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NAME OF PATIENT:
DATE OF REPORT:
DATE OF EXAMINATION:
REFERRING PHYSICIAN:
TESTING FACILITY:

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Washington Open MRI

Sample Digital Motion X-Ray Report Cervical Spine

Indications: Headaches, posterior neck pain, pain increased with movement, and cognitive symptoms following MVC 2 years ago.

Technique: The following positions were utilized during real-time imaging of the cervical spine: neutral lateral, lateral nodding, full flexion and extension, full oblique flexion and full oblique extension, cervical rotation, AP lower cervical with lateral flexion, AP open mouth with lateral flexion, and oral excursion.

Impressions:

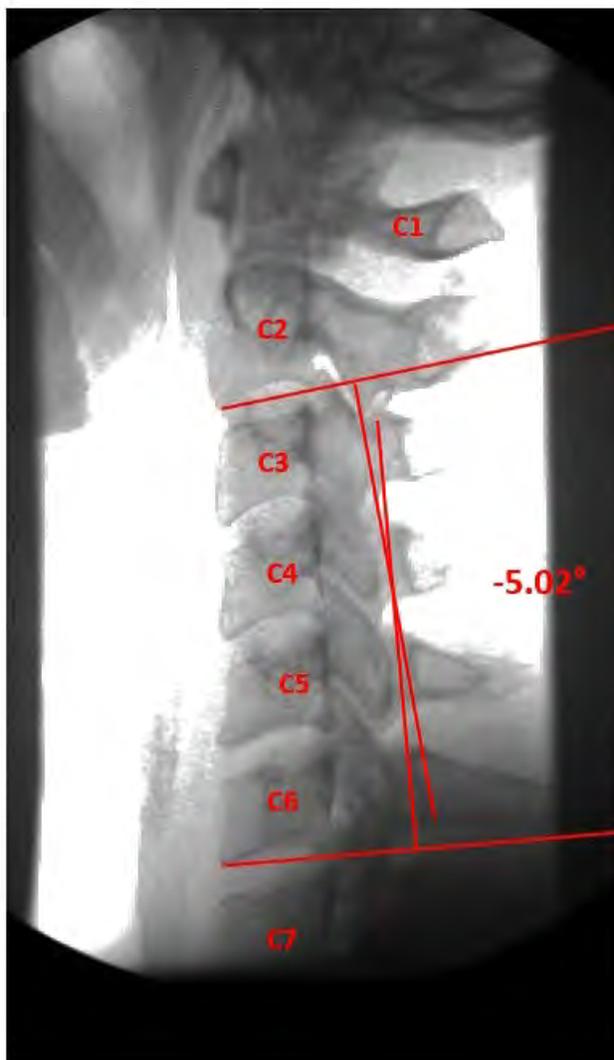
- High-grade damage to the alar and accessory ligaments is indicated by a significant overhang of the lateral mass of C1 bilaterally, and by significant changes in the para-odontoid spaces during bilateral lateral bending.
- High-grade damage to the anterior longitudinal ligament is indicated by a significant retrolisthesis at C2 on C3.
- Moderate-grade damage to the interspinous ligaments is indicated by abnormal separation between the spinous processes of C2-C3, C3-C4, C4-C5, and C5-C6.
- Moderate-grade damage to the capsular ligament is indicated by significant gapping of the facet joint at C6-C7 on the right during both flexion and extension.
- Central canal stenosis at C6.
- High-grade subluxation of C7

1. **In the 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.
 - There is reversal of the cervical lordosis with the apex of the reversal at C5-C6. The normal range of the cervical curve is 35°-45°, with an average of 40°, and is usually measured from C2-C7, unless C7 is not adequately visualized.¹ Measurement of the cervical lordosis from C2-C6 is -5.02°. The cervical spine is a rigid structure with some flexibility and is supposed to be a C-shaped structure, convex to the anterior, with the external auditory meatus directly aligned vertically above the shoulders. The C-shape is derived from the shapes of the vertebral bodies and the intervertebral discs, but its shape can be altered depending on the tonicity of the cervical spinal muscles. It is typical after trauma for the cervical curve to be reduced, straightened, or reversed. A head forward position or a kyphotic cervical curve induces tension into the cervical spinal cord, nerve roots, and hindbrain, and increases the cerebral spinal fluid

THIS SAMPLE REPORT IS ACCOMPANIED BY ADDITIONAL VIDEOS AND EXPLANATIONS OF PATHOLOGY FOUND WHICH REPRESENTS THE ENTIRE REPORT FOR THIS PATIENT

pressure and intramedullary pressure in the spinal cord.² Lordosis is the most stable configuration for the cervical spine, so a loss of the curve indicates that it is less stable.

- There is no pre-existing degeneration.
- The C6-C7 disc is swollen. A swollen disc is often found superior to the level of a subluxated vertebra.³
- There is calcification of the thyroid cartilage. While calcification of the thyroid cartilage is a common finding on x-ray, it is significant because there is usually concurrent dysfunction of the thyroid gland, which is essential for healing.



Reduced cervical lordosis

2. **The nodding projection** evaluates the integrity of the transverse ligament which is responsible for preventing abnormal anterior translation of C1 and C2 and for excessive flexion of C1 on C2. An increase in the ADI or a sign of V indicates damage to the transverse ligament.



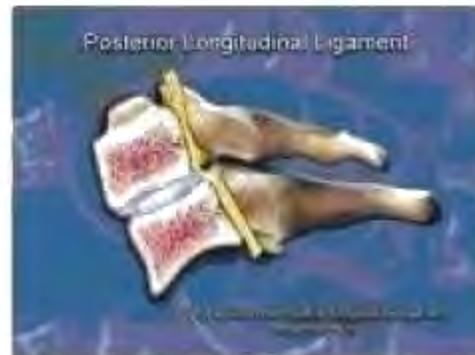
Increased ADI space

- Motion at the atlanto-occipital articulation is within normal limits.
- There is no increase in the atlanto-dens interspace.
- There is no significant tilting of C1 laterally.
- Early retrolisthesis occurs at C2-C3. Early retrolisthesis is considered to be more clinically significant than end-of-range listhesis⁴ because most people function only within the first 50% of their range of motion, and rarely at the end of their range.⁵ This will be further explained in section 4.

3. **The flexion lateral projection** evaluates the integrity of the posterior longitudinal ligament, the facet capsular ligaments, and the interspinous ligaments. The posterior longitudinal ligament is evaluated by measuring the anterolisthesis of a superior vertebral body upon the adjacent inferior one and by posterior widening of the intervertebral disc space. The facet capsular ligaments are evaluated by the relationship of the articular surfaces to one another. The interspinous ligaments are evaluated by excessive widening of the spinous processes.

