Return to Play After Cervical Spine Injury in Sports

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Abstract
Spinal cord injuries (SCIs) resulting from sports now represent 8.9% of the total causes of SCI. Regardless of cause, there are bound to be return-to-play decisions to be made for athletes. Since catastrophic cervical spine injuries are among the most devastating injuries in all of sports, returning from a cervical spine injury is one of the most difficult decisions in sports medicine. Axial loading is the primary mechanism for catastrophic cervical spine injuries. Axial loading occurs as a result of intentional or unintentional head-down contact and spearing. Most would agree that the athlete returning to a contact or collision sport after a cervical spine injury must be asymptomatic, have full strength, and have full active range of motion; however, each situation is unique. The following review discusses the pathophysiology of these conditions and suggests guidelines for return to contact sports after traumatic cervical SCI.

Introduction
It is estimated that the annual incidence of spinal cord injury (SCI), not including those who die at the scene of the accident, is approximately 12,000 new cases or approximately 40 cases per million population in the United States each year. SCIs resulting from sports now represent 8.9% of the total causes of SCI, as compared with motor vehicle collisions, which cause 47.5% (7,15). Regardless of cause, there are bound to be return-to-play (RTP) decisions to be made for athletes. Since catastrophic cervical spine injuries are among the most devastating injuries in all of sports and the stakes can be so high for the athlete, returning from a cervical spine injury is one of the most difficult in sports medicine.

Axial loading is the primary mechanism for catastrophic cervical spine injuries. Axial loading occurs as a result of intentional or unintentional head-down contact and spearing. The normal cervical spine has a lordotic curve, allowing it to absorb shock. When the neck is flexed slightly forward, the cervical spine becomes straight. When a force is applied to the top of the head in this position, the energy is transmitted along the axis of the cervical spine, which results in axial loading. With a collision, the head is stopped and the trunk keeps moving, crushing the spine between the two. When maximum compression is reached, the spine will fail. In the laboratory, fracture or dislocation of the neck occurs with less than 150 ft-lb of kinetic energy, which is supplied easily by a running football player who possesses 10 times this energy.

Because there are no randomized control trials examining sport-related cervical spine injuries, we are left most often with expert opinion. Most would agree that the athlete returning to a contact or collision sport following a cervical spine injury must be asymptomatic, have full strength, and have full active range of motion (ROM); however, each situation is unique. The following review discusses the pathophysiology of these conditions and suggests guidelines for return to contact sports after traumatic cervical SCI.

Burners or Stingers
Burners or stingers are defined as a transient sensory and/or motor loss that occurs involving the arms and/or legs. These are usually due to an injury to the brachial plexus or the exiting nerve roots in the cervical vertebrae (18). The injury to the brachial plexus may be caused by traction, which stretches the plexus, or a direct blow resulting in compression at Erb’s point by the shoulder pads (12). The sensory deficit is characterized by tingling and burning, sometimes with numbness and pain in one or more extremities. The motor deficit may vary from most commonly a mild C5 and C6 weakness to monoplegia of an arm. Chronic stingers may result in muscle wasting. There remains controversy whether cervical disc degeneration and
stenosis or brachial plexus injury is the predominant etiology of stingers. Younger athletes with a lower incidence of cervical spine disease and those with acute symptoms may be more likely to have trauma to the brachial plexus. Those with chronic stingers at the college and professional level likely involve a cervical nerve root “pinch” phenomenon within the neural foramen (11). Because the dorsal root ganglion occupies most of the space within the foramen and lies underneath the subluxing facet, it often takes the brunt of the injury, and symptoms may be purely sensory in a dermatomal distribution. This is especially true if the athlete has had similar symptoms before. It is important to rule out a cervical spine or SCI when a stinger occurs on the field. If there are any residual symptoms, neck pain, incomplete ROM, or suspicion of a neck injury, RTP should be deferred (3,5), and especially for a first stinger, a more extensive workup, including cervical spine radiographs, magnetic resonance imaging (MRI), computed tomography (CT) scan, and electromyogram, should be considered.

