

The Cranio-cervical junction, Hypermobility & Upright M.R.I.

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UPRIGHT M.R.I.

Why do we persist in scanning the spine lying down?



Upright MRI

Upright MRI allows patients to simply walk in and be scanned while lying supine, standing up or sitting down.



UPRIGHT M.R.I.



GRAVITY

GRAVITY



UPRIGHT M.R.I.



GRAVITY



GRAVITY

Cerebellar Tonsils



GRAVITY



GRAVITY

Case Study

Case courtesy of J.P. Elsig, M.D.
Zurich, Switzerland

A 50-year-old woman had been suffering for years from neck pain. A prior recumbent MRI had shown a C5-6 disc degeneration with a posterior bulge and a moderate segmental kyphosis.

Despite repeated attempts with conservative treatment, the patient's symptoms worsened and were marked by the onset of:

- ***transient paresthesia***
- ***transient loss of muscle tone in the legs***
- ***drop attacks***

Which could not be explained by the disc bulge.

The recumbent cervical MRI shows a C5-6 disc bulge in a patient with neck pain which sometimes radiates to the arms



The **UPRIGHT** MRI shows a position-related downward herniation (Chiari I malformation) with compression of the brain stem. This correlates with the additional complaints of dizziness and occasional drop attacks when bending forward.

Cervical Whiplash and Chiari : Coincidence, Correlation or Causation ?

A case-control study of Cerebellar Tonsillar Ectopia and
Cervical Spine trauma

Freeman M D,
Rosa S,
Harshfield D,
Smith F W,
Bennett R,
Olson T,
Centeno C,
Kornel E,
Hefez D,
Nystrom A,
Kohles S,

Forensic Epidemiologist
Chiropractor
Radiologist
Radiologist
Rheumatologist
Anatomist
Physiatrist
Neurosurgeon
Neurosurgeon

Biomechanist

Brain Injury July 2010; 24(7-8): 988-994

Method

MRI studies of the cervical spine and base of the skull from 1200 consecutive neck pain patients 18 years and older presenting to 4 different outpatient radiology centers over a 3 year period were reviewed.

Half of the scans (600) were acquired from a facility with a 0.6T upright open MRI scanner.

The other half (600) were obtained from a facility with a 0.7T conventional recumbent open MRI scanner.

The scans were further subdivided into 2 subgroups;

Half were from patients with neck pain following a road traffic accident.

Half were from patients with no recent history of trauma.

The resulting 4 groups comprise 300 scans each

Recumbent Non-trauma	(RNT),
Upright Non-trauma	(UNT),
Recumbent Trauma	(RT),
Upright Trauma	(UT).

The images were interpreted by two radiologists, blinded with regard to the clinical history and scanner type.

The scans were categorized by the level of the lowest point of the cerebellar tonsils relative to the basion-opisthion line



Basion – Opsthion Line

Tonsil position - grading criteria

Tonsil position	Position relative to B-OL
+3	>5 mm above
+2	3 mm to <5 mm above
+1	1 mm to <3 mm above
0	<1 mm above to <1 mm
below	
-1	1 mm to <3 mm below
-2	3 mm to <5 mm below
-3	>5 mm below

Results

Average tonsil station

The relative frequency of tonsil at and below the foramen magnum for each group and by gender.

Analysis of variance (ANOVA) with a Tukey pairwise comparison was used to evaluate for significant differences in average station among the subgroups and genders.

Chi-square goodness of fit test used for evaluation of the proportional differences between the groups.

A Kappa statistic was used to assess the level of agreement between the two radiologists. (Analyse-It, Leeds UK).

Results

Of the 1200 scans 5 were considered uninterpretable for tonsil station by one or the other of the radiologists.

All 5 were in the recumbent trauma group.

Amongst the remaining 1195 subjects

The average age was

41.5 and 39.7 years in the trauma group

57.4 and 54.0 years in the non-trauma group
(recumbent and upright, respectively).

The majority of subjects were female in all groups.

Results

There was good agreement between the two radiologist readers regarding tonsil station (kappa range 0.85 to 0.95).

Both injury status and scan type (recumbent vs. upright) were associated with significant differences in the average tonsil station ($p = <0.0001$).