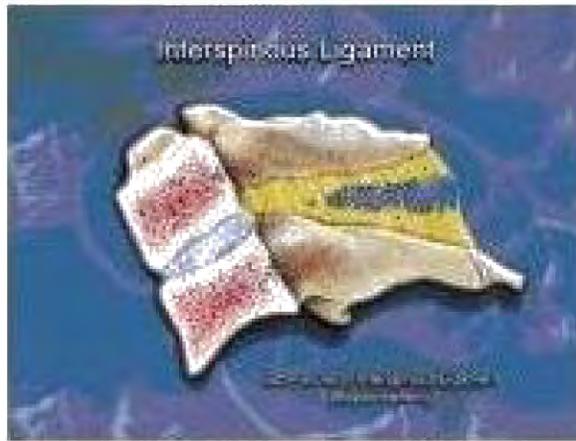


Widening of posterior disc space



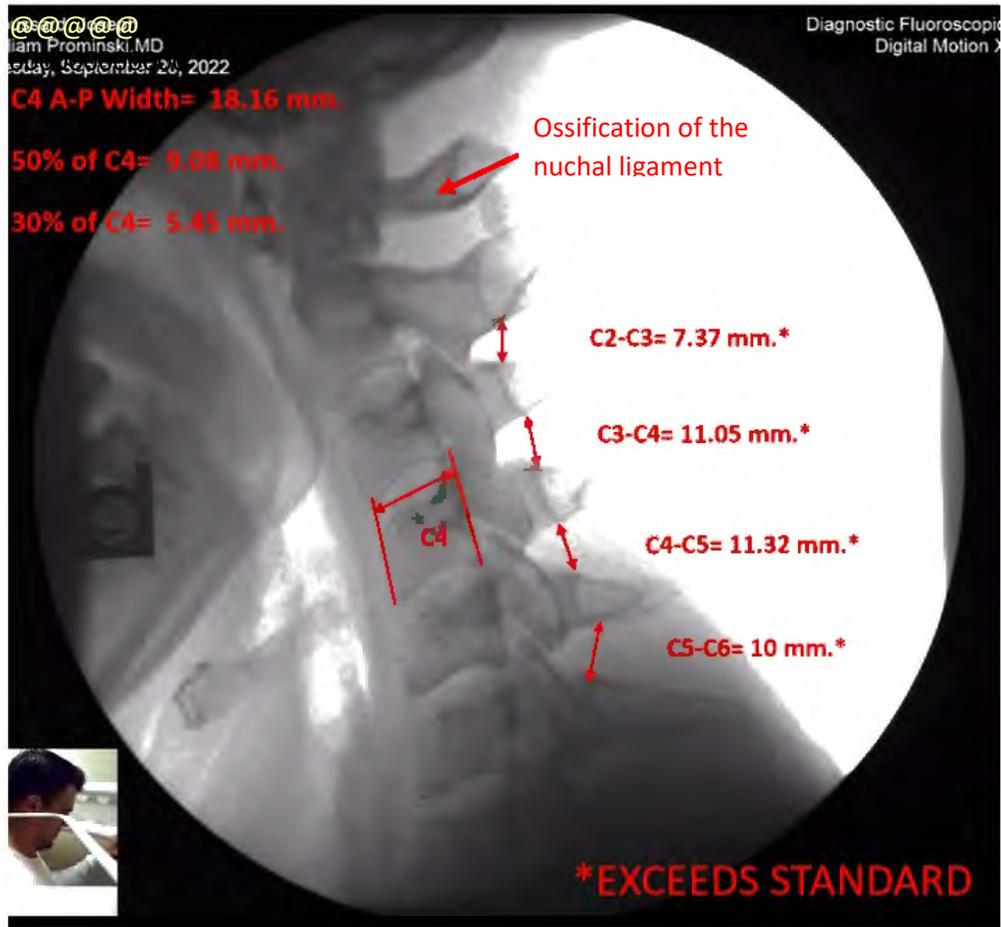
Anterolisthesis

- Motion in the neutral lateral projection to full flexion is severely restricted.
- There is no significant anterolisthesis.
- There is no posterior widening of the intervertebral disc spaces.
- There is increased separation between the spinous processes at C2-C3, C3-C4, C4-C5, and C5-C6, as per Eubanks' formula (if the distance between the spinolaminar lines from C3-T1 is greater than 50% of the AP width of the C4 superior endplate on the lateral projection, the interspinous ligaments have been damaged (30% for C2-C3).⁶ Three contiguous segments with excessive widening between the spinous processes is considered to be a sign of instability.⁷ Widening of the interlaminar or interspinous space can occur only when there is injury to the posterior ligamentous structures, the facet joints, and the posterior aspect of the annulus fibrosis.⁸ The separation between the spinous processes of C6-C7 could not be measured accurately but the two bones appear to excessively separated as well.



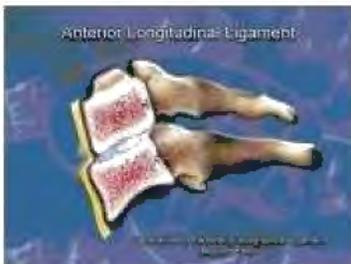
Interspinous ligament damage

- There is paradoxical motion at C2-C3. Measurement of the angular displacement at C2-C3 is -2.41° . Normal range of motion values for the cervical spine can be found on the Angular Motion Analysis Table, which is found in the next section. Negative values during flexion (and positive values during extension) are indicative of paradoxical motion, which occurs when tissue irritation due to inflammation is so great that normal motion cannot be tolerated. Paradoxical motion is motion which occurs which is opposite of the intended and expected motion. In other words, when you expect a vertebra to move into flexion, it actually goes into extension, which is a form of pain-avoidance. Muscle guarding secondary to injury to ligaments and/or intervertebral discs can cause the abnormal motion.
- The -2.41° in flexion at C2-C3 combined with 11.21° in flexion at C3-C4 to result in a calculated flexion angulation of 13.62° . An angular motion difference of 11° greater than an adjacent level is indicative of a ratable spinal ligament injury, or a third-degree sprain (in this case, to the posterior longitudinal ligament).^{9,10,11,12,13} Widening of the interlaminar or interspinous space can occur only when there is injury to the posterior ligamentous structures, the facet joints, and the posterior aspect of the annulus fibrosis.¹⁴
- There is an opacity in the posterior ligamentous tissue seen in most of the projections, but this particular projection shows it well. It is located between the posterior tubercle of the atlas and the spinous process of C2 and is visible in image below. It is most likely a forming nuchal bone. Over the past two years, the patient has had spinal instability verified by this study, leading to hypertrophic ossification in the nuchal ligament because of chronically abnormal segmental motion.¹⁵

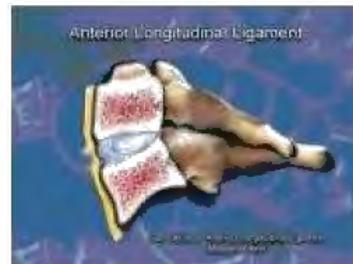


Abnormal widening of the spinous processes

4. **The extension lateral projection** evaluates the integrity of the anterior longitudinal ligament, the facet capsular ligaments, and the central canal. The anterior longitudinal ligament is evaluated by measuring the retrolisthesis of a superior vertebral body upon the adjacent inferior one and by anterior widening of the intervertebral disc space. The facet capsular ligaments are evaluated by the relationship of the articular surfaces to one another (imbrication), and the degree of intervertebral foraminal encroachment produced. The integrity of the central canal is evaluated with Pavlov's ratio.



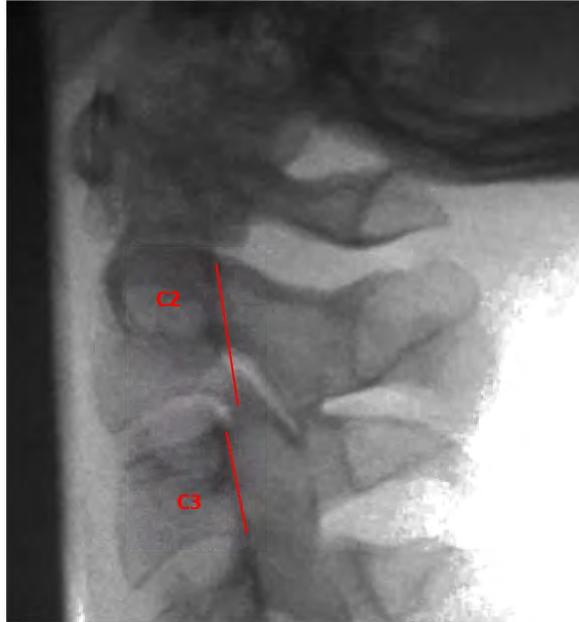
Retrolisthesis



Widening of the anterior disc

- Motion in the neutral lateral projection to full extension is severely restricted.
- There is a significant retrolisthesis of C2 on C3. This does not occur during the extension view, but during the nodding projection, and to quantify it, I had to run the video through the CRMA software twice to get the correct mensurations. Static flexion/extension views are taken at the end of the range of motion and

fail to show what has happened within the range. Within-range information is considerably more valuable because subjects normally function within the first 50% of their movement, and rarely at the end of their range.^{16,17,18,19,20,21,22,23} Measurement of the translational displacement at C2-C3 during the extension phase of nodding is **3.43 mm., or 29.06% translation**. Displacement of a vertebra by 2 mm. or more in any direction is considered to be a sign of spinal instability,²⁴ and >20% translation is indicative of high-grade loss of motion segment integrity.²⁵



