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REVIEW

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Assessment of trauma in the subaxial cervical spine by the first contact physician

Valoración de traumatismo en columna cervical subaxial por el médico de primer contacto

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ABSTRACT

Subaxial cervical spine traumatic injuries represent a problem with high medical, social, and economic impact for health systems which is increasing with changes in the increasingly urbanized lifestyle, therefore, the use of diagnostic tools in a protocolized way, correct clinical assessment, multidisciplinary management, and adequate treatment by the spine specialist doctor have a positive impact in the short and long term. Considering the challenge of always having a spine surgeon available, a narrative review of the literature in the databases Google Academic, PubMed, with MeSH terms: Cervical spine, Spinal Injuries, ligament injury, Vertebral artery injury, Subaxial cervical spine injury classification system, is performed as an aid for the first contact physicians, allowing them to optimize resources, materials and diagnostics, to positively impact on the reduction of complications due to failure to detect traumatic injuries of the subaxial cervical spine.

Keywords: Cervical spine, spinal injuries, ligament injury, vertebral artery injury, subaxial cervical spine injury classification system.

RESUMEN

Las lesiones traumáticas de columna cervical subaxial representan un problema con alto impacto médico, social y económico para los sistemas de salud, que va en aumento con los cambios en el estilo de vida cada vez más urbanizado, por lo cual, el uso de herramientas diagnósticas de manera protocolizada, la correcta valoración clínica, el manejo multidisciplinario y el tratamiento adecuado por el médico especialista en columna tienen un impacto positivo a corto y largo plazo. Teniendo en cuenta la dificultad de contar a todo momento con un cirujano de columna, se realiza una revisión narrativa de la literatura en las bases de datos Google Académico, PubMed, con términos MeSH: Cervical spine, Spinal Injuries, ligament injury, Vertebral artery injury, Subaxial cervical spine injury classification system, *a modo de ayuda para el médico de primer contacto, permitiéndole así optimizar los recursos, materiales y diagnósticos, para impactar de manera positiva en la disminución de complicaciones por no detectar lesiones traumáticas de columna cervical subaxial.*

Palabras clave: *Columna cervical, lesiones de la columna vertebral, lesión de ligamentos, lesión de la arteria vertebral, sistema de clasificación de lesiones subaxiales de la columna cervical.*

Introduction

Changes in lifestyles in society and current urbanization are predisposing factors for high-energy trauma that cause bone-ligament injuries of the C3-C7 subaxial spine, occurring in 2 to 3% of general trauma; injuries can range from ligament strains to fracture-luxations, resulting in serious spinal cord injury (SCI); subaxial cervical spine is particularly vulnerable to traumatic injury due to its considerable mobility and proximity to the rigid thoracic spine, this region accounts for

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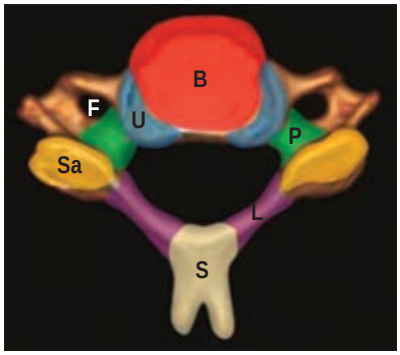
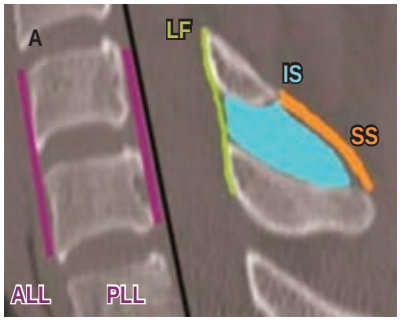
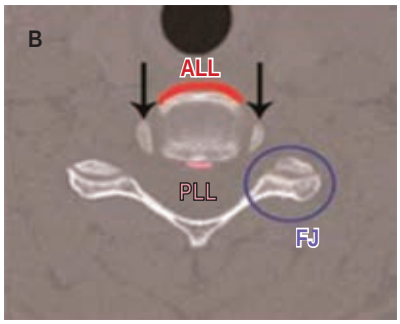
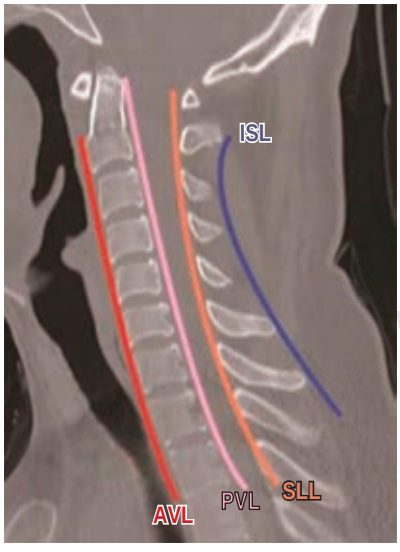