Results - Mean tonsil station

Non-trauma group tonsils were below the B-O Line in

5.7% recumbent

5.3% upright

Trauma group the tonsils were below the B-OL in

9.5% recumbent

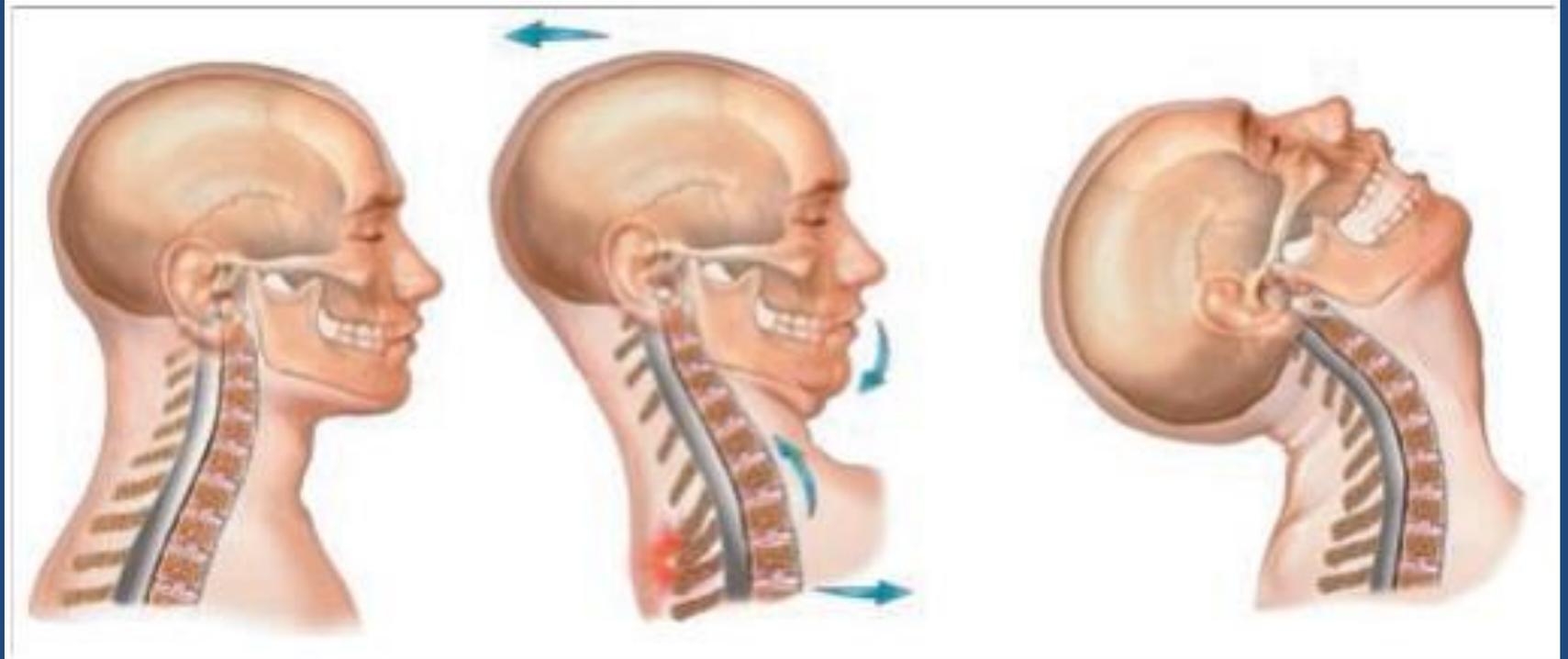
23.7% upright

($\chi^2=0.0001$).

WHIPLASH ASSOCIATED DISORDER.

- Neck pain
- Headache
- Shoulder pain
- Difficulty Swallowing
- Blurred vision
- Ringing in the ears
- Nausea
- Fatigue & Weakness
- Irritability
- Dizziness
- Vertigo

WHIPLASH ASSOCIATED DISORDER





Healthy Normal

10 Years After Whiplash

Good Discs

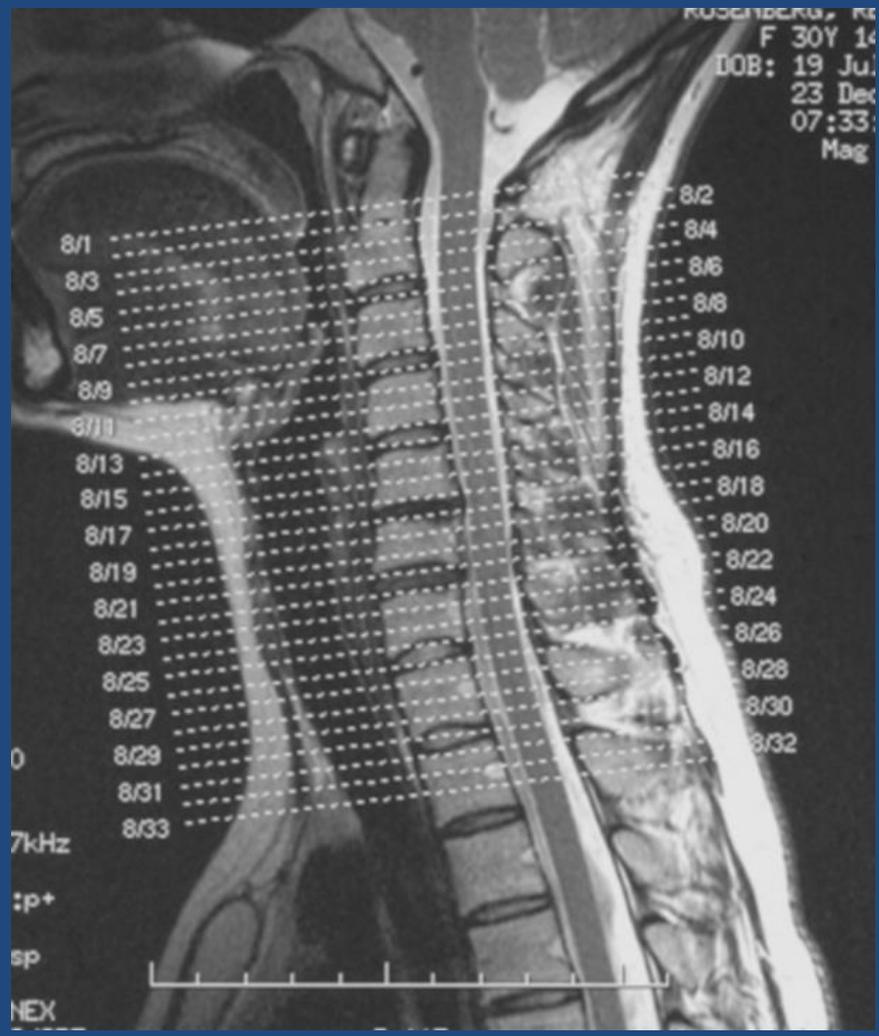
Smooth Curve

Even Alignment

Flatlined Curve

Sharp Misalignment

Disc Injury



Method and Materials :

40 patients 15 - 72 yrs. (Mean 48yrs),

All the patients previously investigated following hyperextension injury of the neck , who had reportedly normal MRI examination of the cervical spine were entered in to the study.