Retrolisthesis of C2 on C3 (from the nodding projection)

- There is no abnormal anterior widening of the intervertebral disc spaces.
- Pavlov's ratio was applied to the measurement of the cervical sagittal canal diameter, with the following results: C3= 1.09, C4= 0.85, C5= 0.90, and **C6= 0.73**. Unfortunately, C7 could not be measured (>1.0=optimal, <0.85= borderline stenosis, <0.80= pathological stenosis).²⁶ Pavlov's ratio is only a measure of the bony contribution to the narrowing of the spinal canal, so in light of the chronic nature of his complaints, cervical MRI (preferably upright) is recommended in order to assess any soft tissue contribution to the narrowing of not only his spinal canal but also his neural canals. The presence of stenosis is a serious complicating factor for patients injured in motor vehicle collisions. Patients with low Pavlov's ratio have a worse long-term prognosis when they are injured in collisions.²⁷ A Pavlov's ratio <0.75 is associated with cervical spondylotic myelopathy.²⁸
- There is paradoxical motion at C3-C4. Measurement of the angular displacement is +5.09°, which results in a hypomobile C3-C4 segment, despite the 11.21° measured in flexion.

Angular Motion Analysis-

Level	Flexion	minus	(-Extension)	equals	Total ROM	Normal ROM
C0-C1	-5.22°	minus	(-21.88°)	equals	16.66°	0-25°
C1-C2	0.42°	minus	(-14.31°)	equals	14.73°	<20°
C2-C3	-2.41°	minus	(-7.33°)	equals	4.92°	10°
C3-C4	11.21°	minus	(+5.09°)	equals	6.12°	15°
C4-C5	7.19°	minus	(-3.37°)	equals	10.56°	20°
C5-C6	1.13°	minus	(-10.86°)	equals	11.99°	20°

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In both the craniocervical junction and the subaxial spine, the formula for measuring flexion and extension designates flexion as the “positive” value and extension as the “negative” value (see top line of the chart). The extension measurement is subtracted from the flexion measurement to calculate the total range of motion. If you remember what you learned about integers in 5th grade math, you know that subtracting a “minus” from a “minus” results in a plus.

All segments highlighted in red are exhibiting abnormal motion. Evaluating motion tables is fairly simple in that no matter what the total range of motion should be (far right column), the total motion should be divided up roughly evenly between flexion and extension, i.e., if the total range of motion at C5-C6 is supposed to be 20°, that should be represented by 10° of flexion and 10° of extension- a 50-50 split. Based on that, all the numbers highlighted in red are representative of intersegmental joint dysfunction.

At C0-C1 and C1-C2, the rules for evaluating range of motion are different. Most of the motion should occur in extension, and, for the most part, flexion is merely the return movement from extension because the superior articulating surfaces of the atlas converge to the anterior and present a bony block to further flexion. At C1-C2, the transverse ligament of the atlas wrapping around the odontoid process of C2 prevents not only translation, but angular motion as well. In normal studies, because of each individual’s unique configuration at C0-C1 and C1-C2, most of the time flexion is measured in the negative range, at 0°, or maybe 1-3°, while the greater portion of the motion is measured as extension.

5. **The oblique flexion projection** evaluates the integrity of the facet capsular ligament by observing excessive distraction of the facet joints. In keeping with local convention, films are labeled so as to identify the IVF’s which are being imaged. The left posterior oblique shows the right IVF’s and the right posterior oblique shows the left IVF’s.

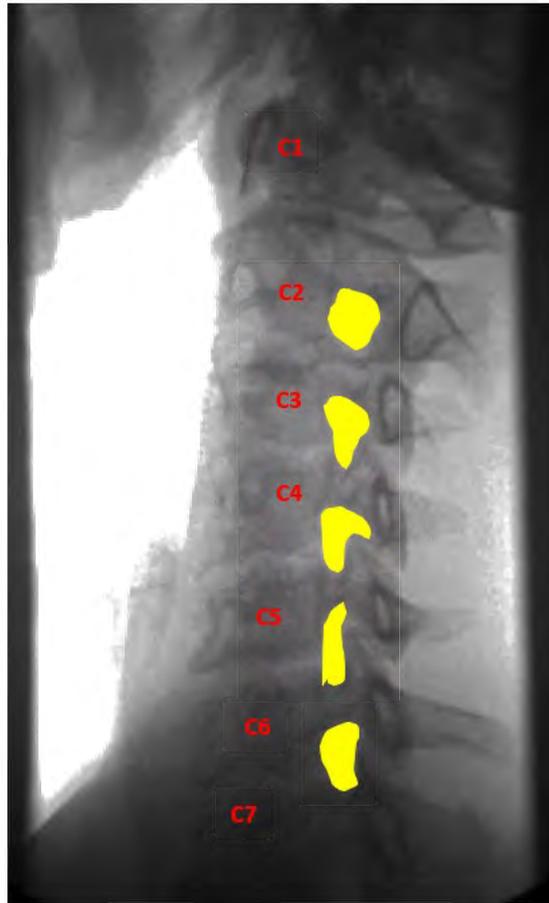


Capsular ligament damage

- Motion in the oblique flexion projection is severely restricted.
- There is significant gapping of the facet joints at C6-C7 on the right.

6. **The oblique extension projection** evaluates the integrity of the capsular ligaments as they limit the extent of imbrication and the patency of the intervertebral foramina as they naturally decrease in size.

- Motion in the oblique extension projection is severely restricted.
- There is hypermobility and intervertebral foraminal encroachment of the facet joint at C5-C6 on the right. The C2-C3 IVF may be used as a normal exemplar.