Typical cervical vertebra anatomy. Vertebral body (*B*) is anteriorly located (*red*)-cylindrical in shape, pedicles (*P*) are directed posterolaterally (*green*), laminae (*L*) are directed posteromedially (*purple*) and give rise to spinous process (*S*) with bifid tip (*light yellow*). Vertebral canal is triangular. Transverse processes contain vertebral foramen (*F*) and vertebral artery passes through it. Lateral masses are seen at the junction of pedicle and lamina-contains the articular facet at the superior (*Sa, orange*) and inferior aspect. Uncinate process (*U*) arises from the posterolateral corner of the vertebral body's superior surface (*blue*)





Colour-coded schematic shows disco-ligamentous complex and spinal motion segment. **A)** Spinal motion segment consists of two adjacent vertebrae connected together by the joints and ligaments. Ligamentous restrainers from anterior to posterior include: anterior longitudinal ligament (*ALL*), intervertebral disc, posterior longitudinal ligament (*PLL*), ligamentum flava (*LF*), interspinous (*IS*) and supraspinous (*SS*) ligaments. Intervertebral disc, facet and uncovertebral joints stabilise the motion segment. **B)** Axial CT image shows the stabilising ligaments, ALL and PLL, the facet and the uncovertebral joints. Uncinate processes (*black arrows*) are in symmetrical, concentric relationship at the posterolateral aspect of the cranial vertebra. The facet joint (*FJ*) on axial image resembles a «hamburger bun» with the flat surface articulating



Normal alignment of the spine as seen on mid-sagittal CT: anterior vertebral line (*AVL, red*)-connecting the anterior cortices of the vertebrae; posterior vertebral line (*PVL, pink*)-connecting the posterior cortices of the vertebrae; spinolaminar line (*SLL, orange*)-connecting the base of the spinous processes at the spinolaminar junction; interspinous line (*ISL, blue*)-connecting the tips of the spinous processes. All of these lines should be gently curved, smooth and continuous

Figure 1:

Computer tomography, shows principle anatomic structures.
Taken from: Raniga SB, et al.[4]

approximately 65% of fractures and more than 75% of all spinal dislocations, with an annual incidence of 150,000 cases in North America, of which 11,000 have SCI to some degree.[1,2]

The sixth and seventh cervical vertebrae together account for 39% of all cervical spine fractures. The most common causes are car accidents (41%), falls (27%), violence (15%), sports (8%), and trauma from a heavy object falling on the head (3%). SCI is seen in 1.3% of all blunt trauma; eighty percent of patients with associated SCI are men and 40% are between 18 and 44 years old. The C5-C7 region contributes 60% of all disc-ligament injuries; talking about SCI, incomplete tetraplegia is found in 40% of patients, complete paraplegia is reported in 22%, incomplete paraplegia in 22% and complete tetraplegia in 16%.