The previous MRI examinations had comprised :

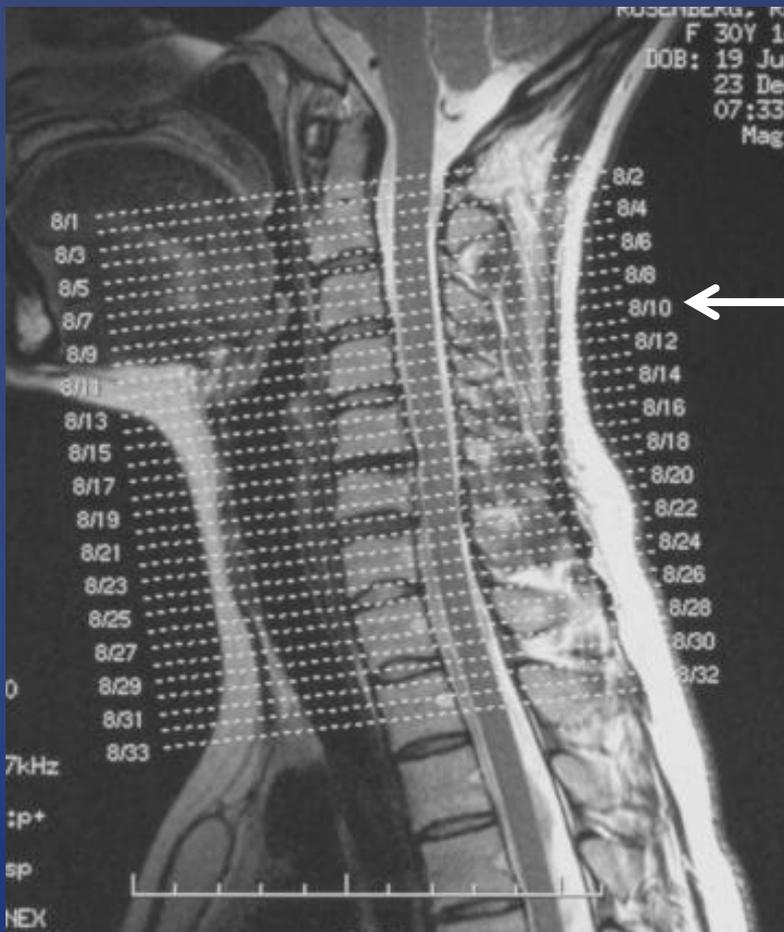
Sagittal T1 & T2 weighted images

Axial T2 weighted images at all levels from C2 - T1

Conventional MRI examinations comprise:

Sagittal T1 & T2 weighted images

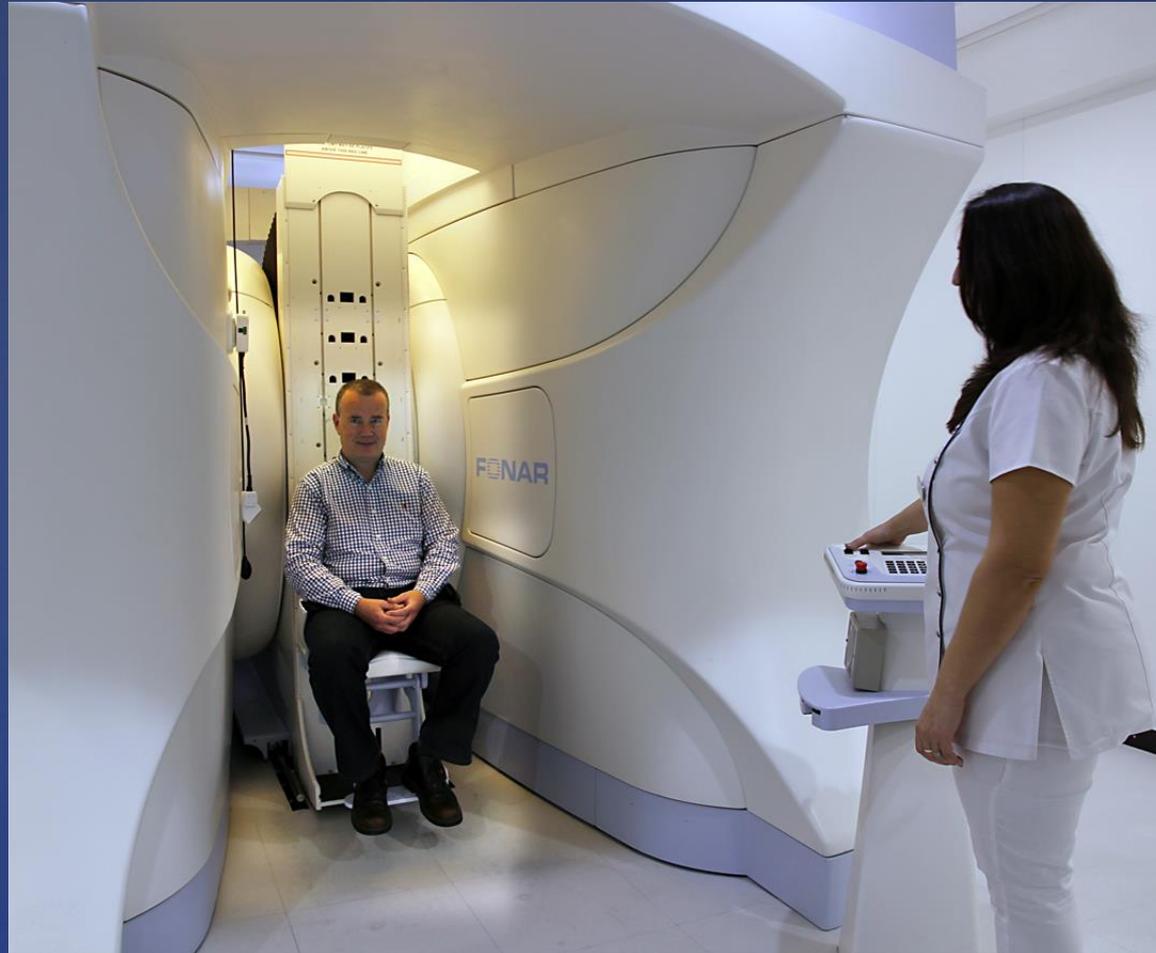
Axial T2 weighted images at all levels from C2 to T1



This Scout view from a conventional Supine (Lying down) MRI Scan, shows the limited levels at which the axial sections are made

You will note the junction between the head and spine is not routinely scanned (The cranio-cervical junction)

Patients are studied in the seated upright position



Images are made as follows:

All patients were scanned seated in an Upright MRI scanner

1. Sagittal T1 & T2 weighted images together with axial T2 weighted images at all levels from C2/3 to C7/T1
(The same as is routinely performed in supine position)
2. Sagittal T2 weighted images with the neck in flexion and extension.
3. Coronal and axial proton density images made from the skull base down to the C2/3 level.
4. Axial proton density images of the atlanto-axial joints made with head turned to the right and to the left

All studies are assessed for:

- Spinal alignment and measurement of the Cervical Spine Angle
- Integrity of the intervertebral discs
- Integrity of the neck muscles
- Facet joint alignment
- Spinal instability
- Measurement of the Clivo-axial Angle, Grabb-Oakes interval and the Harris measurements.
- Alignment of the atlanto-axial joints and atlanto-occipital joints
- Integrity of the alar and cruciate ligaments
- Cerebellar tonsillar ectopia

RESULTS

In over 50% of patients (22), no additional information was gained.