Spear Tackler’s Spine
The entity of spear tackler’s spine was described originally in 1993 after careful evaluation of data from the National Football Head and Neck Injury Registry (17). Spear is the use of the top of the helmet against the opponent. Permanent neurological injury occurred in four athletes who were identified as having the following characteristic combination of abnormalities on plain cervical spine films: 1) narrowing of the cervical spinal canal, 2) straightening or reversal of the normal cervical lordotic curve, and 3) preexisting minor posttraumatic X-ray evidence of bony or ligamentous injury. In addition to these radiographic criteria, all of these players were documented as having used spear-tackling techniques.

The existence of a spear tackler’s spine, in some authors’ opinions, absolutely prohibits the return to contact/collision sports, even if the abnormality is an incidental finding because of minor complaints or symptoms. Other experts believe that although concerns should be raised, if the normal cervical lordosis is restored by treatment and the athlete refrains from any further spear-tackling techniques, then there is not a high degree of risk for injury from allowing return to athletic activity (5). Overall, there is a paucity of data to make definitive recommendations, and further study is needed in this area.

Muscular and Ligamentous Injury—Sprain/Strain
Most cervical injuries will involve a ligamentous sprain, muscle strain, or contusion. With such injuries, there is no neurological or osseous injury, and the athlete can return to competition when he or she is free of neck pain with and without axial compression, when the ROM is full, and when the strength of the neck is normal. Cervical radiographs should show no subluxation or abnormal curvatures.

It is well known that ligament damage may accompany a cervical spine injury and can occur in the absence of bony injury. Generally, this is minor and self-limited, but on occasion, it may result in progressive instability, cervical spine deformity, and SCI. There are guidelines to assist in determining ligament stability. Under normal circumstances, conditions permit very little motion between the cervical vertebrae. In cadaver studies with all ligaments intact, horizontal movement of one vertebral body on the next does not exceed 3.5 mm, and the angular displacement of one vertebral body on the next is always 11 degrees or less. Only when most of the restraining ligaments are injured or destroyed do motions in excess of this occur. In the clinical setting, measurements of the horizontal or angular displacements can be made on neutral or flexion/extension radiographs. It is important, however, to remember that the younger the athlete, the more likely there is to be physiologic ligamentous laxity, and the given criteria may not always be applicable (19).

Incipient, severe ligamentous injury in the acutely injured athlete may not be recognized because a normal degree of spinal ligamentous laxity in younger patients is accepted generally and cervical muscle spasms, which can compensate for ligamentous instability, may be present. For these reasons, when any subluxation is seen after a sports-related injury, the patient should wear a hard cervical collar, and flexion/extension films of the cervical spine should be repeated 2 to 4 wk after injury. If the films show no evidence of progression and if there is a return to normal function without pain, it is unlikely that any significant injury has occurred and the athlete can most likely return safely to his or her competitive sport.

Cervical Spine Fracture
Some bony injuries, such as spinous process fractures or unilateral laminar fractures, do not cause instability and may require no treatment or only immobilization in a cervical collar. Even the bilateral pars interarticularis fracture of C2 (hangman’s fracture) can be treated with a cervical collar if not significantly displaced. Unstable spine injuries, however, should be reduced quickly and stabilized temporarily with cervical traction using Gardner-Wells tongs or a halo ring device. Contrast-enhanced CT scan or MRI of the cervical spine may be obtained before fracture reduction to rule out the presence of retropulsed intervertebral disk material. Unrecognized retropulsed disk material has been implicated in the sudden neurological deterioration of patients undergoing reduction of their cervical fractures. Surgical treatment subsequently may be required for severe comminuted vertebral body fractures, unstable posterior element fractures, type 2 odontoid fractures, and incomplete SCIs with canal or cord compromise and in those patients with progression of their neurological deficit to higher levels of spinal cord function (13).

