DMX IMAGING
A division of Restore Health of Va

44121 Harry Byrd Hwy. Suite 120
Ashburn, VA 20147
Phone: (703) 777-1234
Fax: (703) 552-7532

Cervical Spine Digital Motion Fluoroscopic (Low-Radiation) X-ray with Computer Digitized Measurement Analysis

Sample Report

setting a new standard for diagnostic fluoroscopy in motion

seeing is believing

with annotated explanation

headache

- ✓ The Gold Standard in Providing **VISUAL & QUANTATIVE Objective Proof** of Spinal Ligament Injury and Permanent Instability commonly missed by other tests.
- ✓ Improve clinical and motor vehicle collision related injury outcomes with accurate diagnosis.
- ✓ Supported by the American Medical Association Guides to the Evaluation of Permanent Impairment along with numerous published peer reviewed studies and Medical Guides.

Facts and Questions About DMX

What is Digital Motion X-ray (DMX)?

Digital Motion X-ray (DMX) technology is a revolutionary diagnostic tool that has transformed the lives of people with chronic undiagnosed pain. DMX is an evolution of X-ray technology to view a video of the spine in real-time motion at 30 exposures per second; at considerably less radiation exposure than would be possible using standard x-ray. It is performed with the patient standing and actively moving in a weight bearing position. DMX is used to evaluate segmental spinal motion. Excessive motion is commonly an indication of ligament damage. Once the images are collected, our facility uses a sophisticated computer digitization software with artificial intelligence to measure and quantify abnormal spinal joint motion based on normative data collected from nationally recognized medical studies and agencies.

When is DMX needed?

o Persistent pain or other related symptoms associated with movement or position of the head or neck.
o Recurrent headache, neck pain, pain across the top of the shoulders and upper back, base of the skull, dizziness, ringing noise in ear (tinnitus), feeling of poor balance, or clicking or clunk when moving your neck.
o There is not a definitive diagnosis as to the cause of symptoms. Other Imaging tests such as MRI, X-ray, CT do not support symptoms.
o Injury has been labeled as soft tissue that should have resolved in 6 weeks.

Can the computerized measurement analysis be performed with standard static (still) x-ray films?

Yes, we can import standard DICOM images to perform the measurement analysis. The advantage of DMX is the ability to see the spine in motion and better visualize proper patient positioning to reduce x-ray exposure.

How does my doctor order a DMX? Do I need a referral?

All they need to do is write "DMX C-spine" on their prescription pad or letterhead along with your name, date of birth, diagnosis code, the provider's name, phone number, address, and their email. If they would like just the measurement analysis for DICOM images that have already be taken, they can call us, and we will provide directions. If you do not have an order from a physician, our doctor can examine you to establish necessity, review results, and provide recommendations.

Does insurance cover DMX?

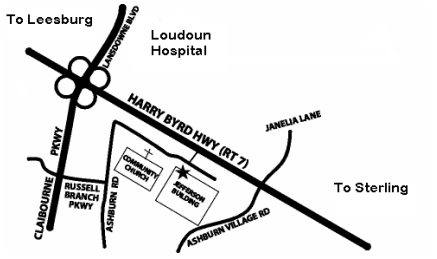
It is often covered by Auto policies medical expense coverage when you have an open claim following a car accident. Some major medical policies cover a portion as well. Our office will assist you in filing a claim with your carrier.

Why do so few imaging centers provide DMX?

We are proud to be the premier facility in Northern Virginia providing this leading-edge diagnostic imaging service since 2005. Unfortunately, it is not utilized as much as it should be in many imaging centers since it is not routinely covered by all insurance carriers, it takes expensive software to digitize and measure the images, and the measurement analysis report takes over an hour to complete. Therefore, it is more cost effective to focus on other services that are better covered through insurance and take less time.

Where is DMX Imaging?

Restore Health of Va
Shandon Thompson, DC, CCSP - Director
44121 Harry Byrd Hwy, #120
Ashburn, VA 20147
www.DigitalMotionXray.com



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(703) 777-1234

This report is for illustration purposes only. X-ray pictures may not correlate with measurements.