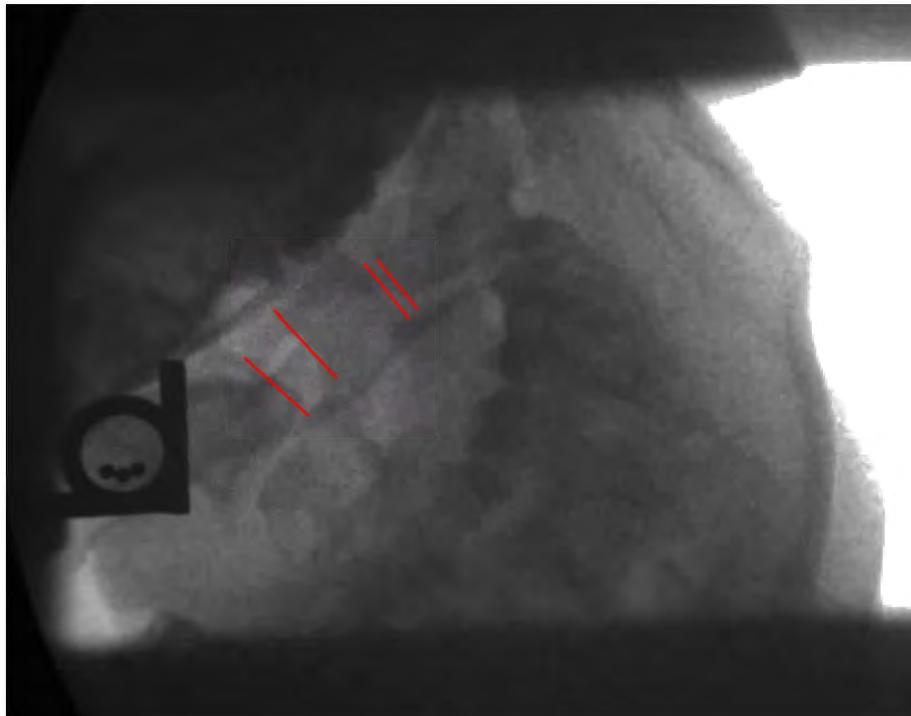
Right IVF encroachment C5-C6

7. **The A-P lower cervical with lateral flexion projection** evaluates the integrity of the facet capsular ligaments via the articular pillars, as well as the coupled motion of the spinous processes. Spinous processes are supposed to rotate to the contralateral side during lateral flexion and rotation. In this case, the APOM view with lateral flexion supplies the best view of the articular pillars.
 - Motion in the A-P projection lateral bending is restricted.
 - There is an increased lateral tilt of the cervical spine to the right.
 - There is no abnormal gapping of the facet joints as observed in the articular pillars.
 - During lateral bending the coupled motion of the spinous processes C3-C6 is normal, as they rotate to the contralateral side, but the C7 spinous process is fixated to the midline. This is related to the medical-grade subluxation present at C7-T1.

8. **The AP rotation projection** evaluates the integrity of the alar ligaments, which are the limiting factor in rotation of the head upon the cervical spine. The internal standard for the evaluation is the relationship of the angle of the mandible to the odontoid process, which represents the midpoint of the body. With intact ligaments, the angle of the jaw should directly overlie the odontoid process at full rotation.
 - Motion in the A-P rotation projection is within normal limits

9. **The APOM with lateral flexion projection** evaluates the integrity of the alar and accessory ligaments during lateral flexion by measuring the amount of laterolisthesis (“overhang”) of the lateral mass of C1 on the lateral mass of C2 bilaterally, and by measuring the asymmetry of the para-odontoid spaces during the lateral flexions. Under normal circumstances, there should be no overhang of C1 on C2 and the para-odontoid spaces should be symmetrical in all positions.

- Motion in the A-P open mouth lateral bending projection is restricted.
- The C2 spinous process is to the left.
- There is a significant abnormal lateral translation of C1 on C2 with an overhang bilaterally. Measurement of the lateral translational displacement is **27% to the left** and 19% to the right. These findings are accompanied by <10% reduction in the width of the adjacent C2 lateral masses, so it is likely that these findings are representative of high-grade alar and accessory ligament lesions (3rd degree sprain on the left and 2nd degree sprain on the right).
- Significant changes are noted at the para-odontoid spaces bilaterally. Asymmetrical para-odontoid spaces “are clinically significant because hypermobility at the atlantoaxial joint can reduce blood flow in the contralateral vertebral artery.”²⁹ As per Taniguchi’s formula, the patient has a score of **16.61%** which is consistent with high-grade alar and accessory ligament lesions (>15.1%=high grade dynamic lateral instability at C1-C2).³⁰ Further evaluation of the integrity of the upper cervical spine by upright cervical MRI is recommended.

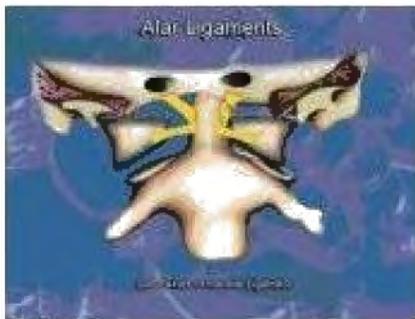


Asymmetrical para-odontoid spaces in LLF

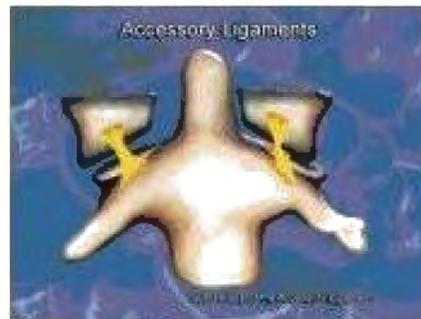


C1-C2 lateral offset to the right. Note the asymmetrical para-odontoid spaces

The instability at the C1-C2 level is known to produce the Craniocervical Syndrome (CCS), which in addition to producing headaches and neck pain, also produces what Dr. Joel Franck, MD, a neurosurgeon in Tampa, FL, calls “bizarre” when he describes the constellation of symptoms which are associated with this, which include poor concentration, diminished memory, tinnitus, ataxia, nausea/vomiting, autonomic disturbances, paresthesia, weakness, and chronic pain.³¹ The last one, chronic pain, is especially interesting, because by the most conservative estimates, more than 20% of all patients with neck injury develop fibromyalgia syndrome shortly after a motor vehicle collision (3.2 months on average).³² Other authors state that the incidence is much higher.



C1 lateral mass overhang



Change in Para-odontoid space

Doctor’s note: Unfortunately, due to the limitations of the Visualizer 2000 technology, C7 and T1 are not adequately visualized. But the measurements at C5-C6 in flexion combined with the visual experience of watching the video leads to the conclusion that the C6-upper thoracic levels are not moving. The literature on cervical spine stress x-rays is unequivocal when it comes to the inclusion of C7-T1 on stress x-rays- they all specifically mention that C7-T1 has to be included. However, on most patients, the shoulder shadow blocks everything inferior to the middle of the C6 or C7 body, and T1 and its spinous process aren’t seen, so the area is not examined properly.

Whiplash literature establishes that both the cervicothoracic facet capsular ligaments and the anterior longitudinal ligament are damaged before the ligamentomuscular reflex can engage, resulting in injury to and dysfunction of the stellate ganglion, a bilateral neurological structure found on the anterior-lateral surface of the C7-T1 level, which functions as the “gatekeeper” for blood flow into the head, neck, and upper extremities.³³ C7-T1 hypomobility is an indication that specific spinal adjustment is required to restore the kinematics of the joint and the normal function of the stellate ganglion. The spinal adjustment delivered cannot be just any spinal adjustment. Diversified adjustment, either prone or supine, will only jam the facets and will not restore the function of C7-T1, and it is not likely that instrument adjusting will be forceful enough to restore the biomechanics of C7-T1. The recommended technique for the restoration of function is a seated Gonstead technique; there has to be someone in your area who can do his, and I would be happy to discuss this further with the referring doctor.

Prior to finding a Gonstead practitioner, though, the status of C7-T1 needs to be defined. A swim view of the cervicothoracic junction with flexion and extension views added can confirm or rule out the involvement of C7-T1. The spinous processes of C7 and T1 have to be included in the image, and this does not have to be done bilaterally. This can be done either with plain films or with the DMX machine, as long as the DMX machine doesn't blow through the spinous processes.

And, if you are able to find a Gonstead practitioner who can do the job, the recovery of motion at C7-T1 will change everything. Despite the fact that it has been 2 years since the patient was injured, it is obvious that whatever treatment he has had has failed because he is so painfully hypomobile. Resolution of the C7 subluxation will change the biomechanics superior to the adjustment radically. The hypomobility is most likely obscuring some of the ligament damage, particularly in the facet joints. It is recommended that after C7-T1 is mobilized, the motion x-ray study be repeated. To this point, I am including with this report an excerpt from my DMX interpretation seminar which will further explain the C7-T1 hypomobility problem and its solution. It's in the form of a PowerPoint movie. Let me know if you have questions

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Questions about this report?

