radiographs of the cervical spine to rule out instability and fracture. An MRI of the cervical spine should be performed if there are any persistent neurological changes detected on physical exam.
3.2.3 Treatment

The treatment is identical to that for cervical strain.

3.2.4 Return to Play

The return to play criteria are identical to that for cervical strain.

3.3 Acute Cervical Disc Herniation

3.3.1 Mechanism of Injury

An acute cervical disc herniation most often occurs as a result of excessive neck flexion. The annulus of the intervertebral disc can tear with extrusion of the nucleus pulposus to tissues outside the disc. The nucleus pulposus contains proinflammatory cytokines, most notably TNF-α that can chemically irritate surrounding tissue, in addition to physically compressing neighboring structures. The ligamentous architecture of the cervical spine dictates that the most common orientation of herniation is posterior-lateral.

3.3.2 Clinical Presentation

Acute cervical disc herniation usually occurs in older athletes. However, high-performance wrestlers and football players are at especially high risk. Compression of a particular nerve root by a herniated nucleus pulposus (HNP) or chemical irritation of that nerve by this material may cause radicular symptoms with localized cervical pain. Such patients are often most comfortable with the neck in a neutral or slightly hyperextended posture; symptoms are often relieved by gentle traction. Symptoms are often reproduced by a positive Spurling’s test. In this test, the patient’s head is passively extended and laterally rotated to the side of symptoms. Gentle axial compression is then applied by the examiner. Reproduction of symptoms indicates a positive test.

3.3.3 Diagnosis

Athletes with any persistent radicular symptoms or evidence of myelopathy should undergo an MRI of the cervical spine to evaluate for nerve root or spinal cord compression.
3.3.4 Treatment

If there is evidence of cord compression with myelopathy, i.e., tetraplegia, emergent decompression is indicated; this is accomplished most often through an anterior surgical approach and usually includes removal of the offending disc and fusion of the adjacent vertebral bodies. If the patient is nonmyelopathic, then rest, NSAIDs, immobilization, cervical traction, and potentially fluoroscopically guided epidural steroid injections are indicated. In the rare event that an injured athlete with an extremely laterally oriented cervical HNP presents with only arm pain and there is no cord compression, the athlete may benefit from a less invasive microforaminotomy instead of discectomy and fusion. This is a procedure in which the affected foramen is surgically widened to relieve pressure on the peripheral nerve being compressed by the HNP.

3.3.5 Return to Play

Absolute contraindications to returning to contact sports include the following: a three-level cervical spine fusion and symptomatic cervical disc herniation. Relative contraindications include a healed and stable two-level subaxial cervical fusion. Athletes who have undergone fusion at one to two levels of the lower cervical spine are at a lower risk for further injury when returning to play than those undergoing instrumentation at higher levels as a fusion structure present in the distal cervical spine is able to absorb more force than one more proximally oriented. Players who have undergone a one-level subaxial fusion without instrumentation as well as those status-post single or multilevel posterior microlaminoforaminotomies have no contraindication to returning to contact sports participation. Observing these caveats, athletes may return to sport once asymptomatic with normal cervical spine stabilizing muscle strength and expected cervical spine mobility.

3.4 Transient Brachial Plexopathy and Radiculopathy

3.4.1 Mechanism of Injury

Transient brachial plexopathies and radiculopathies, commonly referred to as “stingers” or “burners” result from trauma to the brachial plexus or nerve roots. The mechanism of injury is traction to these neurological structures that occur when the head is forcibly laterally tilted and extended as the contralateral shoulder is depressed. They often occur at the time of a block or tackle in football. As many as 65% of collegiate football players are diagnosed with at least one career stinger; most of these players are defensive linemen. Other etiologies include compression of nerve roots in their foramina during forced lateral neck bending or a direct blow to the brachial plexus at Erb’s point. Most transient brachial plexopathies affect the
upper trunk of the brachial plexus. There is a higher incidence of transient brachial plexopathies and radiculopathies in athletes with cervical spinal stenosis. MRI evaluation of athletes with recurrent events showed that 53% had cervical spinal stenosis and 87% had degenerative disc disease. The Torg ratio is a measure of congenital spinal stenosis that has been found to correlate with transient brachial plexopathy and radiculopathy incidence; the Torg ratio is determined by drawing an AP diameter line is drawn connecting the midpoint of the posterior vertebral body line to the spinothalaminlar line. This value is then divided by the width of the vertebral body from the anterior to posterior-most parts. In a study by Meyer et al, college athletes with a Torg ratio of <0.8 were three times more likely to sustain transient brachial plexopathy and radiculopathy with cervical spine injuries involving neck compression and extension than those with a Torg ratio >0.8.