Patient Name: Sample Patient
Referring Physician: John Smith, MD

Date of Birth: 08/24/1990
Date of Exam: 02/06/2023

CERVICAL SPINE DIGITAL MOTION FLUOROSCOPIC X-RAY WITH COMPUTER DIGITIZED MEASUREMENT ANALYSIS

The purpose of this evaluation is to view, measure, and analyze the position and movement of vertebral motion for stability. This radiographic computer digitization motion analysis is not intended to determine pathology beyond evaluating segmental vertebral motion. Clinical correlation of abnormal finding advised. The digital motion x-ray, image digitization, and computer analysis was performed at DMX Imaging / Restore Health of Va. The radiographic computer digitizing analysis methods used in evaluating this study are published for reliability and validity.

HISTORY: Neck pain, headache swallowing, ear pain, tinnitus, dizziness, blurred vision, balance.

STUDY: Views of the cervical spine include: Neutral Lateral, Flexion, Extension, Obliques, AP Open-Mouth Neutral and Lateral Bending, Oblique Flexion and Extension.

RADIOGRAPHIC IMPRESSION: (based on computer digitized measurements - see following pages)

- **Lateral cervical spine**: George's posterior body vertebral offset line on neutral projection. Within normal limits. (Measurements over 1.7mm suggestive of ligamentous injury).

  Cervical lordosis measurement: 16 degrees, representing a 62% loss from ideal.

  Forward head translation C2 from C7: 5mm. (Normal considered less than 15mm)

  Lateral atlanto-dental interspace (transverse ligament): within normal limits on neutral and extension, slight increase in flexion.

  Bilateral C1 posterior ponticus. Appears to be complete ossification of the C1 posterior arch arcuate foramen/ posterior atlanto-occipital ligament around the vertebral artery.

- **APOM Lateral Bending: Lateral translation of C1 on C2** (alar/accessory ligament complex):

  Neutral position of C1 lateral masses relative to C2. Right: 4.9mm / Left: 0.8mm

  Left Lateral Flexion: C1 overhang of 7.3mm, consistent with atlantoaxial ligamentous laxity with asymmetrical paraodontoid spaces.

  Right Lateral Flexion: C1 overhang of 5.9mm, consistent with atlantoaxial ligamentous laxity with asymmetrical paraodontoid spaces.

- **Segmental angulation during flexion** (posterior longitudinal ligament, interspinous, supraspinous, capsular ligament complex): within normal limits.

- **Segmental angulation during extension** (anterior longitudinal ligament): Excessive motion C3-C4 and C5-C6 indicative of spinal ligament laxity.
- **Total Angular Excursion***:* Excessive motion at C5-C6 indicative of spinal ligament instability.
- **Segmental translation during flexion** (posterior longitudinal ligament, interspinous, supraspinous, capsular ligament complex): within normal limits.
- **Segmental translation during extension** (anterior longitudinal ligament): Excessive motion at C3-C7 indicative of spinal ligament laxity.
- **Total Translation Excursion***:* Mild global laxity but not exceeding alteration of motion segmental integrity limit.
- **Total segmental range of motion during flexion and extension:** Segmental hypermobility: C3-C4. Segmental hypomobility noted at C2-C3, C4-C5. Note: Multi-level segmental ROM hypomobility for combined flexion/extension may indicate protective muscle guarding thus limiting detection of greater laxity.
- **Oblique Flexion/ Extension and Lateral Bending:** (capsular ligament integrity) Note: for posterior oblique projections - viewing opposing facet/IVF. Posterior Oblique Extension (facet encroachment, IVF narrowing): Left: C3-C5 Right: C3-C5

Comment: Most prominent area of significant hypermobility/laxity is noted with C1 lateral bending with bilateral posterior ponticus formation. This could compromise the vertebral arteries. Her C1 hypermobility without global hypermobility throughout her cervical spine may be considered more likely a result of past trauma.