Any athlete with a permanent neurological injury should be prohibited from further competition; however, there are some lower intensity or noncontact sports that they may participate in safely. Those without cord injury (i.e., a normal neurological exam), however, who have stable fractures as evidenced by flexion-extension radiographs can be allowed to return to their normal daily activities. Those whose fractures require a halo vest or surgical stabilization are considered to have insufficient spinal strength to safely return to contact sports unless bony fusion and the neurological exam are shown to be normal. Even after the fracture has healed, the altered biomechanics in surrounding spinal segments and loss of normal motion may produce high risk of future sports-related injury (1).
Generally stable fractures that have healed completely will allow the player to return by the next season. If there is a one-level anterior or posterior fusion for a fracture, athletes usually are allowed to go back when the neck pain is gone, the ROM is complete, the muscle strength of the neck is normal, the fusion is solid, and there is a normal neurological exam. In any athlete with a fractured neck, proper warnings against contact or collision sports are advisable until it is certain that the patient is healed completely.

Managing athletes with traumatic spine or SCI presents unique challenges for the spine surgeon. Even in the presence of an apparently stable spine, as seen on flexion/extension radiographs, and a normal-sized spinal canal, continued participation may not be advisable. Currently, there are no experimental or clinical data to help physicians predict the stability of healed spinal fractures or fusions when they are placed under extreme degrees of mechanical stress. There is increased mechanical stress above and below fused spinal segments, and repetitive microtrauma to a stiff spine exacerbates the stress. In fact, there is no conclusive evidence that the injured cervical spine is made stronger than normal by fusion. Thus, in the absence of any objective ability to measure the degree of dynamic stress stability of the spine, any healed fracture (with the exception of chip, minor wedge/compression, isolated laminar, or spinal process fractures) and any injury that has required internal stabilization must be dealt with caution.

Where there are multilevel fusions or a fusion involving C1–C2 or C2–C3, return to contact collision sports is contraindicated, but the athlete could participate in a noncontact sport with low risk of neck injury, such as tennis or golf.

**Spinal Stenosis and Transient Quadriplegia**

While transient quadriplegia may occur after hyperextension or hyperflexion, it most commonly occurs with an axial load injury to the cervical spine (16). The symptoms are most consistent with variations of the central spinal cord syndrome (14).

Cervical spinal stenosis is known to increase the risk of permanent neurological injury (4). Firooznia et al. (8) presented three case reports of patients who became quadriplegic after only “minor trauma.” Cantu et al. (5) also discussed three transient quadriplegia cases, in which radiologic studies revealed marked stenosis of the spinal canal. Some debate exists, however, over the definition of spinal stenosis. In the past, anteroposterior (AP) diameter of the spinal canal, as measured from the posterior aspect of the vertebral body to the most anterior point on the spinolaminar line, determined the presence of stenosis. General consensus has been that between C-3 and C-7, canal widths are normal above 13 mm and spinal stenosis is present below 13 mm. Plain x-rays fail to disclose the width of the cord and are not useful when stenosis results from ligamentous hypertrophy or disc protrusion. Ladd and Scantlan (10) state that the AP diameter of the spinal canal is “unimportant” if there is total block of the contrast medium. They argue that metrizamide-enhanced myelogram is needed for the injured athlete because CT alone fails to reveal neural compression adequately. Thus, spinal stenosis cannot be defined by bony measurements alone. “Functional” spinal stenosis, defined as loss of the cerebrospinal fluid (CSF) around the cord or, in more extreme cases, deformation of the spinal cord, whether documented by CT, MRI, or myelography, is a more accurate measure of stenosis (2). The term functional is taken from the radiologic term functional reserve as applied to the protective cushion of CSF around the spinal cord in a nonstenotic canal (9). In the data from the National Center for Catastrophic Sports Injury Research, cases of quadriplegia without spine fracture have been seen only when functional spinal stenosis is present (2). Also, complete recovery of neurological function after initial neurological deficit, after spine fracture, or after dislocation has been seen only in the absence of functional spinal stenosis. When presented with an athlete with cervical spinal stenosis, it is important to determine the mechanism of injury causing transient or permanent neurological deficit. Eismont et al. (6) stated that such athletes are “remarkably susceptible to hyperextension injuries known to produce maximal narrowing (up to 2 mm) of the ventrodorsal diameter of the spinal canal.” Torg noted that hyperextension causes “an inward indentation of the ligamentum flavum,” which can compress the cord (16).