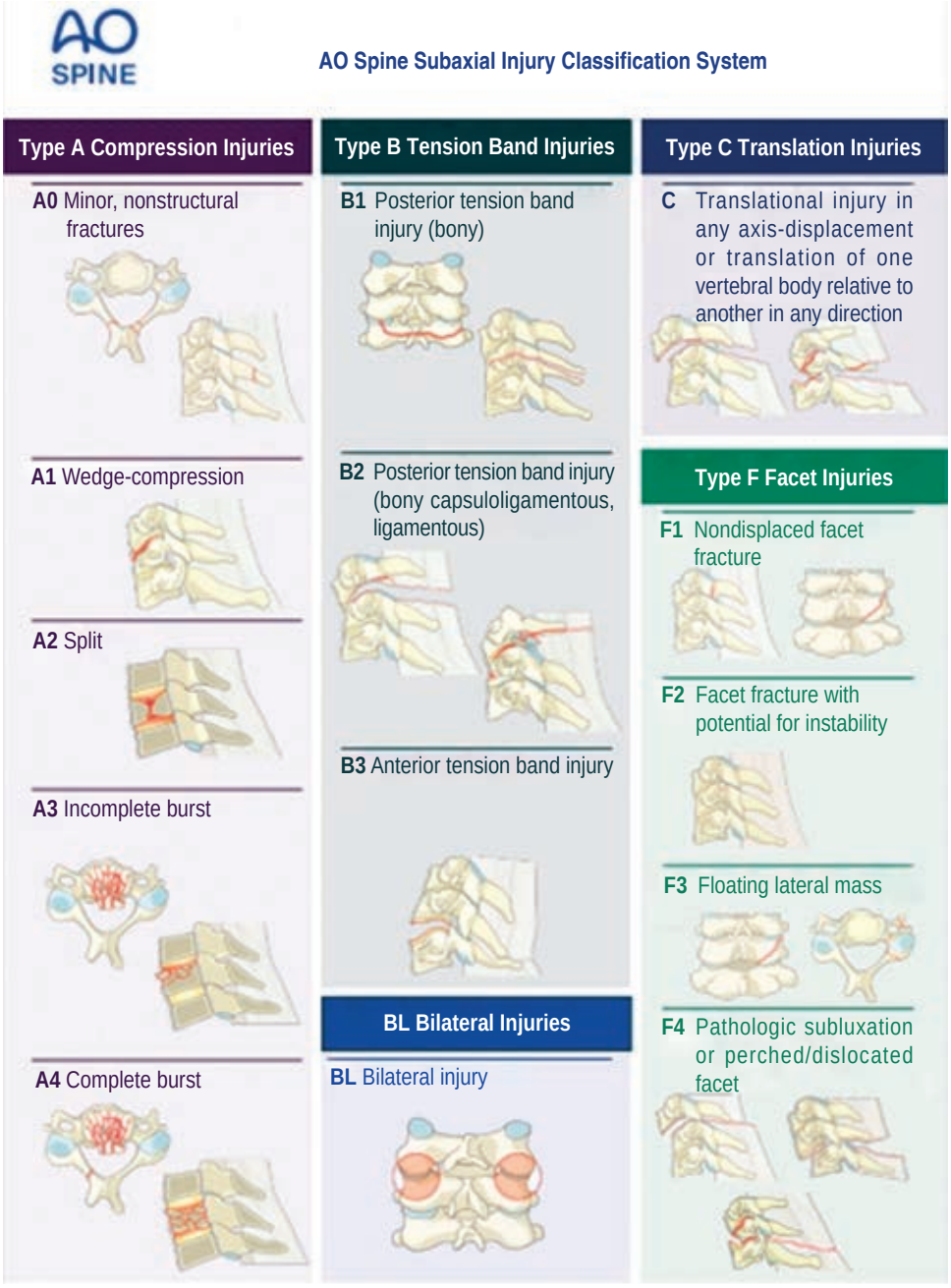


Figure 2:

AO spine subaxial injury classification system.