Doctor's Signature

Neutral Lateral Cervical Digital Radiograph

Picture in Picture technology allows for both patient identification and correlation of the patient's external and internal body movements.

The GREEN curved line represents the Normal Spinal Lordotic Position and expected path of the posterior longitudinal ligament. The RED hashed line represents the Patient's Position.

Loss of cervical lordosis is a significant indicator of long - term chronic pain and cervical spine dysfunction.

Lordotic Curvature Analysis

*Ideal Lordosis	Patient (°)	%Loss	Forward Head Position (mm)
-42°	**-16**	**62**	**5**

*The cervical lordosis measured from C2-C7 for a normal average adult population is -34º with ideal alignment measuring -42º.[1,2] In the pediatric age group 16 years and under, the ideal lordosis measurement is -26.4 º. Note that the negative sign preceding the measurement of degree indicates direction, thus the normal lordotic/extended position is noted by a negative angle and an abnormal flexion angle/kyphosis is noted by a positive angle). There is a statistically significant association between cervical pain and lordosis < -20º.[3]

Further, there is no evidence that hypertonicity as seen in muscle spasms in muscle groups responsible for anterior cervical translation and head flexion have any significant impact on cervical lordosis.[4] Regarding anterior cervical translation from C2 relative to C7 (forward head position) findings of less than 15mm has been established as a normal.[1,2]

Atlanto-dental Interspace

The atlanto-dental interspace is the distance between the anterior margin of the C2 odontoid to the posterior mid margin of the anterior arch of C1. Excessive motion suggests laxity of the transverse, alar ligament complex.

	Neutral	Flexion	Extension
Normal <3 mm adult, <5 mm child	2.2	3.1	2.9

Abnormal finding italicized in RED.

C1-C2 Lateral Translation Values During A-P Open-Mouth Lateral Bending

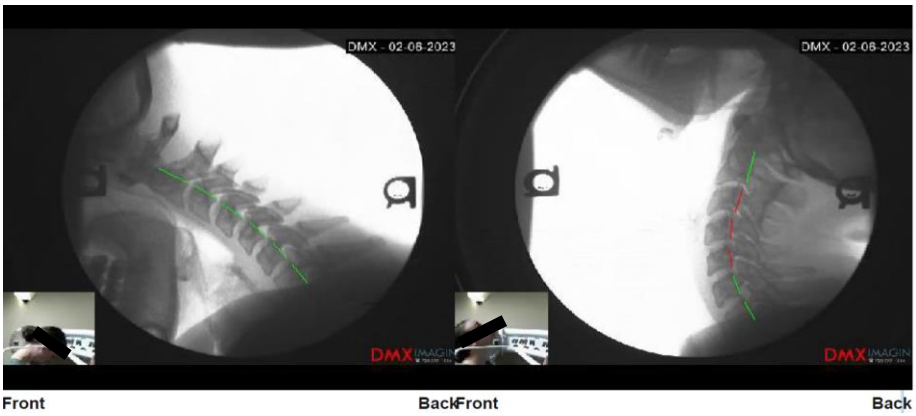
Instability of the alar and atlanto-axial ligaments may cause episodes of vertebral basilar artery insufficiency provoked by turning of the head.

Direction of Lateral Bending	Para-odontoid spacing- (mm)	Patient's Values- (mm)
C1-C2 Neutral	asymmetric	Right: 4.9mm / Left: 0.8mm
C1-C2 Lateral Translation – Left	asymmetric	***7.3***
C1-C2 Lateral Translation – Right	asymmetric	***5.9***

Abnormal finding italicized in RED.

Lateral slippage of C1 away from C2 greater than 2.0mm is indicative of hypermobile subluxation.[10-11]
Lateral slippage greater than 3.0mm indicates atlantoaxial instability.[12-14]
Lateral slippage greater than 4.0mm indicates strong correlation between atlantoaxial instability and symptomatic presentation following a whiplash associated injury.[10]

Lateral Cervical Flexion/Extension Radiograph



These measurements show the amount of intervertebral angulation (or tilting between two vertebrae) during each movement.