In the other 18 patients, 16 showed ligamentous damage at the atlanto-axial joint, of which 10 had dislocation, 2 of which showed instability on the rotation images. 2 had atlanto-occipital joint dislocation.

Cerebellar tonsillar ectopia was seen in 10 patients.

CONCLUSION

When cost implications of under diagnosis of mechanical damage at the cranio-cervical junction is very large, the current practice of limiting imaging to below C2 is inadequate and under-estimates the incidence of post traumatic ligamentous damage.

For thorough MRI examination, imaging of the cranio-cervical junction is important, to find or exclude ligamentous damage.

CLINICAL RELEVANCE/APPLICATION

The cost implications of under diagnosis of mechanical damage at the cranio-cervical junction, both in terms of patient suffering and cost in insurance claims, is very large

We believe it is of paramount importance :

1. To show any dislocation and ligamentous damage when present
2. Also to exclude such damage when it is not present

(Unless it is specifically looked for, any damage at the cranio-cervical junction cannot be excluded from a limited cervical spine examination.)

The Craniocervical junction syndrome

Whiplash injury

Hypermobility Spectrum Disorder

Ehlers Danlos Syndrome

Myalgic Encephalomyelitis (M.E.)

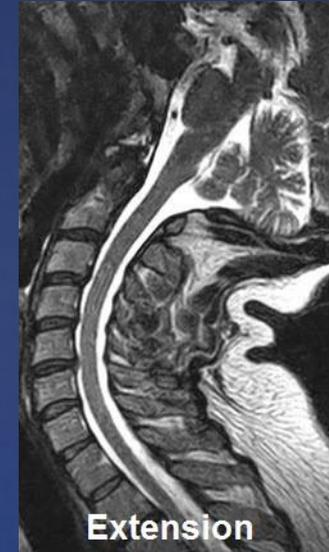
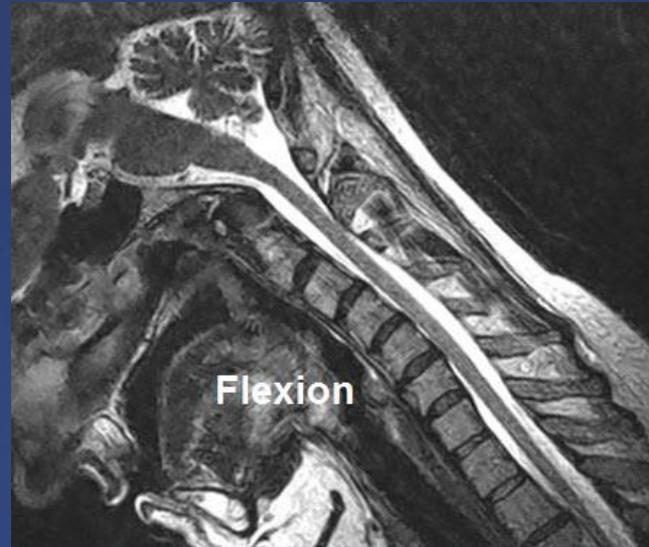
The chronic fatigue syndrome (C.F.S.)

Fibromyalgia rheumatica

Lyme disease

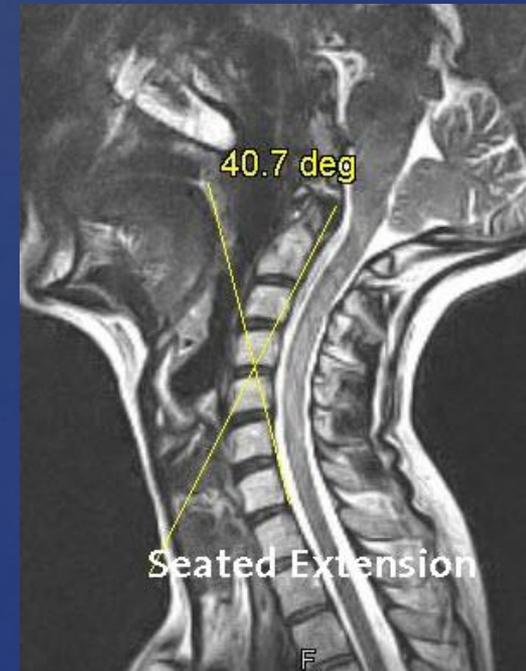
Chiari syndrome

Views used to examine the cervical spine



Cervical Spine

Cervical Spine Angle



Clivo-vertebral or Clivo-axial angle
(normal range 150°-180°).