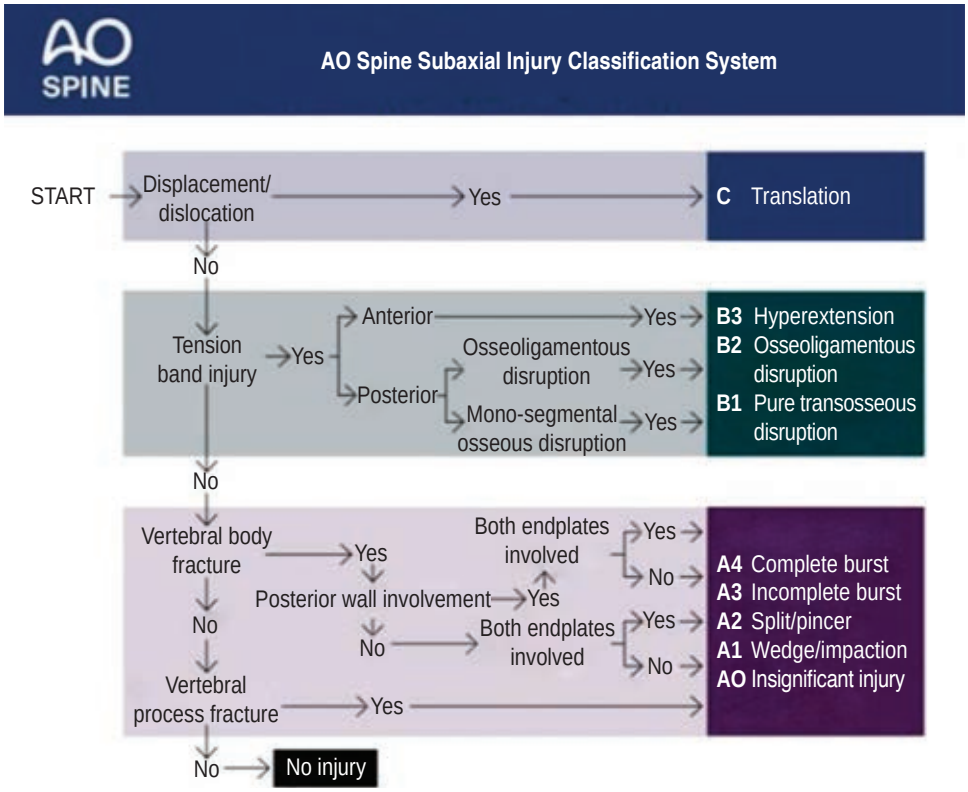


Figure 3:

AO Spine subaxial injury algorithm classification.

Totally, the mortality rate for cervical spine injuries is approximately 6%, therefore, the timely diagnosis of these injuries is vital in the short, medium, and long term with important medical and economic repercussions.[3]

1. **Radiographic anatomy assessment.** The initial evaluation of every patient with subaxial spinal trauma requires knowledge of bone structures and their anatomical relationships, which can determinate the severity of the injury. Radiographic anatomy is essential in the emergency department for making decisions *(Figure 1)*.[4]
2. **Classification.** The need to have a consensus in diagnosis, treatment and prognosis leads to the application of multiple scales, which have been improved with imaging studies advances and knowledge of trauma mechanisms. The variety in management trends by geographic regions predisposes a problem, because there was no information about the diversity of trauma mechanisms, availability of diagnostic and economic resources for treatment, therefore, AO Spine Knowledge Forum Trauma (AOSpine) validated the application of the scales;[5] several studies compare the AOSpine vs Allen Ferguson scales[6,7] with a kappa greater than 0.75 interobserver and intraobserver, all of them in favor of the AOSpine classification, which has presented a constant improvement adding facet components and special modifiers, which guides us in treatment and prognosis in a standardized way *(Figures 2 to 4)*.[8-11]
3. **Associated injuries assessment.** Subaxial cervical fractures can be accompanied by other injuries, such as traumatic brain injury (TBI) in 18 to 40% of cases, ligament, bone, joint, vascular and nerve, for this reason we emphasize adequate emergency assessment.[12]

The facet joints by themselves are considered a vital element in deciding criteria of severity; retrospective studies average normal values of inter facet space of less than 2 mm, as well as a maximum of translation in dynamic studies of 2 mm with 11 degrees of opening between a vertebral body and de adjacent body, in case of presenting higher values, there is the possibility of hidden disc-ligament injury.[13,14]

The presence of facet fractures generates the need to complement with diagnostic studies like computed axial tomography (CT), magnetic resonance (MRI) or diagnostic studies for the search of associated vascular injury, according to a survey directed at orthopedists and neurosurgeons, it was reported that, in case of F1 and F2 fractures, orthopedists are more likely to request MRI and in F3 and F4 fractures, neurosurgeons and young orthopedists, request vascular studies thinking about the relationship with vertebral artery injury.[15]

Vertebral artery injuries occur in 14.7 to 17% of cervical traumas in which 33-55% are fatal injuries, mainly at the C5-C6 level in flexion-distraction trauma secondary to this level is the center gravity of the adult head in relation to the spine. In the presence of facet luxation, vertebral foramen fracture, or type C cervical lesion detected by CT, T2 axial sequence MRI image should be taken to rule out the «half-moon» sign, suggestive of arterial injury, and, if it is positive, an angiotomography should be indicated to decide treatment *(Figure 5)*.[16-18]

4. **Biomechanics.** Subaxial spine injuries are related to the movement generated by the trauma vector, having multiple mechanisms that, mostly are presented in combination for each type of fracture or ligament injury *(Figure 6)*.[4,12]
5. **Clinical assessment.** Every patient with a history of subaxial trauma implies the possibility

Figure 4:

Neurological status and modifiers AO spine subaxial injury.

