Instability concept

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AOSpine Principles
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Disclosure information

I have no financial relationships with commercial entities that produce health-care related products.
Case problem.

- 51 years old man.
- Occipital trauma due car accident.
- Cervical pain.
- Normal neurological assessment.
- X-ray:
Case Problem.

- Soft collar.
- Persistence of neck pain.
- Deformity in flexion.
- Re-consulting two weeks later...
Case problem.
Case problem.
Case Problem.

Dynamic X-ray
Case Problem.

CT-Scan
Case Problem.

1 year
Definition

“loss of ability of the spine under physiologic loads to maintain relationships in such a way that there is neither damage nor subsequent irritation to the spinal cord or nerve roots and, in addition, there is no development of incapacitating deformity or pain”


Under physiologic loads. Potential for:

- Increased deformity (first degree instability)
- Neurologic Damage (second degree instability).
- Pain / Disability
Definition

- Basic elements of Systematic Analysis of Instability in cervical spine:
  - Anatomic elements of stability.
  - Biomechanics of normal cervical spine
  - Instability criteria of cervical spine.
Anatomic Considerations: cervical vertebrae
Trabecular Anatomy

- Important transition point for forces within the c-spine
- Important anatomical points
  - Superior and inferior articular processes are “offset” in the AP direction due to different functions at each articulation
  - Pars interarticularis - due to this transition is a frequent fracture site
  - Odontoid process - the “pivot” for rotation

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Dens verti</td>
<td>1.37 mm</td>
<td>0.54</td>
<td>13</td>
</tr>
<tr>
<td>Anterolateral</td>
<td>Pharyngoby</td>
<td>1.68 mm</td>
<td>0.81</td>
<td>13</td>
</tr>
<tr>
<td>Lateral</td>
<td>Dens verti</td>
<td>1.63 mm</td>
<td>0.37</td>
<td>13</td>
</tr>
<tr>
<td>Posterior</td>
<td>Dens verti</td>
<td>1.09 mm</td>
<td>0.21</td>
<td>10</td>
</tr>
<tr>
<td>Lateral</td>
<td>Dens verti</td>
<td>1.14 mm</td>
<td>0.40</td>
<td>13</td>
</tr>
</tbody>
</table>

The trabecular anatomy of the axis Authors: Heggeness, M.H.; Doherty, B.J. Source: Spine, 1993, 18, 14, 1945-1949, UNITED STATES
Anatomic Considerations: Atlanto-Axial Anatomy

- Allow for the wide range of motion of upper C-spine while maintaining stability
- Classified according to location with respect to vertebral canal
  1. Internal ligaments:
     - Tectorial membrane
     - Cruciate ligament – including transverse ligament
     - Alar and apical ligaments
2. External ligaments:
   - Anterior and posterior atlanto-occipital membranes
   - Anterior and posterior atlanto-axial membranes
   - Articular capsules
   - Ligamentum nuchae
Anatomic Considerations: Lower C- Spine


2. Posterior complex:
   - Ligamentum nuchae
   - Ligamentum interspinous.
   - Ligamentum flavum.
   - Capsule of facet joints
Biomechanics of cervical spine.

<table>
<thead>
<tr>
<th>Interspace</th>
<th>Combined Flexion/Extension (2-axis rotation)</th>
<th>One Side Lateral Bending (1-axis rotation)</th>
<th>One Side Axial Rotation (3-axis rotation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limits of Ranges (degrees)</td>
<td>Representative Angle (degrees)</td>
<td>Limits of Ranges (degrees)</td>
</tr>
<tr>
<td>Middle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2-3</td>
<td>5–16</td>
<td>.10</td>
<td>11–20</td>
</tr>
<tr>
<td>C3-4</td>
<td>7–28</td>
<td>15</td>
<td>9–15</td>
</tr>
<tr>
<td>C4-5</td>
<td>13–29</td>
<td>20</td>
<td>0–16</td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5–6</td>
<td>13–29</td>
<td>20</td>
<td>0–16</td>
</tr>
<tr>
<td>C6–7</td>
<td>0–26</td>
<td>17</td>
<td>0–17</td>
</tr>
<tr>
<td>C7–T1</td>
<td>4–7</td>
<td>9</td>
<td>0–17</td>
</tr>
</tbody>
</table>

Biomechanics of cervical spine.

