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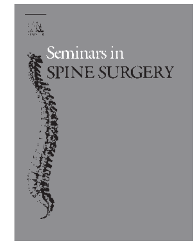

Compressive Flexion and Vertical Compression Injuries of the Subaxial Cervical Spine

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ABSTRACT

Cervical spine injury is a common cause of mortality and morbidity in young adults. This manuscript focuses on compressive flexion (CF) and vertical compression (VC) injuries of the cervical spine. CF injuries vary from mild blunting and wedging of the vertebral body to severe teardrop fracture dislocations with retrolisthesis and posterior ligamentous disruption, whereas VC injuries range from simple end plate fractures to severe burst fractures with retropulsion of fragments into the canal. Neurologic injury and instability from the injury will determine the treatment selected. Surgery for severe CF and VC injuries usually requires anterior decompression with vertebral column reconstruction.

Injury to the cervical spine is a common cause of mortality and morbidity in young adults, resulting in significant disability and loss of productivity. Cervical spine fractures are observed in 2%-3% of all blunt trauma patients.[1] Subaxial cervical spine fractures constitute two-thirds of all cervical spine fractures,[2] and the sixth and seventh cervical vertebra together account for 39% of all cervical spine fractures.[1]

The annual incidence of spinal cord injury in the United States is 40 per million, with 12,000 new cases each year. More than half of these patients sustain injury to their cervical spinal cord, with considerable personal disability and at substantial socioeconomic cost.[3] Improvements in on-site treatment of injury, better diagnostic modalities, early surgical treatment, and specialized spinal rehabilitation facilities have all led to an overall improvement in outcome following these injuries.

1. Classifications

Injuries to the cervical spine have traditionally been classified based either on the mechanism of injury or on the radiographic findings. One of the earliest classifications based on the mechanism of injury was proposed in 1960 by Whitley and Forsyth.[4] Injuries were classified as either flexion, extension, or combined. Flexion injuries were further divided into those with or without compression. This classification tried to differentiate between mechanisms of injury based on radiographs, but did not consider ligamentous injuries and instability, or clearly distinguish between grades of injury.

In 1970, Holdsworth[5] came up with a unified classification for cervical, thoracic, and lumbar spine, again based on the mechanism of injury. This classification was one of the first to recognize posterior ligamentous injury and its contribution to stability. He classified injury mechanisms as pure flexion, flexion-rotation, extension, vertical compression, and direct shear force, and further classified these injuries as stable or unstable. Loss of vertebral body height of >50% was considered a sign of posterior ligamentous disruption and was classified as unstable. This classification did not consider unique morphologic characteristics of the cervical spine. Holdsworth also described the patterns of neurological injuries associated with spine injuries but did not incorporate this aspect into his classification.

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Marar[6] in 1974 tried to correlate neurological pattern with the mechanisms of injury. He classified cervical spinal injuries into 5 groups based on the neurological pattern. Group I had complete cord injury, and as postulated by him, resulted from bilateral facet dislocations and burst fractures. Group II consisted of central cord syndrome pattern and occurred mainly in hyperextension injuries. Group III had an anterior cord syndrome pattern, and were seen most commonly in vertical compression (burst) injuries and teardrop fractures. Group IV included partial motor loss with intact sensory system. This group included cases with minimal canal compromise, for example, unilateral facet dislocation. Group V had Brown-Sequard syndrome and were rare. Although this classification was among the first to incorporate neurological pattern in the contemporary understanding of mechanistic classifications, there was a lot of overlap in the groups, and the classification did not provide any guidelines for planning treatment.

The most comprehensive and most widely used classification of indirect injuries to the cervical spine is that of Allen et al.[7] Injuries are grouped into 6 major mechanistic categories based on the 4 "cardinal" force vectors—flexion, extension, compression, and distraction. The 6 types, namely, compressive flexion (CF), vertical compression (VC), distractive flexion, compressive extension, distractive extension, and lateral flexion are further subdivided into stages based on the proposed spectrum of injury. The risk and severity of neurological injury increased with increasing stage in each type of injury, and the classification has been shown to be a good predictor of neurological outcome.[8] This classification gave us a systematic way of grouping injuries, which were earlier given varied names such as burst fractures, teardrop fractures, or wedge fractures. The deficiencies of the Allen et al classification are that force vectors are considered predominantly in 1 plane of motion, and rotational injuries are not included in the classification. The classification contains a spectrum of relatively more severe injuries and may be inadequate in dealing with more subtle injuries seen in hyperflexion sprain,[9] Clay-shoveler fractures, or injuries in spondylotic or ankylosed spines.

Later in 2006, Moore et al[10] proposed a morphologic classification based on 4 anatomic "pillars" in the cervical spine—anterior column, posterior column, right lateral column, and left lateral column. Stability was quantified by a "cervical spine injury severity score," which was hypothesized to direct treatment decisions. Each of the 4 columns was given a visual analog score from 0 to 5, taking into account both bony and ligamentous injuries. Adding the 4 scores resulted in a composite score between 0 and 20, with 20 being the most severe injury. Thus, the limitations of a descriptive classification of not aiding in treatment were overcome to some extent by the scoring system.

The subaxial cervical injury classification system by Vaccaro et al[11] is a new system, which includes 3 major injury characteristics—injury morphology, the status of the discoligamentous complex, and the neurological status of the patient. The authors believe that the ligamentous injury and the neurological status of the patient are essential for treatment decision making. A higher score (5 or more) (Table 1) indicates more severe injury and warrants surgical treatment. All 3 "axes" of this scoring system showed good to excellent reliability and validity, except for the discoligamentous injury, which had a lower inter- and intrarater agreement.[13]

Table 1 – The Subaxial Cervical Injury Classification (SLIC) System by Vaccaro et al[11]

	Injury Characteristics Points
Morphology	
No abnormality	0
Compression	1
Burst	+1 = 2
Distraction (eg, facet perch, hyperextension)	3
Rotation/translation (eg, facet dislocation, unstable teardrop or advanced staged flexion compression injury)	4
DLC	
Intact	0
Indeterminate (eg, isolated interspinous widening, MRI signal change only)	1
Disrupted (eg, widening of disk space, facet perch or dislocation)	2
Neurological status	
Intact	0
Root injury	1
Complete cord injury	2
Incomplete cord injury	3
Continuous cord compression in setting of neurodeficit (neuromodifier)	+1

2. Mechanisms of Injuries

Spinal fractures and spinal cord injury are more common in white men aged 15-30 years, in individuals from lower socioeconomic strata, with lower educational levels and in those who exhibit high-risk behaviors.[14] Motor vehicle accidents, diving accidents in shallow water, fall from a height, sports injuries, and direct injuries are frequently associated with injury to the cervical spine. Sports-related spine injuries are known to occur in football, ice hockey, wrestling, diving, skiing and snowboarding, rugby, and baseball.[15]

3. Specific Characteristics of CF and VC Injuries

CF Injuries

CF injuries involve a compressive force vector in a flexed cervical spine, which, in severe cases, can secondarily create an anteroposteriorly directed vector acting like a shear force driving the posteroinferior margin of the fractured body into the spinal canal (Fig. 1). The anteroinferior portion of the body breaks off in this process and forms a triangular fragment, frequently known as the "teardrop fracture,"[16] as seen in the