Sample Report

setting a new standard for diagnostic fluoroscopy in motion

seeing is believing

headache
whiplash
hypermobility
loss of balance

dizziness

neck pain
radiating pain

ligament injuries

increased pain with movement

soft tissue diagnostic testing
This report is based upon biomechanical analysis and protocols that have been established for roentgenological digitization of the spine. This evaluation will include a pathological report and a Digitized Biomechanical Analysis. Radiologic images used were of acceptable quality and in compliance with normal protocols for x-ray digitization.

**HISTORY:** Motor vehicle collision, front-end impact; neck pain.

**STUDY:** DMX views of the cervical spine include: Lateral Nodding, Lateral Flexion & Extension, Oblique Flexion & Extension, A-P Lateral Bending, A-P Rotation, A-P Open Mouth Lateral Bending.

**FINDINGS:** The neutral lateral film demonstrates straightening of the lordotic curve. Intervertebral disc spaces are well maintained. Vertebral bodies, arches, and processes are of normal size, shape, and dimension. No cervical ribs are identified. There is no evidence of acute fracture or lytic change. The surrounding soft tissues as visualized are unremarkable.

During extension, the lateral film demonstrates excess posterior angulation at C5-C6; during flexion, excess anterior angulation is noted at C4-C5; findings indicative of Alteration of Motion Segment Integrity (AOMSI). Additional analysis of total intersegmental angulation from flexion to extension revealed excess total motion at C4-5 and C5-6 suggestive of ligamentous instability.

Interruption in George’s Line noted at C2-3 due to retrolisthesis during extension, consistent with intersegmental ligamentous instability. Motion in the A-P Open Mouth lateral bending projection shows excess translation of C1 on C2 to the left. Intervertebral hypermobility described above related to annulus and ligamentous stretching and/or tearing. No evidence of surgical instability. Clinical correlation of abnormal findings advised. Motion is unremarkable in the A-P lateral bending, A-P rotation, Right and Left Oblique flexion and extension, and lateral nodding projections.

**IMPRESSIONS:**
1. Excess posterior angulation during extension at C5-6, consistent with AOMSI.
2. Excess anterior angulation during flexion at C4-5, consistent with AOMSI.
3. Excess total angulation noted at C4-5 and C5-6 indicative of ligamentous instability.
4. Excess lateral translation of C1 on C2 to the left, consistent with atlantoaxial ligamentous laxity.
5. Postural changes described above.

**NOTE:** The computerized analysis of this patient’s DMX appears to have been performed correctly and corresponds to my own interpretation of the study.

**Date of DMX Exam:** 04/25/2012  
**Date of Digitization Report:** 04/26/2012  
**Date of Radiologist Report:** 04/27/2012  
**Referring Physician:** XXXXX, M.D.
Name: Jane Doe  
Date of Digitization: 04/26/2012

Lateral Cervical, Flexion/Extension

Neutral

Anterior
- This colored line represents the patient's position and the path of the posterior longitudinal ligament.
- This colored curved line represents the Normal Spinal Position and expected path of the posterior longitudinal ligament.

Posterior

Flexion

Extension

Anterior
- This colored line represents the path of the posterior longitudinal ligament and exceeds normal allowable segmental motion indicating ligament laxity.

Posterior
- This colored line is the path of the posterior longitudinal ligament and appears to be stable with no significant ligamentous laxity.

Picture in Picture technology allows for both patient identification and correlation of the patient’s external and internal body movements.
Lateral Cervical Flexion / Extension Impressions and Assessment

There is anterior widening of the intervertebral disc space at the C5-C6 level evidenced by excessive segmental extension, which indicates possible damage to the anterior longitudinal ligament (ALL) and/or intervertebral disc at that level.

There is probable significant damage to the posterior longitudinal ligament and/or posterior intervertebral disc and/or interspinous ligament which is indicated by an increased widening of the posterior intervertebral disc space angulation and increased separation of spinous processes at the C4-C5 level.

According to the above biomechanical assessment, there are findings of Alteration of Motion Segment Integrity (AOMSI). Consequently, this patient may be ratable for a permanent injury upon reaching maximal medical improvement.