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ALTERATION OF MOTION SEGMENT INTEGRITY (AOMSI)

	Patient (mm)		Established Abnormal (mm)	Established Ratable (mm)	Total Translation (mm)	% Foraminal Encroachment	% Translation	
	A	P					A	P
C2-3	-0.08	1.11	0.60 - 3.50	3.50	1.03	13.32	0.69	9.63
C3-4	0.13	-0.35	0.60 - 3.50	3.50	0.22	---	1.03	2.72
C4-5	1.31	-0.07	0.60 - 3.50	3.50	1.24	---	9.67	0.55
C5-6	0.84	0.17	0.60 - 3.50	3.50	1.01	2.04	5.75	1.16

■ Abnormal / Ratable Segment ■ Normal Segment

Translational loss of motion segment integrity is defined as an anteroposterior motion of one vertebra over another that is greater than 3.5 mm.

Motion Segment Integrity, Translational A - Anterior, P - Posterior

Translational motion is measured by determining the anteroposterior motion of one vertebra over another. Alteration of motion segment integrity (AOMSI) is defined by translational motion that is greater than 2.5 mm in the thoracic spine and 4.5 in the lumbar spine. Using DBI Cervical Category IV, loss of motion segment integrity may be assessed as 25%-28% Impairment of the Whole Person. Using DBI Lumbar Category IV, loss of motion segment integrity may be assessed as 20%-23% Impairment of the Whole Person.

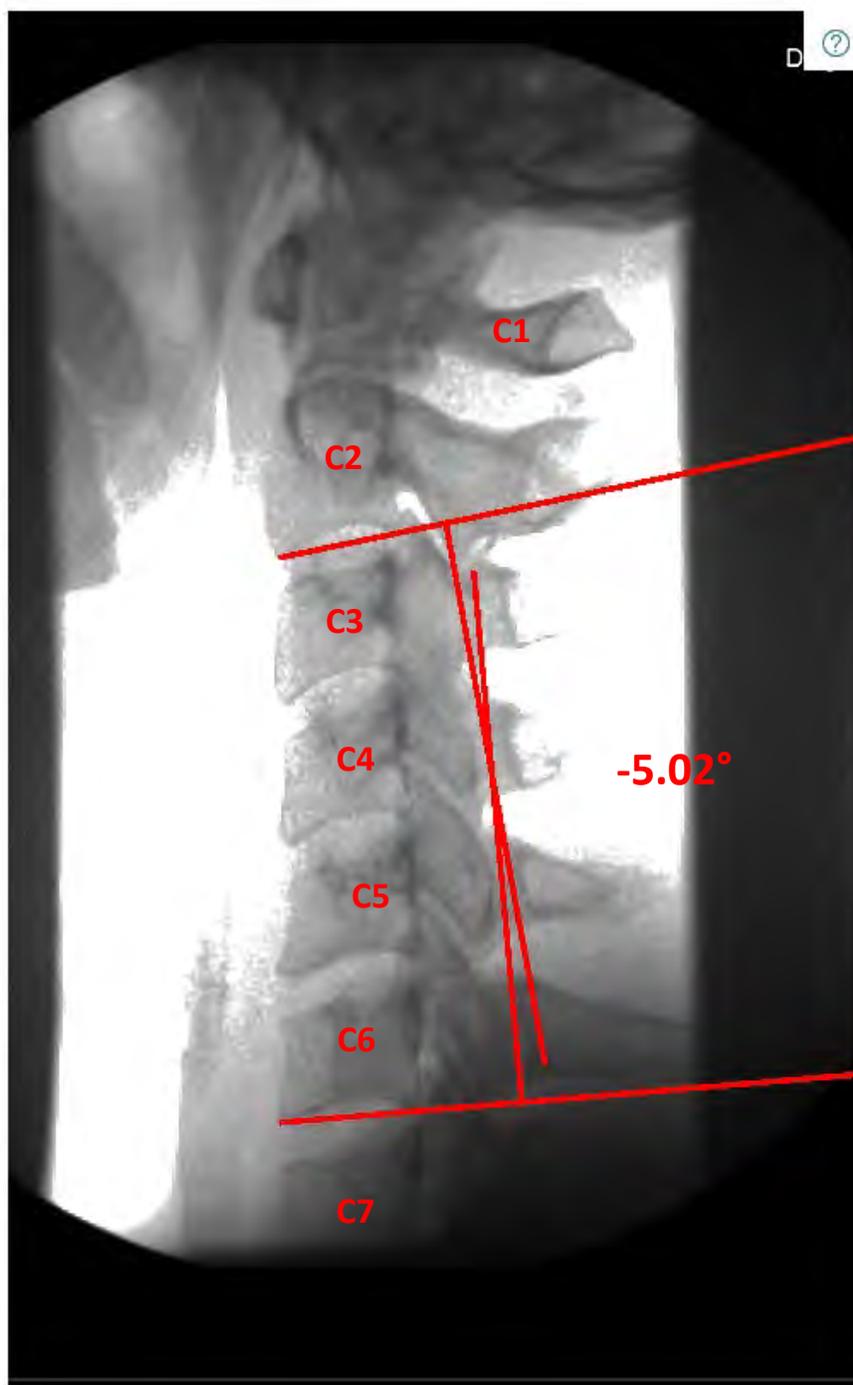
	Patient (°)		Established Abnormal (°)	Established Ratable (°)	Calculated Flexion Angulation (°)
	I (Flex)	S (Ext)			
C2-3	-2.41	-7.33	7.00 - 11.00	11.00	13.62
C3-4	11.21	5.09	7.00 - 11.00	11.00	4.02
C4-5	7.19	-3.37	7.00 - 11.00	11.00	6.06
C5-6	1.13	-10.86	7.00 - 11.00	11.00	---

■ Abnormal / Ratable Segment ■ Normal Segment

Pavlov's Ratio

Segment	Vertebral Width (mm) (B)	Cervical Sagittal Diameter (mm) (A)	Pavlov's Ratio (A/B)
C3	10.68	11.69	1.09
C4	12.35	10.49	0.85
C5	12.53	11.22	0.90
C6	14.81	-10.88	-0.73