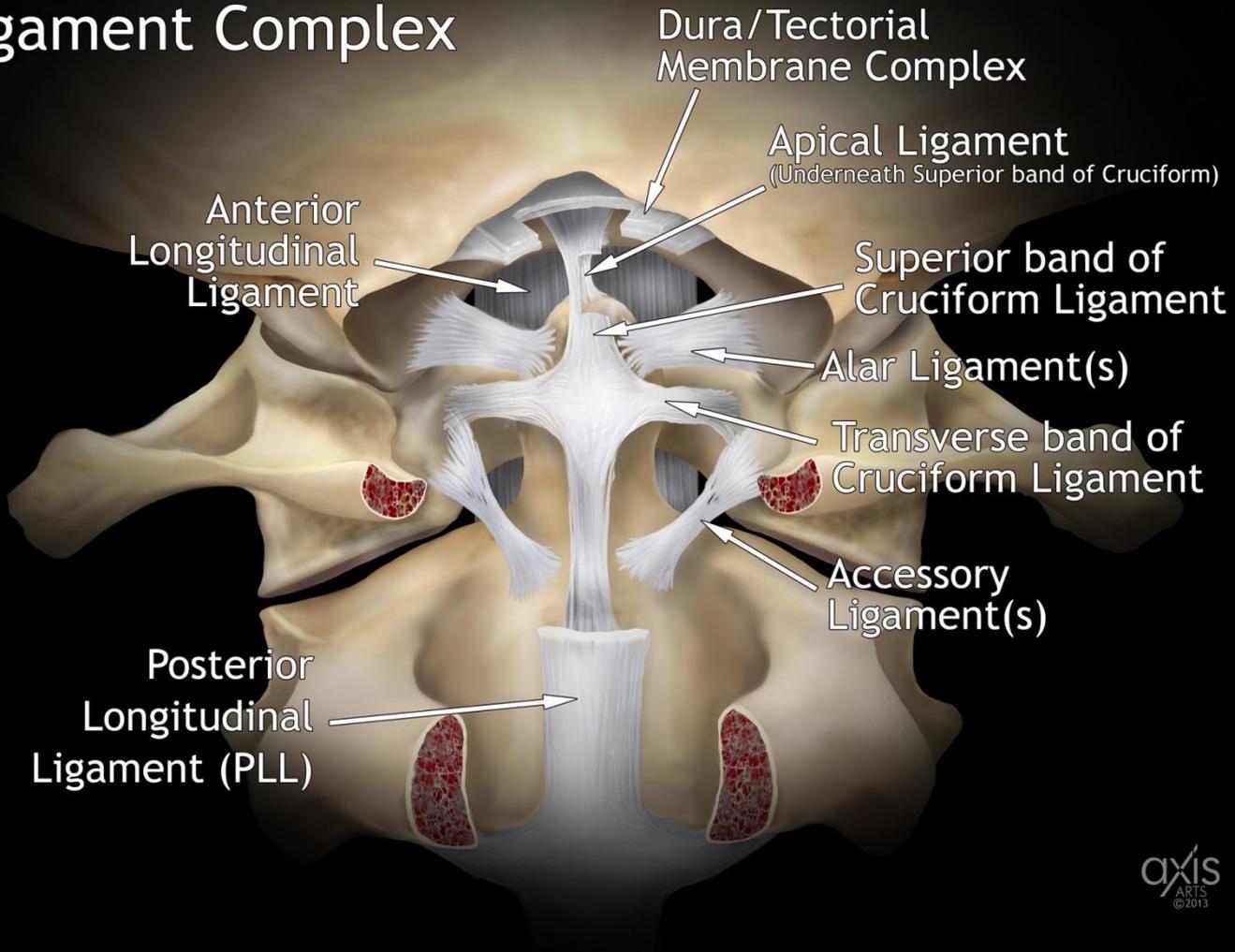


(The Grabb-Oakes measurement is the perpendicular distance from the BpC2 line [Basion to posterior inferior C2 body] to the dura. A value greater than or equal to 9 mm indicates ventral brainstem compression)

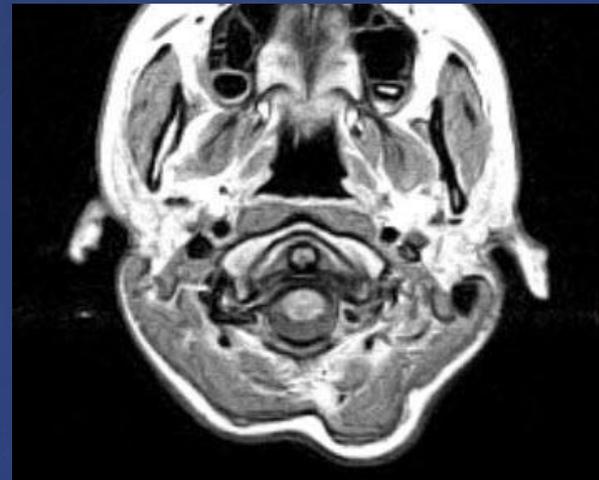
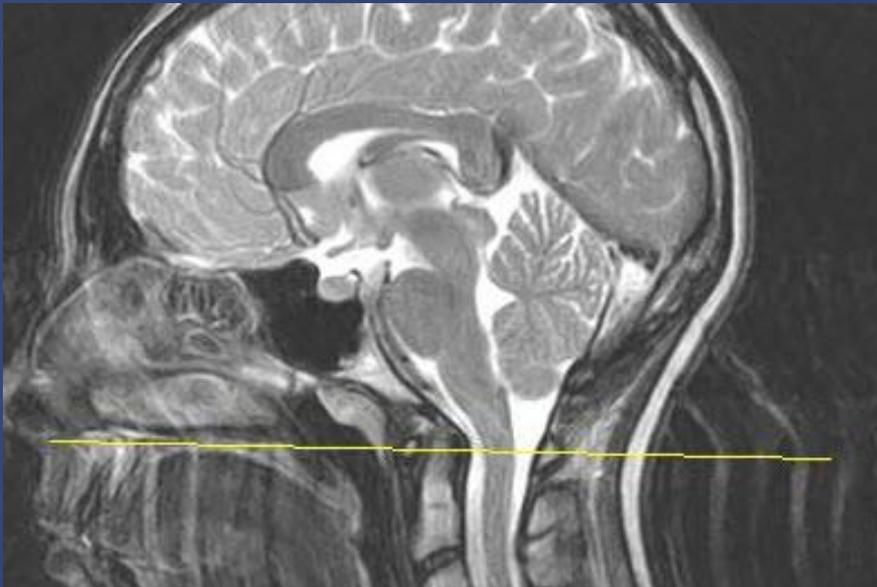