1Measurements over 1mm Translation and/or over 7 degrees Angular Variation are considered to be clinically significant and in excess of normal flexibility of the cervical spine. SPINE 2001, February; 26(3): (256-261), Lin, Tsai, Chu and Chang.


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### Penning Analysis: Total Average Angular Excursion

<table>
<thead>
<tr>
<th>Segment</th>
<th>Normal Values (Penning⁴)</th>
<th>Normal Values (Dvorak⁵)</th>
<th>Normal Values (Wu⁶)</th>
<th>Patient Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2-C3</td>
<td>12.0°</td>
<td>12.0°</td>
<td>13.5°</td>
<td>6.3°</td>
</tr>
<tr>
<td>C3-C4</td>
<td>18.0°</td>
<td>17.2°</td>
<td>17.3°</td>
<td>14.2°</td>
</tr>
<tr>
<td>C4-C5</td>
<td>20.0°</td>
<td>21.1°</td>
<td>22.6°</td>
<td><strong>21.0°</strong></td>
</tr>
<tr>
<td>C5-C6</td>
<td>20.0°</td>
<td>22.6°</td>
<td>19.1°</td>
<td><strong>22.5°</strong></td>
</tr>
</tbody>
</table>

Highlighted Values Exceed Established Normal
Due to body habitus, C7 position was estimated. Therefore, C6-C7 measurements are not included.

**Impressions and Assessment**

Using the Penning system of analysis⁴, the patient’s cervical spine was analyzed using computerized method and total motion at each segmental level was assessed. Penning’s Analysis for cervical spine stability has been shown to be one of the most valid methods for assessing total range of motion from flexion to extension⁵.

Ms. Jane Doe was found to have excessive motion at C4-C5 exceeding normal ranges found by Penning⁴ and Dvorak⁵. Motion at C5-C6 was found to exceed the upper normal limits established by Penning⁴ and Wu⁶. There were no segments that exceeded the upper normal limits determined by Dvorak⁵.

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A-P Open Mouth Lateral Bending

Left Lateral Flexion

Right Lateral Flexion

The red line represents the position of the atlas lateral mass in the side bending position.

The green line represents the position of the Axis superior articular process.

**Shifting of the red line from green greater than 1.7mm is indicative of subluxation.**

**Shifting of greater than 3.0mm laterally indicates laxity of the Alar and/or Accessory ligaments.**

**Clinical correlation is advised with shifting greater than 1.7mm.**

Lateral Translation Values, C1 on C2 During Lateral Cervical Flexion

<table>
<thead>
<tr>
<th>Description</th>
<th>Patient’s Value</th>
<th>Clinical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1-C2 Lateral Translation -- Left</td>
<td><strong>3.8 mm</strong></td>
<td>C1-C2 Ligamentous Laxity/ Instability</td>
</tr>
<tr>
<td>C1-C2 Lateral Translation -- Right</td>
<td><strong>1.1 mm</strong></td>
<td>Within Normal Limits</td>
</tr>
</tbody>
</table>

**APOM Lateral Bending Impressions and Assessment**

Ms. Jane Doe has a C1-C2 Left Translation of **3.8 mm** and a C1-C2 Right Translation of **1.1 mm**. This displacement overhang of C1 on C2 indicates laxity of the Alar and/or Accessory ligaments.

"Lateral shift of Atlas on Axis greater than 1.7mm is considered subluxation and associated with poor prognosis for whiplash injury". Krakenes J, Kaale BR, Moen G, Nordi H, Gilhus NE, Rovik J. MRI assessment of the alar ligaments in the late state of whiplash injury-structural abnormalities and observer agreement. Neuroradiology 2002 Jul;44(7); 617-24.

Digital Motion Fluoroscopic X-ray Study was performed by DMX Imaging, LLC.
Films were digitized and computer-analyzed by Precision Spinal Diagnostics, LLC.
Pathology and Interpretation report by Proscan Reading Services.
X-Ray digitization for spinal biomechanics has been shown to be valid when compared to standard hand drawn methods.
The X-Ray mensuration method used in analyzing this patient has been studied for reliability and validity.