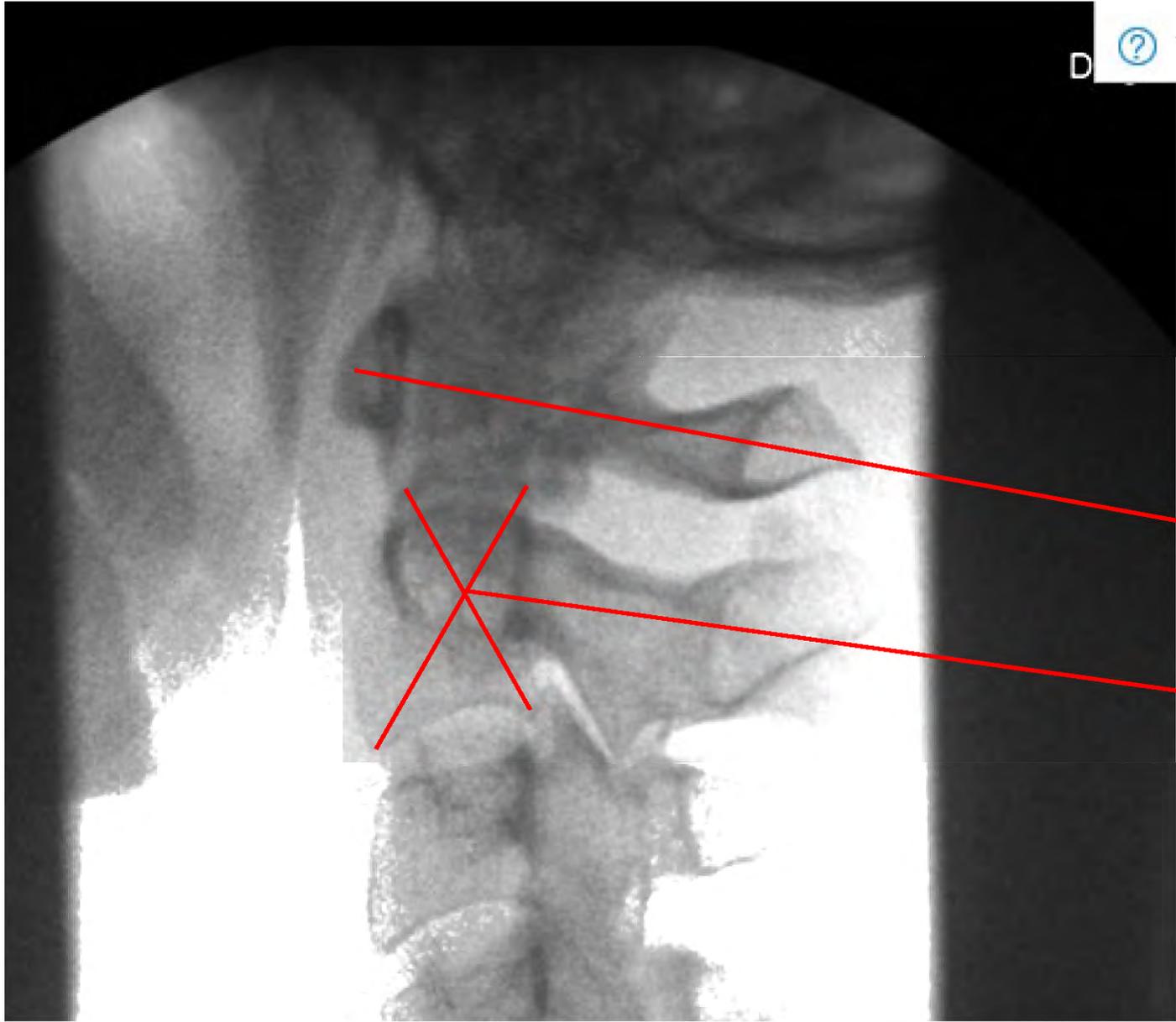
>1.0 is Optimal
0.85 is Borderline Stenotic
<0.80 is Stenotic and Pathological

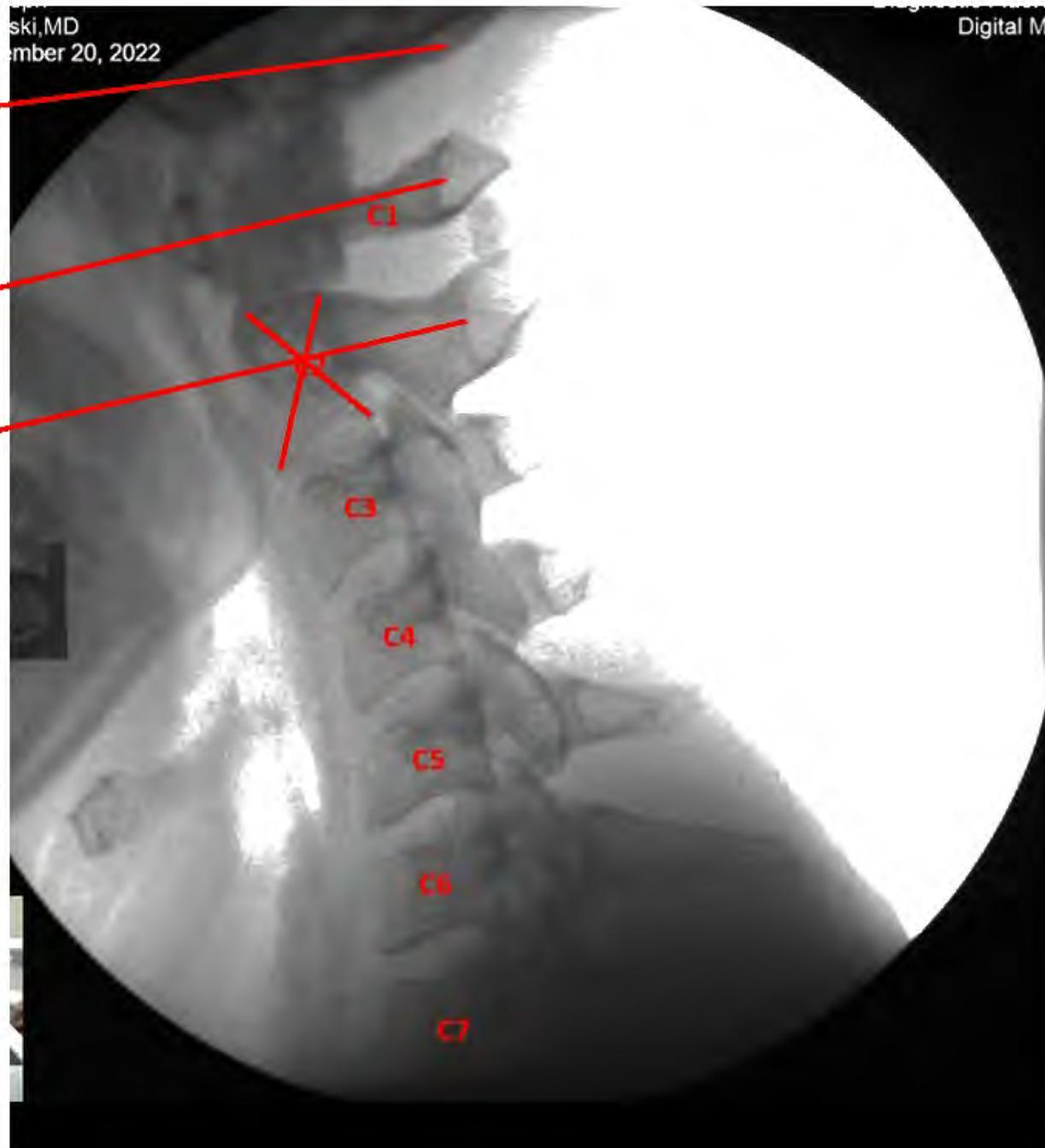






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oussard, Joseph
liam Prominski, MD
uesday, September 20, 2022