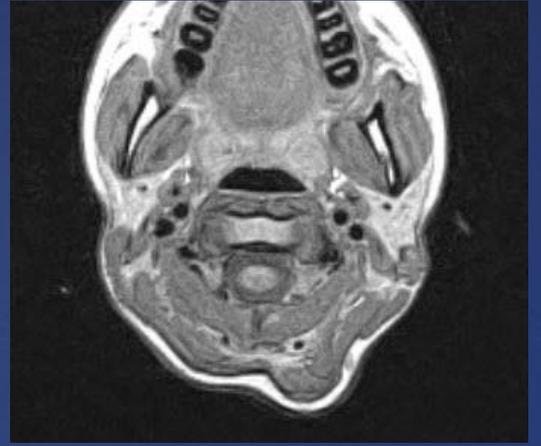
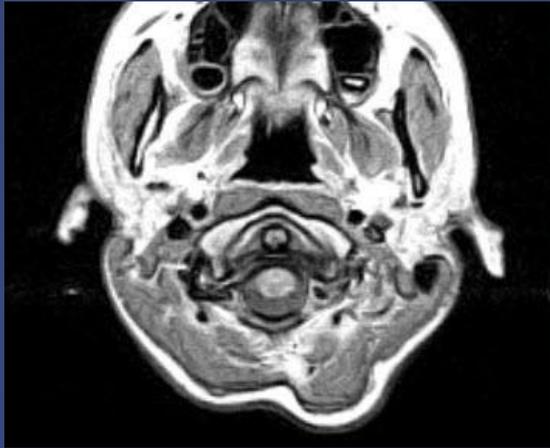
(The basion axial interval is the length of a line drawn between the tip of the basion and a line drawn along the posterior aspect of the odontoid peg. The basion dental interval is a distance measured between the tip of the basion and the tip of the dens. Both these measurements should be less than 12 mm. If they are greater than 12 mm, then occipito-atlantal disassociation has occurred. These measurements are often referred to as "The rule of 12")

Craniovertebral Ligament Complex



Axial sections in line of the Atlas (C1)





Specific coronal views of the crano-cervical junction to show the position of the odontoid peg



Normal position of the odontoid peg

The alar ligaments are intact (arrows)



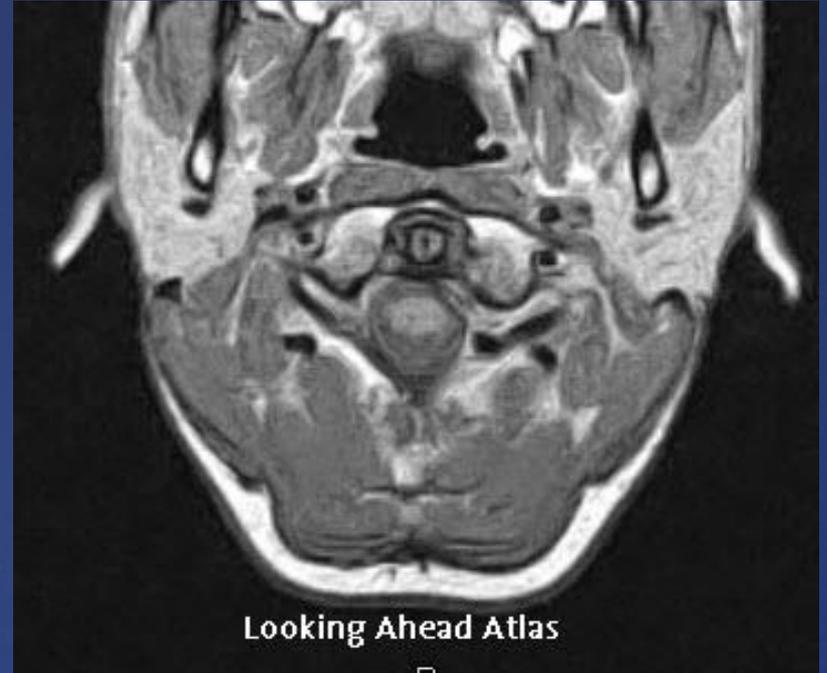
The odontoid peg is deviated to the right