3.4.2 Clinical Presentation and Diagnosis

Transient brachial plexopathies and radiculopathies are usually always unilateral. Athletes demonstrate the inability to move the upper extremity immediately following a high-energy collision. The athlete may complain of a burning pain and/or numbness in the affected limb. As the upper trunk of the brachial plexus is the most commonly affected, the deltoid (C5), biceps (C5, C6), supraspinatus (C5, C6), and infraspinatus muscles (C5, C6) are most often impaired. Affected athletes have impaired shoulder abduction, external rotation, and arm flexion that may be delayed relative to their sensory symptoms. Symptoms usually resolve within minutes of injury. Affected athletes usually hold their necks in a slightly flexed position to relieve pressure of the damaged nerve root in its foramen. Positive Spurling’s maneuver may be found in up to 70% of affected athletes. Athletes with any persistent radicular symptoms or evidence of myelopathy should undergo an MRI of the cervical spine to evaluate for nerve root or spinal cord compression. If persistent symptoms are referable to the brachial plexus, an MRI of the brachial plexus is warranted. Electromyography may be useful for defining the extent of the injury and may help define prognosis in incidences in which signs and symptoms have persisted for more than 2 weeks.

3.4.3 Treatment

The management of transient brachial plexopathies and radiculopathies is supportive. Athletes should be restricted from play until asymptomatic. If there is significant weakness of the extremity, support of the affected arm and shoulder with a sling is indicated. Oral analgesic and anti-inflammatory medications can decrease pain. Ice and heat after 24 hours are useful adjuncts. If symptoms are persistent and no treatable cord, plexus, or spinal cord compression is identified on imaging, prescription of a formal therapy program with a goal of regaining normal ROM of the cervical
spine and the affected limb joints and normal strength of the cervical spine stabilizing musculature and affected limb muscles is warranted. It should be noted that failure to regain full cervical spine ROM may contribute to continued root irritation if this is the cause of the problem.

### 3.4.4 Return to Play

If the athlete has two transient brachial plexopathies or radiculopathies within a single season or spread out over several seasons, then the athlete has no restriction on returning to sports. The athlete can return to play the same day as long as he or she demonstrates full and pain-free cervical spine ROM and upper extremity strength. Relative contraindications to return to play in the future include the following: symptoms lasting more than 24 hours, and three or more previous transient brachial plexopathies or radiculopathies with full pain-free cervical ROM and neck strength. Continued cervical neck discomfort with impaired ROM, or any evidence of neurological deficit represent absolute contraindications to play; the athlete should not be allowed to return to play if he or she has evidence of cervical disc herniation or cervical instability. If the athlete has had one or two prior brachial plexopathies or radiculopathies each lasting < 24 hours and the current brachial plexopathy or radiculopathy does not resolve while the player is sitting out that game, then the athlete must undergo imaging. The goal of radiographic or MRI evaluation is to find an underlying anatomical lesion predisposing the athlete to repeated injury or to find a potentially treatable cause of persistent signs and symptoms.

### 3.5 Cervical Spinous Process Fracture

#### 3.5.1 Mechanism of Injury

Spinous process fractures most often occur at the lower cervical and upper thoracic levels and are often an isolated bony finding. When it affects C7, it is called clay shoveler’s fracture. Three mechanisms of injury have been described: avulsion of the spinous process following strong contraction of trapezius and rhomboid, direct hit to the spinous process, and spinous process avulsion by intraspinous and supraspinous ligaments during forced c-spine hyperextension or hyperflexion. This latter mechanism occurs only with high-velocity trauma such as in football or MVA.

#### 3.5.2 Treatment

A soft cervical orthosis can be prescribed to help limit ROM and the resultant pain, which can arise from movement. ROM should not be advised until at least 4–6 weeks after injury to allow fracture healing. Flexion and extension radiographs should be performed at that time to reassess stability.
3.5.3 Return to Play

The player can return to play if asymptomatic and there is no sagittal plane kyphotic deformity evidenced on follow-up lateral radiographs of the cervical spine.

4 Unstable Cervical Spine Injuries

Cervical instability can result from bony and/or ligamentous damage. White and Johnson et al. defined cervical instability as the inability of the neck to support the head while protecting the spinal cord or its nerve roots from disruption by the cervical column. In contact sports, instability is most often induced by axial compression with neck flexion. White determined that the adult cervical spine is unstable when at least one of the following criteria are met: all anterior or posterior elements are destroyed or otherwise rendered unable to function; > 3.5 mm of horizontal vertebral subluxation is present on lateral radiographs (resting or flexion/extension); or 11 degrees or more of angular displacement exists between adjacent vertebrae as measured on either resting or flexion/extension radiographs. When assessing cervical stability, radiographs must be taken from the occiput to the C7-T1 junction. Several additional radiological abnormalities may indicate cervical instability, including vertebral subluxation, vertebral compression fractures, and loss of cervical lordosis. Loss of cervical lordosis in itself is not a sign of instability, but it may indicate masking of underlying instability by paracervical muscle spasm. In contrast, this muscle spasm causing loss of cervical lordosis may just be the body’s attempt to minimize movement in a painful but not necessarily unstable area after trauma.