Neurology

Type	Neurological
N0	Neurology intact
N1	Transient neurologic deficit
N2	Radicular symptoms
N3	Incomplete spinal cord injury or any degree of cauda equina injury
N4	Complete spinal cord injury
NX	Cannot be examined
+	Continued spinal cord compression

Modifiers

Type	Description
M1	Posterior Capsuloligamentous Complex injury without complete disruption
M2	Critical disc herniation
M3	Stiffening/metabolic bone disease (ie DISH, AS, OPLL, OLF)
M4	Vertebral artery abnormality

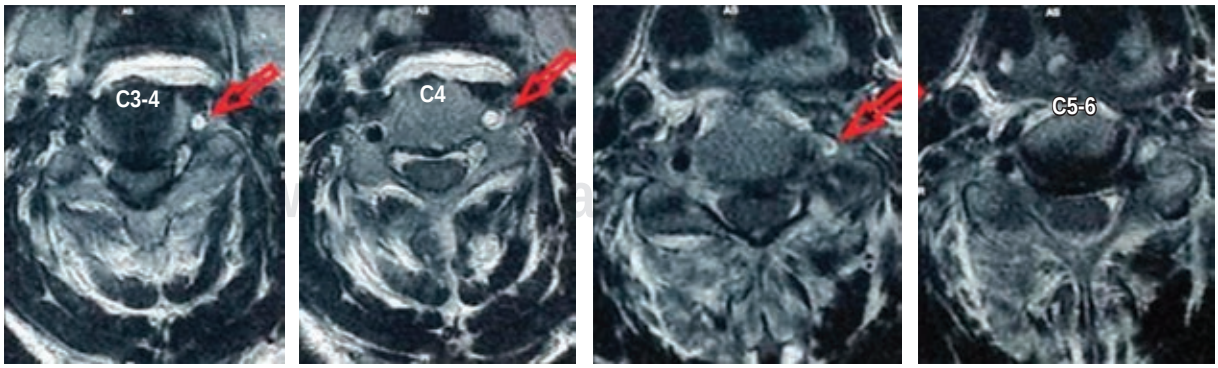
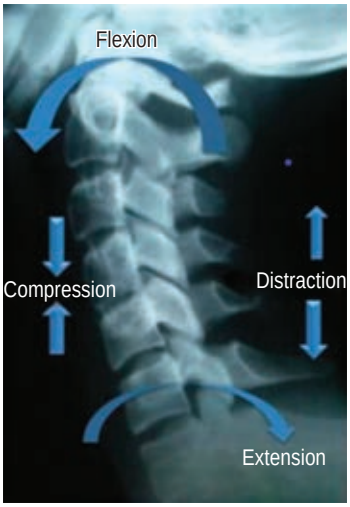


Figure 5: Magnetic resonance image T2 type, where it evidence vascular lesion «half moon».
Taken from: Rathod T, et al.[16]



Schematic shows major injury vectors and forces with their impacts on the vertebral column. Flexion injury results from supraphysiological forward bending and extension injury results from backward banding. Compression forces approximate the bones, while distraction dissociates the bones. Shear forces are applied at a right angle to the long axis of spine and produces significant bony and ligamentous disruption

Biomechanics	Anterior fingerprints	Posterior fingerprints
Hyperflexion	Anterior column compression Curvature: focal kyphosis Alignment: anterolisthesis VB: wedge compression and flexion teardrop. Bust/coronal split: axial loading Disc space: focal posterior widening or diffuse narrowing	Posterior column distraction Facet joint: diffuse widening more than 2 mm, focal posterior widening, subluxation and dislocation Interspinous widening
Hyperextension	Anterior column distraction Curvature: hyperlordosis or normal Alignment: normal or retrolisthesis VB: extension teardrop Disc space: focal anterior widening/normal	Posterior column compression Articular pillar/process fracture Lamina/spinous process fracture Pediculo-laminar separation
Lateral flexion	Always coupled with rotation Frequently association with hyperextension and hyperflexion Reciprocal compressive and distractive injury on right/left side Curvature: coronal plane tilt VB: lateral compression injury on the side of flexion Asymmetrical loss of disc height in coronal plane	Reciprocal compressive and distractive injury on right/left side Unilateral articular pillar or laminar fracture Facet joint distraction on the side opposite of posterior element fracture
Rotation	Usually associated with flexion, extension	Unilateral facet dislocation or fracture Asymmetric posterior column injury

VB = vertebral body.