End of Report
Cervical Spine: 7 Views in Motion

DMX Imaging’s cutting edge Diagnostic Fluoroscopy, also known as Digital Motion X-ray (DMX), is an image intensified fluoroscopic x-ray system that visualizes anatomical structures by converting a pattern of X-radiation into a visible image through electronic amplification. Special “picture in picture” technology allows for both patient identification and correlation of the patients external body movements with internal body movements. At low-level radiation, it provides a crystal-clear motion x-ray of moving joints including the cervical spine, jaw, shoulder, elbow, wrist, knee and ankle. This technology can detect the true cause of the pain or the full extent of the injuries, which can only be revealed by our exam showing the abnormal function of the joints in motion.

Objective X-ray Findings:
There are seven views perform during the Cervical Spine Diagnostic Fluoroscopy Exam.

1. **Neutral Lateral Projection**: The integrity of the cervical lordosis and overall condition of the cervical spine is evaluated. The loss of the cervical lordosis may be a result of *damage to the posterior longitudinal, capsular or interspinous ligaments*.

2. **Lateral Nodding Projection**: This view examines the integrity of the transverse ligament which is responsible for preventing the anterior movement of C-1 on C-2. An increase of the Atlanto-Dens Interspace (ADI) indicates *damage to the transverse ligament*.

3. **Motion in the Neutral Lateral Projection to Full Flexion**: This view examines the *integrity of the posterior longitudinal ligament* demonstrated by a forward (anterior) movement of one vertebrae over the vertebrae below or by the posterior widening of the intervertebral disc space (increased disc angle).

   **Motion in the Neutral Lateral Projection to Full Extension**: This view examines the *integrity of the anterior longitudinal ligament* demonstrated by a backward (posterior) movement of one vertebrae over the vertebrae below or by the anterior widening of the intervertebral disc base (increased disc angle).

4. **Motion in the Oblique Flexion Projection**: This view examines the *integrity of the capsular ligaments* by observing gapping of the facet joints, located on the posterior cervical spine (C2-C7), there are five capsular ligaments on the right and the left.

   **Motion in the Oblique Extension Projection**: This view examines the *integrity of capsular ligaments* by encroachment into the intervertebral foramen, located on the posterior cervical spine (C2-C7), there are five capsular ligaments on the right and the left.

5. **Motion in the AP Projection Lateral Bending**: This view allows us to evaluate coupled motion of the spine is processes which examines *facet joint integrity*.

6. **Motion in the AP rotation projection**: This view examines the rotational range of motion between occiput-C1-C2. Increased motion indicates *damage to the alar and accessory ligaments*.

7. **Motion in the AP open mouth lateral bending projection**: This view examines the *integrity of the alar and accessory ligaments* either by the lateral over hang out C-1 on C-2 or by the changes in the para-odontoid spaces.

DMXIMAGING, LLC
Services of DMX Imaging...

DMX Imaging provides diagnostic motion fluoroscopy for the cervical spine, jaw, shoulder, elbow, wrist, knee and ankle. All exams are read by a diagnostic medical radiologist. Cervical spine images are also digitized and computer analyzed.

Objective Proof of Injury

Diagnostic Fluoroscopic Exam
- Provides VISUAL objective proof of injury
- Gives quick and accurate diagnosis
- Detect soft tissue injuries commonly missed by other tests
- Demonstrates permanent ligament injury
- Provides an assessment of all 22 major cervical ligaments
- Improves treatment compliance

X-Ray Digitization and Biomechanical Analysis
- Provides Quantitative objective proof of injury
- Confirms the presence, extent and location of spinal ligament laxity and instability
- Biomechanical report may include as many as seven different methods of computer analysis
- Justifies use of permanent injury ICD-9 codes

MD Radiologist Interpretation
- Read a by a board-certified medical radiologist
- Adds medical expertise and credibility to the case
- Radiologist report around is typically within 48 to 72 hours