The most common cause of catastrophic cervical spine trauma is the development of an unstable cervical fracture. Mechanistically, axial force application to the top of the head decelerates the head and thereby positions the cervical spine to absorb much of the force of the oncoming body. The position of the neck at the time of impact in addition to the force of impact largely determines the type and extent of injury sustained. The physiological position of the cervical spine is in neutral with a slight lordotic posture. In this position, the posterior elements are engaged in such a way that maximizes the cervical spine’s absorption of axial compressive force. When flexed, the above mentioned lordosis decreases and the cervical spine is much more vulnerable to serious injury on axial compression. The two most common mechanisms of injury causing catastrophic cervical spinal column injuries in contact sports are compression-flexion and straight axial compression. Compression-flexion forces cause fracture of the anterior column. Flexion teardrop fractures result from hyperflexion of the subaxial cervical spine (C3-C7) and are characterized by retropulsion of the fractured vertebral body into the spinal canal. Flexion teardrop fractures are associated with posterior facet and ligamentous disruption and often accompany an anterior cord syndrome. Sometimes these
fractures are associated with complete SCI. Central cord syndrome results when the spinal cord is compressed between the vertebral body and the ligamentum flavum and/or hypertrophied facet joints; central cord syndrome is seen only in cervical spine injury and is characterized by sacral sensory sparing and more pronounced weakness in the arms relative to the legs.

A second type of compression injury results from direct vertical compression and is called a “burst fracture.” In this scenario, the intradiscal pressure increases to such a level that the vertebral body shatters. In the process, pieces of vertebral body bone may be forced backward into the canal, thereby compressing the cord. These fractures usually include at least two columns and are generally unstable and often are associated with SCI. The lower part of the cervical spine is fractured or dislocated most frequently. Fractures and dislocations in the upper cervical spine are rare; such injuries are less apt to compress the cord because the relative canal size is larger in the upper cervical spine compared with the lower. The athlete’s neurological deficits may indicate complete or incomplete cord injury. In athletics, central cord syndrome is the most common injury pattern followed by anterior cord syndrome.

### 4.1 Treatment

Treatment of unstable cervical spine fractures is usually surgical.

### 4.2 Return to Play

The presence of cervical spinal cord abnormality on MRI is an absolute contraindication to returning participation in contact sports. Torg et al. detailed the following comprehensive return to play criteria for unstable cervical fractures as described in this paragraph. Athletes with the following entities have no contraindication to returning to sports participation: status-post one level anterior cervical discectomy fusion (ACDF) without pain or neurological deficit, a healed and stable nondisplaced cervical fracture with no sagittal malalignment, and a one-level cervical fusion with full ROM and no evidence of instability, cervical disc disease, or other cervical degeneration. Relative contraindications include a healed two level fusion, prior upper cervical spine fracture, and healed one level fusion with lateral mass fixation. Absolute contraindications include the following: three level cervical fusion, status-post cervical laminectomy, history of C1-C2 cervical fusion, acute posterior element or cervical body fracture regardless of ligamentous involvement, healed subaxial spine fracture with residual kyphosis, or radiological evidence of distraction-extension on radiographic study.
4.3 Cervical Cord Neurapraxia with Transient Tetraplegia

Transient tetraplegia most often results after an impact forcing the cervical spine into hyperextension, hyperflexion, or axial loading. Affected athletes experience tetraplegic symptoms of relatively short duration that include dysesthesias, and/or weakness in both arms, both legs, or all four extremities. Individuals do not generally complain of neck pain. The clinical symptoms last for as short as 10–15 minutes and as long as 48 hours. The patient regains full function and ROM and radiographs show no evidence of fracture, but these players often have cervical canal stenosis. In individuals with a narrowed canal in the AP diameter, the pathophysiology is thought to be as follows. Hyperextension or hyperflexion of the cervical spine causes further narrowing of the canal with compression of the cord against adjacent bony or ligamentous structures. Torg et al. found the incidence of transient cervical cord neurapraxia with transient tetraplegia to be 7 per 10,000 football athletes.

4.3.1 Return to Play

In addition to cervical stenosis, other pre-existing cervical abnormalities associated with transient tetraplegia include congenital fusion, kyphosis, and disc protrusion or herniation. In addition to a Torg ratio of 0.8, congenital cervical spine stenosis is diagnosed radiographically when the spinal canal diameter is < 14 mm; this condition is thought to increase an athlete’s risk of developing cervical spinal cord trauma. Absolute contraindications to returning to play include more than two episodes of transient tetraplegia. One prior episode of transient tetraplegia injury represents a relative contraindication to returning to play. An athlete may be allowed to play again if he or she has regained full strength and painless ROM in the neck. Mild-to-moderate spinal stenosis in the athlete who has experienced transient tetraplegia also represents a relative contraindication to play.

References

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