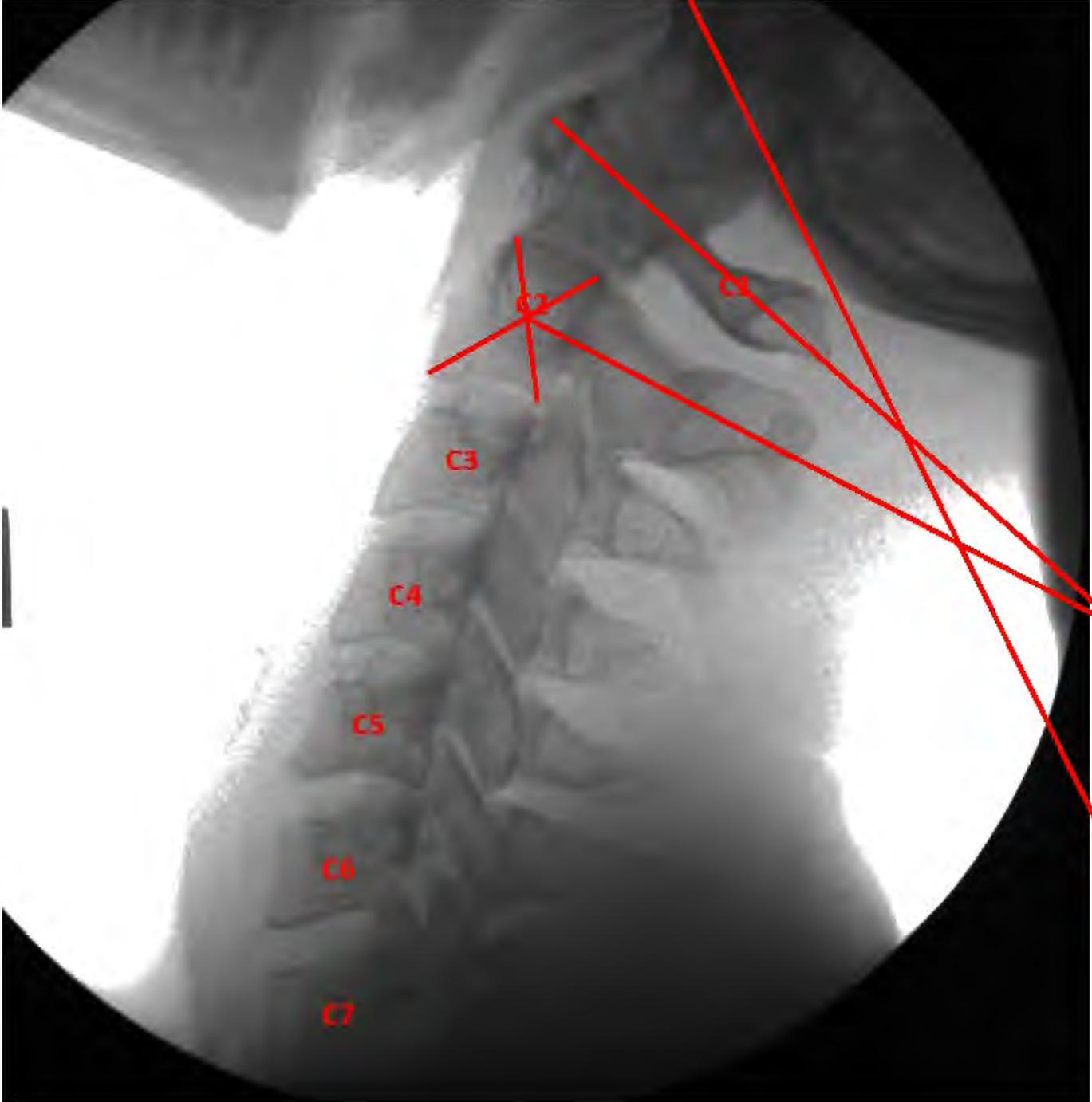
Diagnostic Fluoroscopic
Digital Motion X

C4 A-P Width= 18.16 mm.

50% of C4= 9.08 mm.

30% of C4= 5.45 mm.