The alar ligaments are not clearly seen due to them being damaged

Cranio –vertebral Ligaments

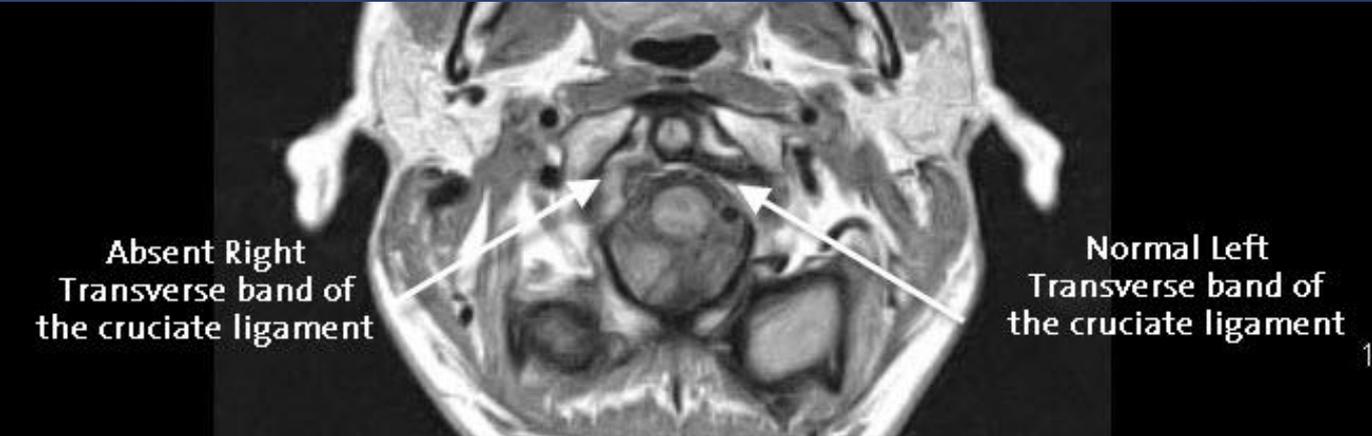


Normal Alar Ligaments

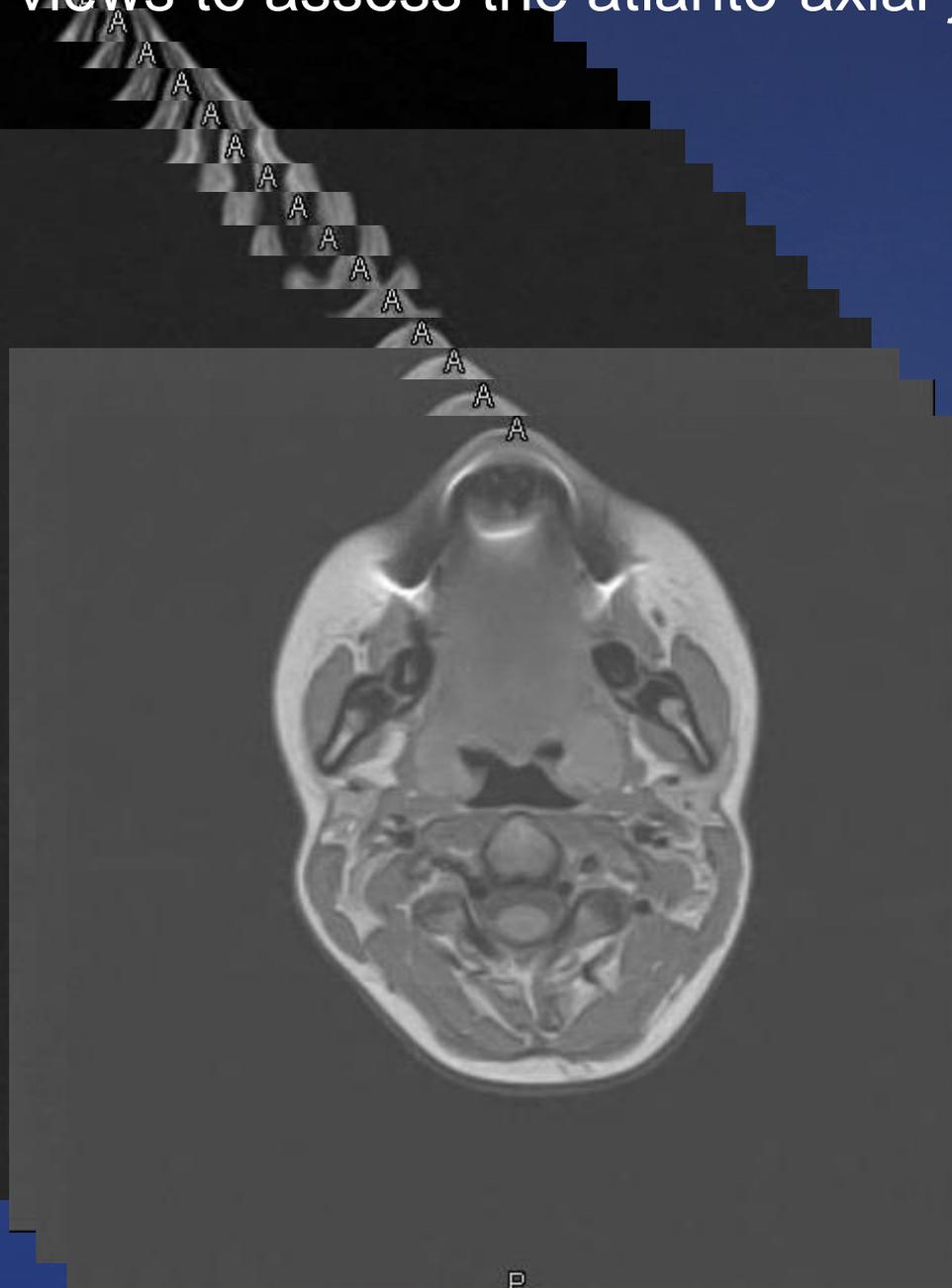


Looking Ahead Atlas

Normal Transverse band of the
Cruciate Ligament



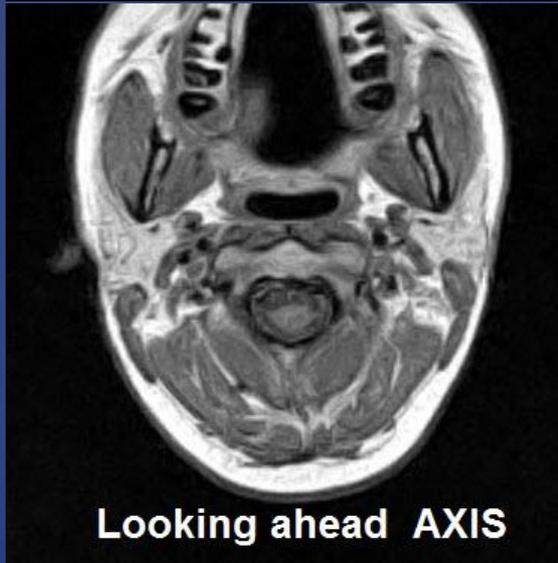
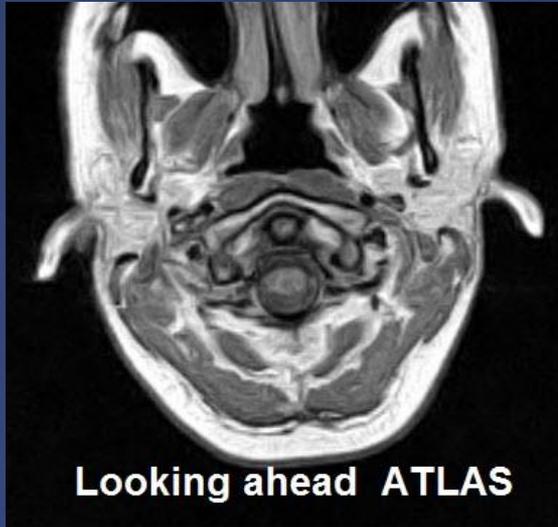
Specific views to assess the atlanto-axial joint.