These measurements show the amount of anterior/posterior translation or slippage during flexion and extension.

Endplate Analysis for Flexion/Extension Positions

Intervertebral Angulation *Normal < 11° < 23°				Intervertebral Translation **Normal < 2mm <3.5mm			
Flexion	**Extension**	**Excursion**	**Segment**	**Neutral**	**Flexion**	**Extension**	**Excursion**
-3.5	-8.8	5.3	C2-C3	-0.9	0.3	*-1.7*	2.0
1.5	***-15.6***	*17.1*	C3-C4	-0.9	0.3	***-2.9***	3.2
1.6	-10.1	11.7	C4-C5	-1.0	0.2	**-3.0**	3.2
8.4	**-15.6**	**24.0**	C5-C6	-0.1	0.2	**-2.7**	2.9
10.2	-11.4	21.	C6-C7	-1.1	0.3	**-2.7**	3.0

Neutral vertebral positioning. A negative value indicates a retrolisthesis.

***Intervertebral Angulation** greater than 11° (italicized in RED)is indicative of spinal instability at that motion segment.[5-7]Note that Extension measurement are NOT rated for angular instabilities by the AMA Impairment Guides. Measurements of 11° or greater difference/variance between adjacent motion segments in flexion indicates a spinal instability that may be ratable as an **AOMSI**. [8-9] Indicated by an **"A"**. See below AOMSI definition.

** **Unilateral Intervertebral Translation** greater or equal to 2.0mm (italicized in RED)is indicative of spinal instability at that motion segment.[5-6,10] Total translation excursion is the full movement throughout flexion and extension. Total measurements of 3.5mm or greater indicates a spinal instability that may be ratable as an **AOMSI**.[8-9]Indicated by an **"A"**. Neutral is the position prior to bending and recorded when over 2.0mm.

The AMA Guides place a high value impairment rating on loss of motion segment integrity. It is so important and severe that that the Guides equate this damage as equal to a 50% compression fracture (collapse) of a vertebrae, and more severe than a intervertebral disc herniation.

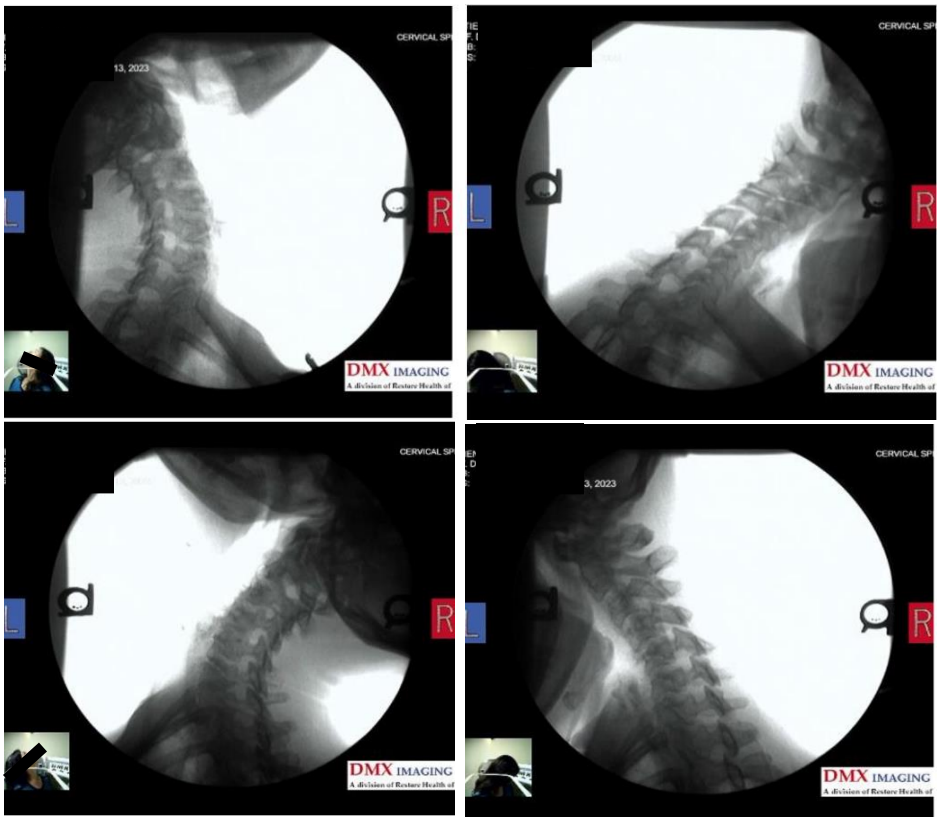
The American Medical Association Guides to the Evaluation of Permanent Impairment,4th-6th Editions, defines **Alteration of Motion Segment Integrity (AOMSI)**as a significant instability providing at least a25% whole body permanent impairment upon reaching maximal medical improvement. The diagnosis of Spinal Instability (M53.2X1/ M53.2X2) may be assigned to this degree of instability. AOMSI measurements are often used by major medical insurance company guidelines as a qualifier for surgical fusion.