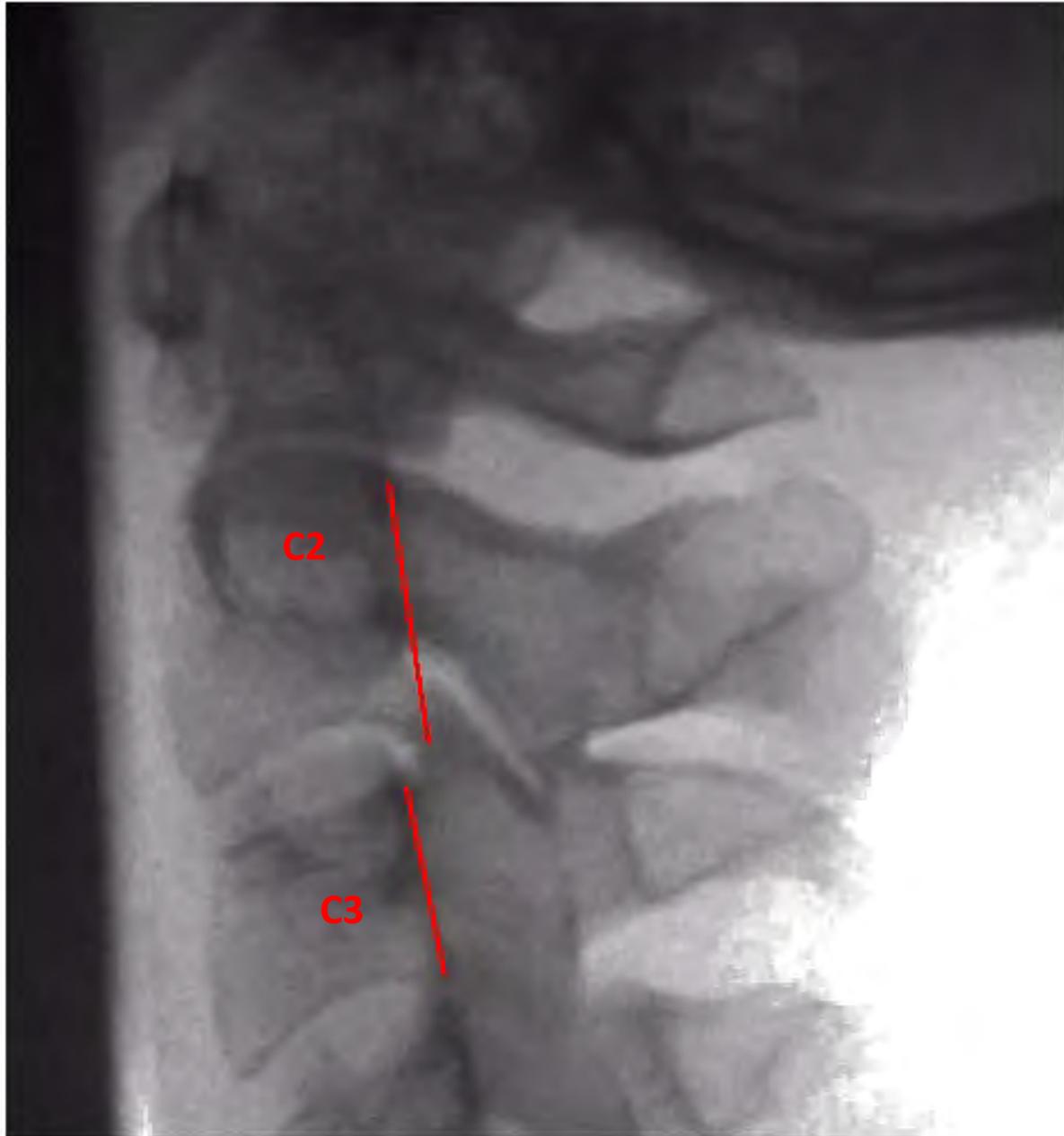


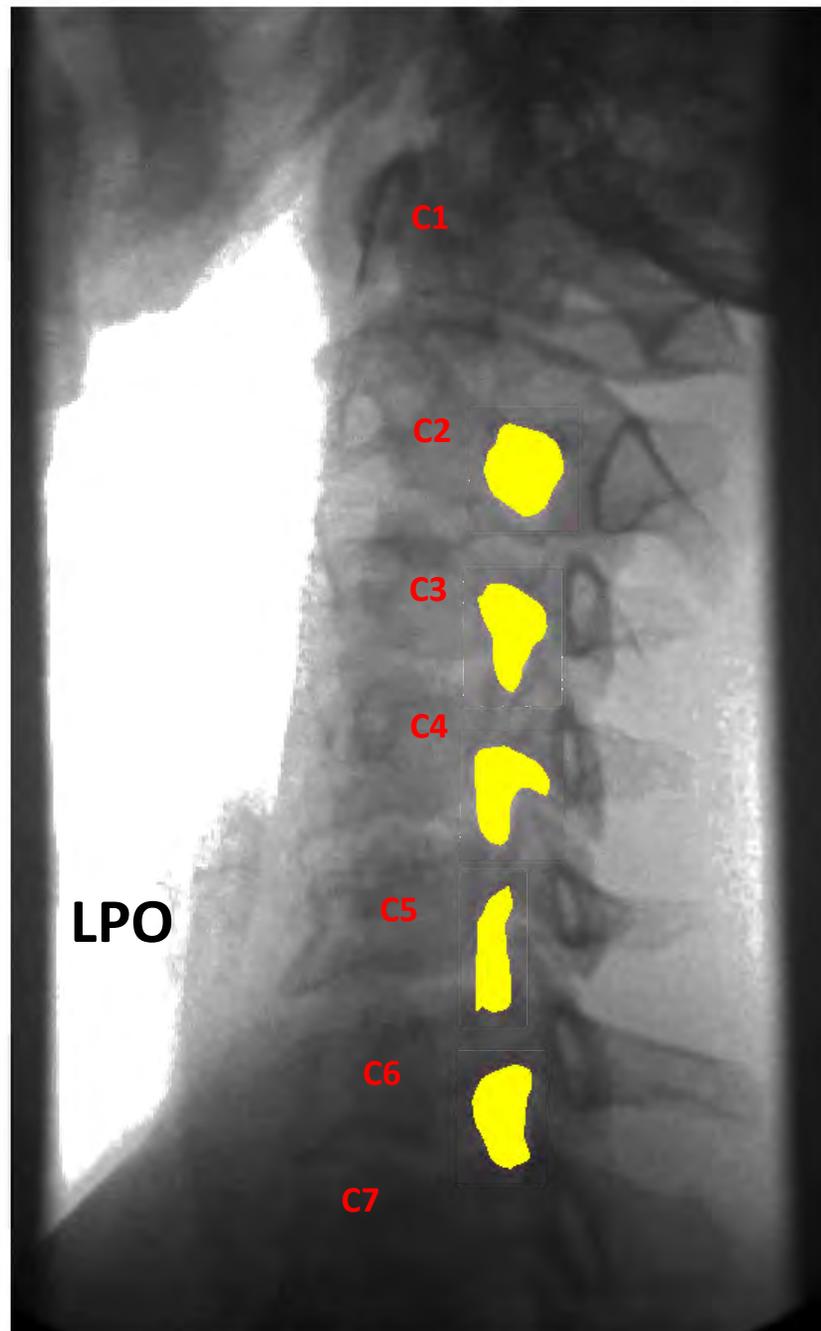


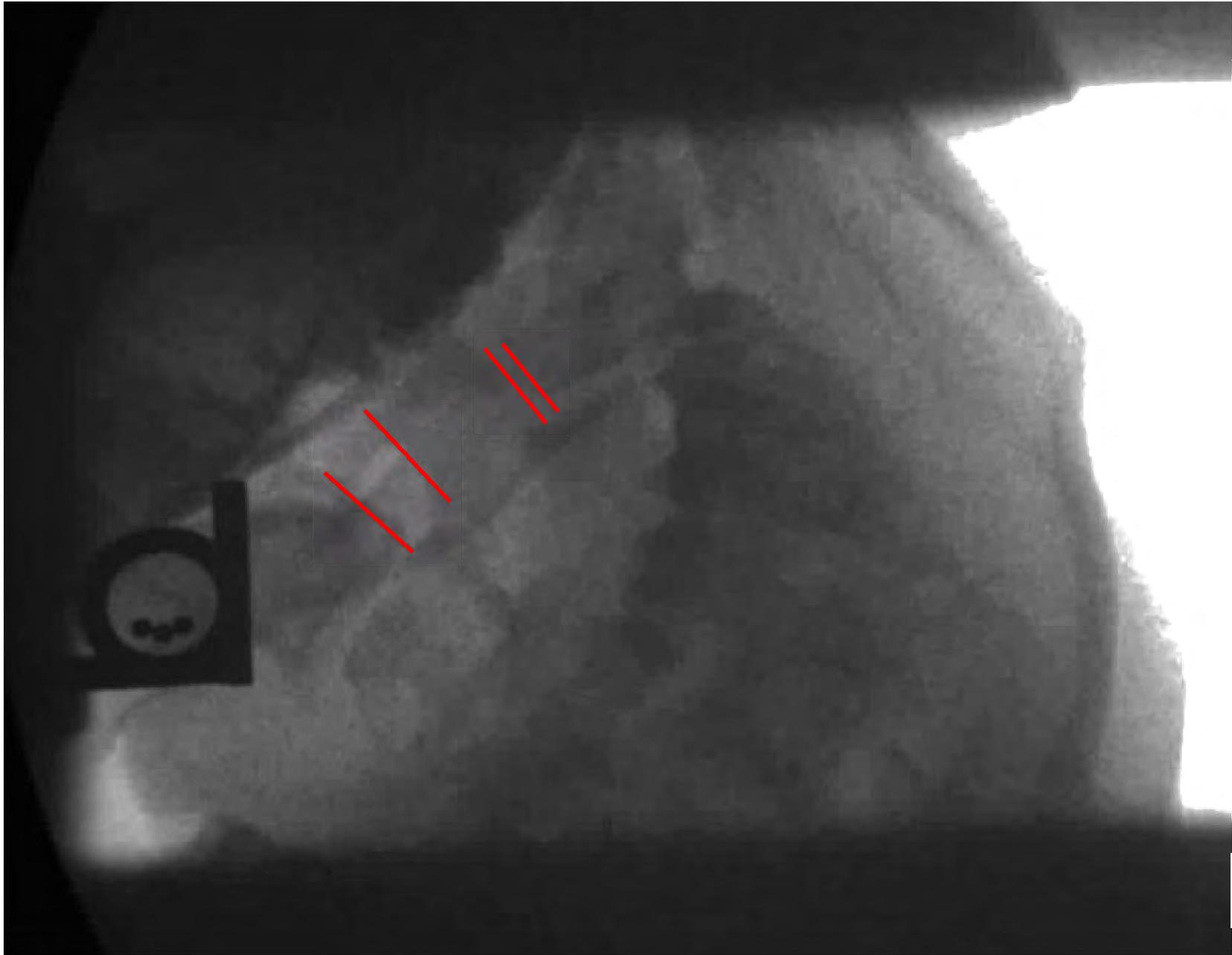


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C1-C2 Lateral Instability

	mm.	left C1 lateral mass width	% translation		mm.	right C1 lateral mass width	% translation
C1-C2	5.42	19.79	27%		4.17	22.08	19%

(0-9% = Grade I Sprain, 10-19% = Grade II Sprain, > 20% = Grade III Sprain)

Interspinous Ligaments

Calculations:	C4	18.16	C2-C3	7.37	C5-C6	10
50% width of C4:		9.08	C3-C4	11.05	C6-C7	
30% width of C4:		5.45	C4-C5	11.32	C7-T1	

Eubanks' Formula:

If the distance between the spinolaminar lines from C3-T1 is greater than 50% of the AP width of the C4 superior endplate on the lateral projection, the interspinous ligaments have been damaged (30% for C2-C3).

Spinal Stenosis

Pavlov's ratio reveals pre-existing spinal stenosis. It is determined by dividing the sagittal canal diameter by the A-P width of the vertebra.

> 1.0 = optimal, < 0.85 = borderline stenosis, < 0.80 = pathological stenosis.

Level	Vertebral Width	Cervical Sagittal Canal Dia	Pavlov's Ratio
C2			
C3	10.68	11.69	1.09
C4	12.35	10.49	0.85
C5	12.53	11.22	0.90
C6	14.81	10.88	0.73
C7			

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