Figure 6: Shows the main mechanism of fractures.
Modified from: Raniga SB, et al.[4]

of presenting neurological damage, which manifests with involvement of the brachial plexus, for which the correct exploration of myotomes and dermatomes of each nerve root is essential *(Table 1)*.

Discussion

Having a complete anamnesis of the mechanism of trauma and adequate physical examination, the type of injury and its severity can be suspected, for this

we need to complement our suspicion with imaging studies upon admission. Various studies protocolize and compare the use of simple radiography, CT, MRI and special studies.[19]

The initial radiographic management protocol, in most emergency departments, establishes that simple radiography in anteroposterior, lateral, right and left oblique positions provides low specificity and sensitivity to complex traumatic injuries, and also, dynamic radiographs entail the potential risk of neurological damage in undetected unstable injuries, therefore it is not recommended in patients with high-impact trauma.[20]

The positive and negative predictive value in simple radiography vs CT is compared, CT demonstrated superiority in the diagnosis of small and large bone lesions evaluated by several medical professionals in the emergency triage, therefore, it is suggested to indicate it routinely for high-impact cervical trauma, both pediatric and adult, bearing in mind that the initial emergency assessment is not performed by a spine surgeon in all trauma centers.[21]

Once the CT scan has been evaluated by the first contact physician and in case of a suspected fracture or indirect injury that suggests ligament involvement, complementary studies such as MRI should be indicated, up to 40% of these patients present injuries that require surgical treatment.[22]

Similarly, patients who do not show bone injury or indirect evidence of instability by CT scan, but who present severe neck pain without neurological deficit, MRI is suggested because it is related to hidden disc and ligament injuries in 3.5% of patients,[23] paying special attention to the STIR sequences to visualize the anterior longitudinal and posterior longitudinal ligament, which may be the cause of the symptoms of pain secondary to its rupture.[24]

Requesting an MRI study in an asymptomatic patient, neurologically complete with normal X-rays and CT, is reported to double hospital costs and only 0.011% of these patients present evidence of ligament injury, which does not affect conservative treatment due to what is not recommended for routine use in the emergency department.[25]

Treatment in the first 24 hours of a subaxial injury can determinate an improvement up to two degrees in the American Spinal Cord Injury Association (ASIA) neurological assessment scale vs late management, leading to a greater socioeconomic impact.[26,27] For this, we consider the following algorithm in the initial evaluation in the emergency department, from the use of a cervical collar, to the request for MRI and evaluation by a spine surgeon for definitive treatment *(Figure 7)*.[28,29]

Conclusion

The initial evaluation of trauma patients must follow a strict protocol that ranges from prehospital care to a systematic evaluation in the emergency room; it is recommended in presence of high-impact trauma or alteration in the neurological examination, to perform a cervical CT scan and, according to the findings, to follow an imaging study protocol, such as MRI, focused on the punctual diagnostic suspicion, this reduces cost for health system and does not delay the correct care of disc-ligament, bone, neurological or vascular injuries that can be fatal.

Table 1: Neurological exam of brachial plexus.

Roth	Dermatome	Myotome	Reflex	Terminal nerve	Motor action
C5	Lateral portion of the arm	Delts and biceps muscles	Bicipital	Axillary	Shoulder abduction
C6	Lateral portion of the forearm, thumb and index and middle finger	First and second outer radials muscles	Long supinator reflex. Bicipital reflex	Sensory branch of the musculocutaneous nerve	Wrist extension
C7	Middle finger	Triceps, palmar major, anterior ulnar, interosseous hand muscles	Tricipital	Radial Medium Ulnar	Wrist flexion. Finger extension
C8	Ring and little fingers, medial forearm,	Superficial common flexor of the fingers Common flexor of the fingers muscles		Medial cutaneous antebrachial (posterior cord)	Finger flexion
T1	Medial portion of the arm	Dorsal interossei. Little finger abductor muscles		Medial cutaneous brachialis (posterior cord)	Finger abduction