Total Segmental Motion during Flexion and Extension

Segmental Angular Excursion	Normal values (degrees)	Patient Values
C2-C3	12.5	3.8
C3-C4	17.5	21.3
C4-C5	21.2	13.6
C5-C6	20.5	22.8
C6-C7	18.1	17.9

The normal values in the above chart are an average from three individual studies (Penning, Dvorak and Wu) which have been shown to be valid methods for measuring total segmental range of motion from flexion to extension in assessing cervical spine stability .[15] Patient values are recorded in the far-right column. Values greater than a 2 degrees difference in ***RED*** indicate regions of global (hyper)mobility. Values greater than 2 degree difference in **GREEN** indicate regions of global (hypo)mobility.

Oblique Projection View(s)



Note: for posterior oblique projections - viewing opposing facet/IVF.
Posterior Oblique Extension (facet imbrication): Left: C3-C5 Right: C3-C5

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[4] Fedorchuk, CA, McCoy M, Lightstone DF, et al. Impact of Isometric Contraction of Anterior Cervical Muscles on Cervical Lordosis. J Radiol Case Rep. 2016 Sep 30;10(9):13-25. E Collection 2016

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[7] White, A.A., Johnson, R.M., and Panjabi, M.M.: Cervical spine mechanics as a function of transaction of components *.J. Biomechanics*, 8:327-336,1975.***(11°,2.7mm)***.

[8] White, A.A , Johnson, R.M., Panjabi, M.M., and Southwick ,W.O.: Biomechanical analysis of clinical stability in the cervical spine. *ClinOrtho*,109:85,1975. (***11°AV,2.7mm=3.5mm)***

[9] Guide to the Evaluation of Permanent Impairment,4th, 5th, and 6th Edition, American Medical Association 1993, 2000, and 2007.(***11°AV,3.5mm)***

[10] Freeman M ,Katz E, Rosa S, Gatterman B, Strommer E ,Leith, W:Diagnostic Accuracy of Videofluoroscopy for Symptomatic Cervical Spine Injury Following Whiplash Trauma. *Int .J of Environmental Research and Public Health* 2020, 17, 1693**(2.0mm,4.0mm)**

[11] Hohl M, Baker HR: The atlanto-axial joint. *J Bone Joint Surg [Am]*46:1739,1964. **(2.0mm,4.0mm)**

[12] Porterfield JA, DeRosa C. **Mechanical Neck Pain: Perspectives in Functional Anatomy**. Philadelphia, Pa: WB Saunders Co;1995 **(2.0mm-3.0mm)**

[13] Louis R: Stability and instability of the cervical spine. **Cervical Spine**. Chicago, Springer-Verlag,1987 **(3.0mm)**

[14]Panjabi MM, Summers DJ, Pelker RR,et al: Three-dimensional load displacement curves due to forces on the cervical spine *.J Orthop* 4:152-161, 1986 **(3.24mm,3.0mm).**

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