For an athlete who has experienced transient quadriplegia and has never had a previous episode, there are criteria that can determine return to contact sports. There must be complete neurological recovery and full range of cervical spine movement. The spinal canal AP diameter should be normal at all levels, and there should be no CT or MRI evidence of functional stenosis or ligamentous injury. What if the imaging shows a minimal abnormality that may not have caused the temporary neurological deficit such as a small herniated disc? Again, if the neurological exam has returned to normal, then RTP can be considered. Contraindication for return include a stenotic canal with AP dimension less than 13 mm, functional stenosis on CT and MRI (loss of CSF space around the cord), cord compression, or edema. It is important to understand that normal canal size on lateral radiograph does not preclude the possibility of functional spinal stenosis, which is a contraindication for return.

**General Considerations**

In general, athletes can return to contact sports after cervical spine injury if they are asymptomatic with full ROM, they regain preinjury neck strength, and their imaging shows no evidence of “functional” spinal stenosis including a normal lordotic curvature, no evidence of disc disease, and no evidence of instability.

No contraindication to RTP:

- Healed fractures including healed C1 or C2 fracture with normal cervical spine ROM, healed subaxial fracture without sagittal plane deformity, asymptomatic clay-shoveler’s (C7 spinous process) fracture.
- Congenital conditions including single-level Klippel–Feil anomaly not involving C0/C1 articulation, spina bifida occulta.
- Degenerative or postsurgical conditions such as cervical disc disease treated successfully with only occasional neck stiffness and pain and no changes in
baseline neurological status. This may include a single-level anterior cervical fusion (ACF) with/without instrumentation and single or multiple level posterior cervical laminotomy.

- Less than three episodes of a stinger lasting <24 h with full cervical ROM and no neurological deficit.
- One episode of transient quadripareis with full cervical ROM, normal neurological exam, normal spinal reserve, and no radiographic instability.

Relative contraindication to RTP:

- Prolonged symptomatic burner/stinger or transient quadripareis lasting >24 h.
- Three or more stingers or two episodes of transient quadripareis. The patient must have full return of cervical ROM, normal strength, and no baseline discomfort.
- Healed one- or two-level ACF or posterior cervical fusion (PCF) with/without instrumentation.

Absolute contraindication to RTP:

- Previous transient quadripareis with a history or neurological exam findings of cervical myelopathy, continued neck discomfort, reduced ROM, or neurological deficit from baseline after c-spine injury.
- Following certain operation including C1–C2 fusion, cervical laminectomy, or a three-level anterior or posterior cervical fusion.
- Soft tissue injury such as asymptomatic ligamentous laxity (>11 degrees of kyphotic deformity compared with cephalad or caudal vertebral functional unit; C1–C2 hypermobility with anterior dens >3.5 mm (adult), >4 mm (child); symptomatic cervical disc herniation).
- Other conditions including spear tacklers spine, multilevel Klippel-Feil anomaly, healed subaxial fracture with sagittal kyphosis, coronal plane abnormality, or cord encroachment; ankyllosing spondylitis; rheumatoid arthritis with spinal abnormalities; spinal cord abnormality, Arnold Chiari, basilar invagination, occipital-C1 assimilation, and C1-C2 fusion.

Conclusion

RTP after a cervical spine injury is complicated, often controversial, and patient specific. There is no universally accepted RTP criteria. The decision to return an athlete to a sport after a cervical spine injury must be individualized based on mechanism of injury, anatomical site, imaging studies, and the athletes’ recovery response. The suggestions made in this article should provide a starting point for these discussions between the athlete and physician.

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References