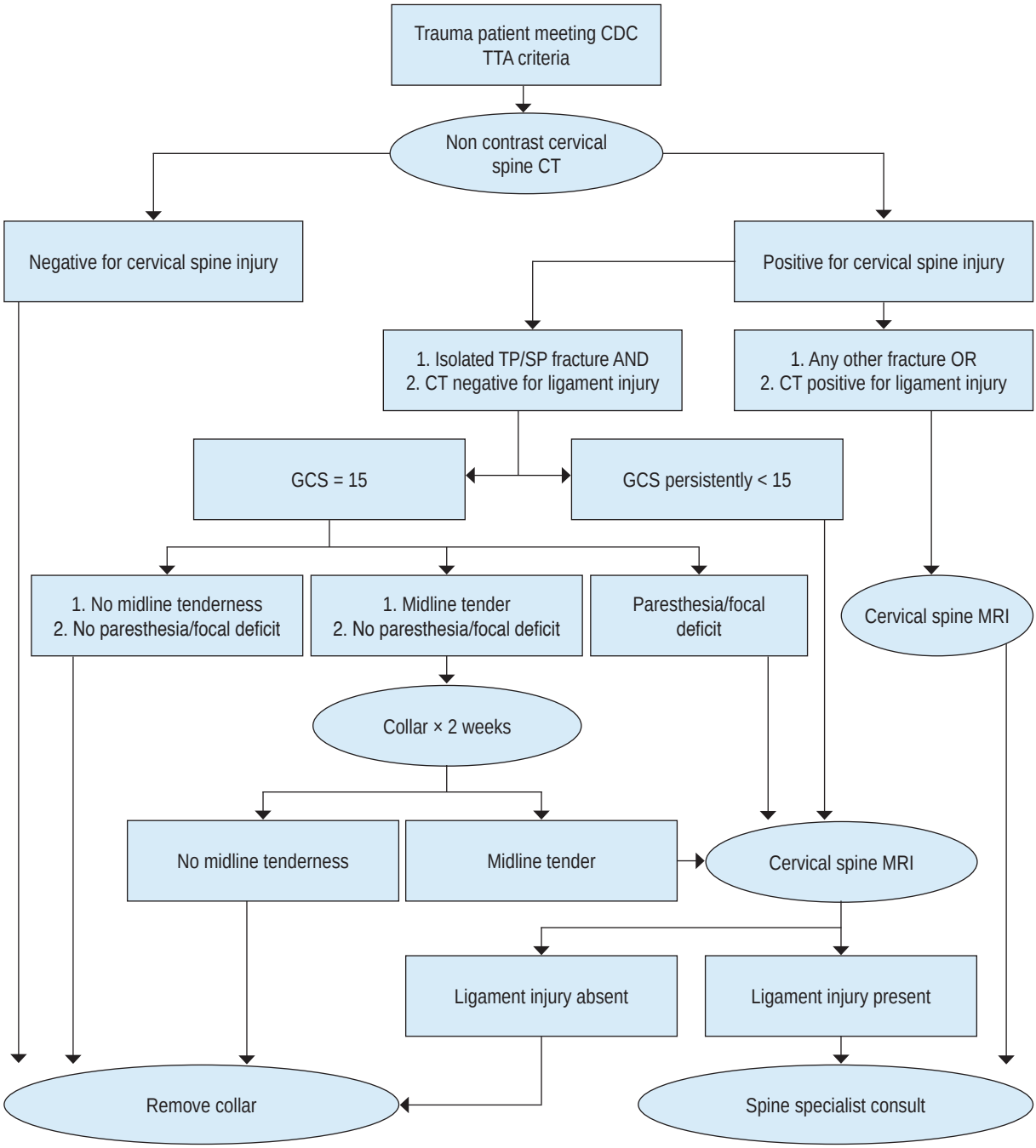


Figure 7: Evidence-based c-spine clearance algorithm after blunt trauma to rule out injury.
Taken from: Duane TM, et al.[28]

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Conflict of interests

The authors declare no conflict of interest.