Total Flexion-extension 130°
C2-C7 flexion extension: 100°
C1-C2 flexion extension: 20-30°

Total Lateral Bending 45°
C0-C1 lateral bending 8°
C2-C7 lateral bending 37°

Total Rotation 80°
C1-C2 rotation 24°
C2-C7 rotation 56°

Kapandji IA, cuadernos de fisiologia articular, Masson 1991
Biomechanics of cervical spine.

The displacement of instantaneous centers of rotation involves Cervical coupling in combined movements.

Biomechanics of cervical spine.

Body resistance to axial load (Newtons).

Instability criteria of cervical spine (C0-C2).

**TABLE 5–3 Criteria for C0–C1–C2 Instability**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;8°</td>
<td>Axial rotation C0–C1 to one side</td>
</tr>
<tr>
<td>&gt;1 mm</td>
<td>C0–C1 translation (as measured in Fig. 5–6A)</td>
</tr>
<tr>
<td>&gt;7 mm</td>
<td>Overhang C1–C2 (total right and left)</td>
</tr>
<tr>
<td>&gt;45°</td>
<td>Axial rotation C1–C2 to one side</td>
</tr>
<tr>
<td>&gt;4 mm</td>
<td>C1–C2 translation (as measured in Fig. 5–6B)</td>
</tr>
<tr>
<td>&lt;13 mm</td>
<td>Posterior body C2—posterior ring C1 (as measured in Fig. 5–6C)</td>
</tr>
<tr>
<td></td>
<td>Avulsed transverse ligament</td>
</tr>
</tbody>
</table>

Instability criteria of cervical spine (C0-C2).

>4mm
Instability criteria of cervical spine (C0-C2).

Overhang C1-C2

- Open Mouth view.
- Lateral displacement of C1 Laterral masses.
- Instability > 7 mm
- Implies rupture of transverse ligament

Spence, JBJS, 1970
Instability criteria of cervical spine (C0-C2).
Instability criteria of cervical spine (C0-C2).
Instability criteria of cervical spine (C0-C2).

Powers’ Ratio
- BC/OA
  - >1 considered abnormal
- Limited Usefulness
- Positive only in Anterior Translational injuries
- False Negative with pure distraction

Powers et al, Neurosurg, 1979
Instability criteria of cervical spine (C0-C2).

Swischuk’s line: pathologic > 2mm. Only indicates regional kyphosis.

Instability criteria of cervical spine (C2-C7).

Pavlov’s ratio (A/B) ≥ 0.8

Instability criteria of cervical spine (C2-C7).

TOTAL: 10 points
Instability criteria of cervical spine (C2-C7).

TOTAL: 7 points
Instability criteria of cervical spine (C2-C7).

White et al. (1975) found that cervical spines with intact anterior structures plus one posterior element, or spines with intact posterior structures plus one anterior structure remain biomechanically stable under physiological loads.

Three-column concept of cervical spine stability: Stabilizing structures divided into three columns. Insufficiency of two or three columns indicates instability, whereas injuries of one column may be stable.

Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 1983; 8:817–831
Instability criteria of cervical spine (C2-C7).

The classification system is based on morphologic descriptions and, secondly, by stability based on a quantifiable value. Four column model

- Severity score of 0 to 20, =>7 surgery
- In patients with multiple levels of injury, only the most severe level is scored
Instability criteria of cervical spine (C2-C7).

- Ant = 5
- R pilar = 5
- L pilar = 5
- Post = 5
TOTAL = 20
Instability criteria of cervical spine (C2-C7).

- Ant = 2.5
- R pilar = 1
- L pilar = 3
- Post = 4

TOTAL = 10.5
Instability criteria of cervical spine (C2-C7)

Interobserver ICC: 0.83
Intraobserver ICC: 0.97

Excellent reliability

Allow more accurate determination of stability and dictate treatment.
Radiologic considerations.

- **Rx-rays, CT scan**: Both are essential to identify and typify the cervical injury.
- **MRI**: the better tool to assess the cervical soft tissues injury and ligament instability.
- **Increased Signal Intensity in**:
  - Joints
  - Capsular
  - Spinal Cord
  - Ligaments
  - Pre-vertebral soft tissues

*Warner et al, Emerg Radiol, 1996*
*Dickman et al, J Neurosurg, 1991*
Conclusions. Take at home message.

- It's important to know the structures at risk in cervical spine trauma.
- Understand the patogenesis of cervical injuries
- Assessment of cervical instability is essential to plan the treatment of fractures.
- Is necessary to identify unstable cervical injuries in order to administer the appropriate treatment.
- Underestimated lesions could lead to catastrophic results.
Excellence in Spine

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