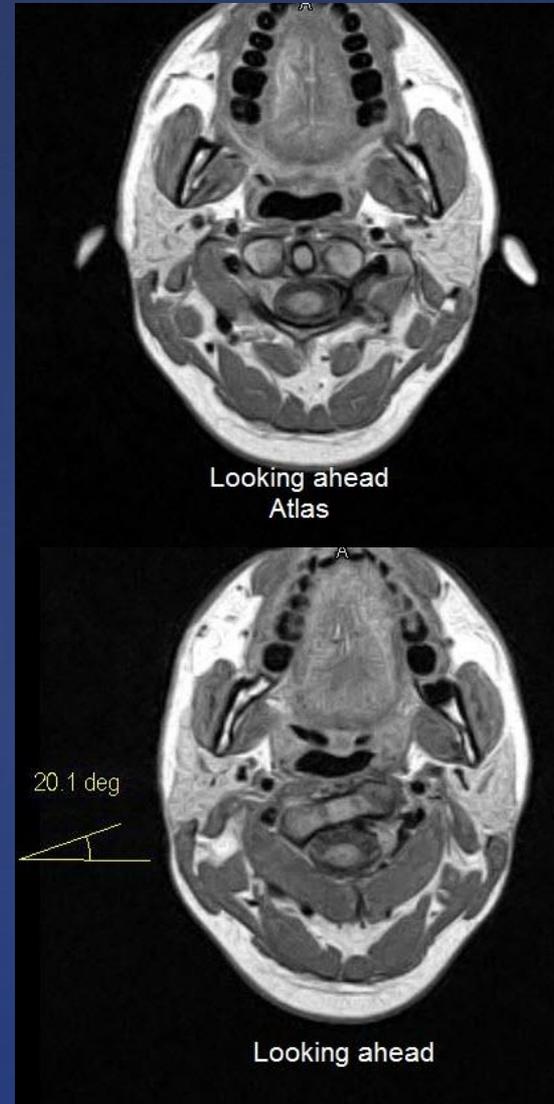
Specific views to assess the atlanto-axial joint



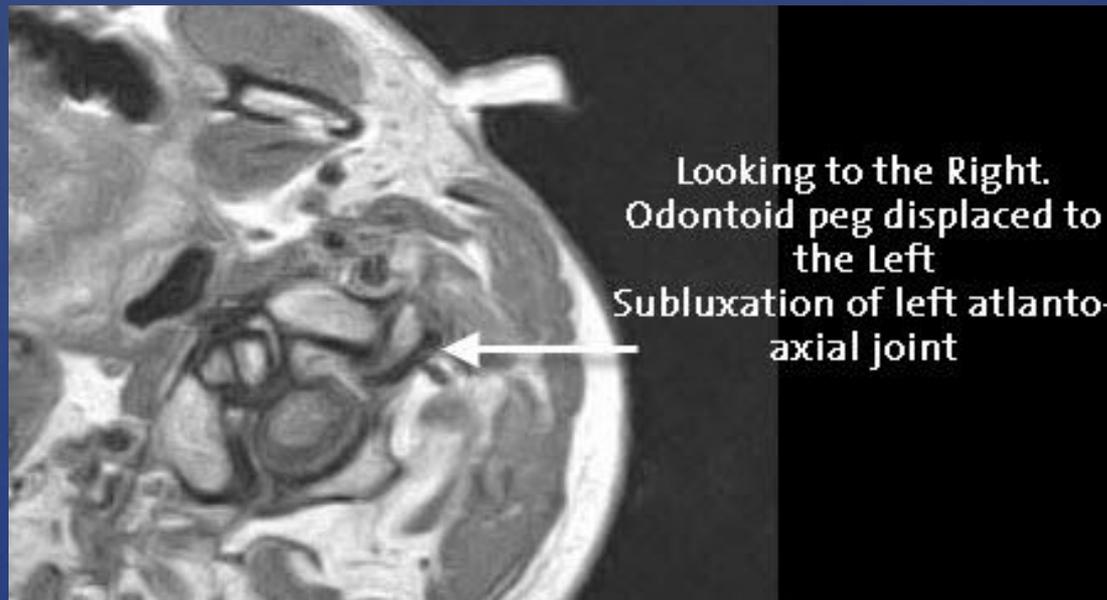
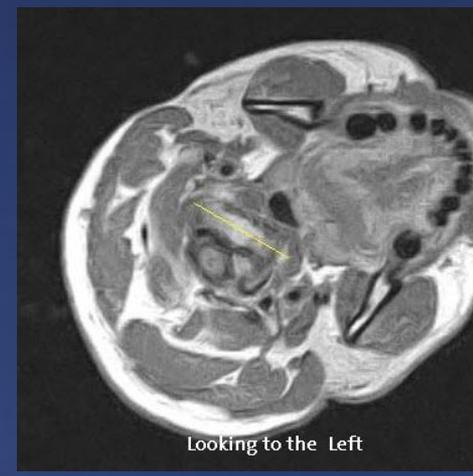
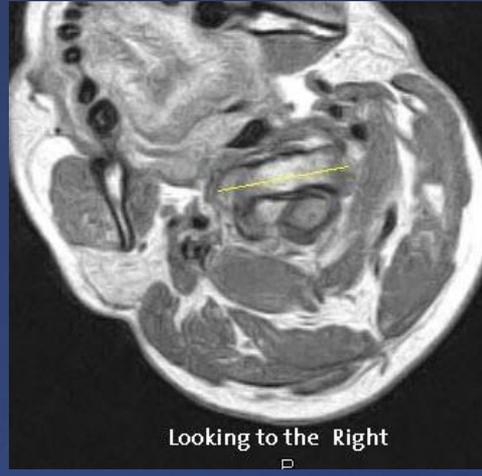
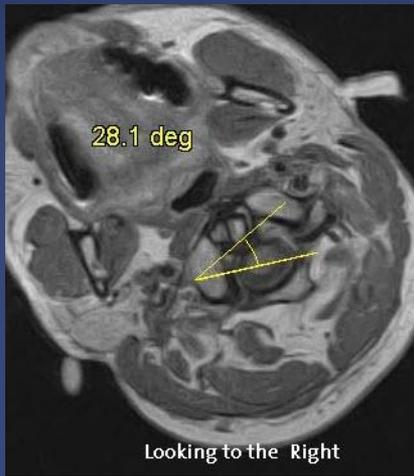
Specific views to assess the atlanto-axial joint



Normal alignment



20° of dislocation at the atlanto-axial joint



Method and Materials :

E.D.S.	49	average age	34.5yrs	(11 - 64)	42F	7M
Normal control	58	average age	58yrs	(22 – 78)	42 F	16 M

CERVICAL SPINE ANGLE

Normal/Control

E.D.S.

Neutral

17.1°

17.7°

Flexion

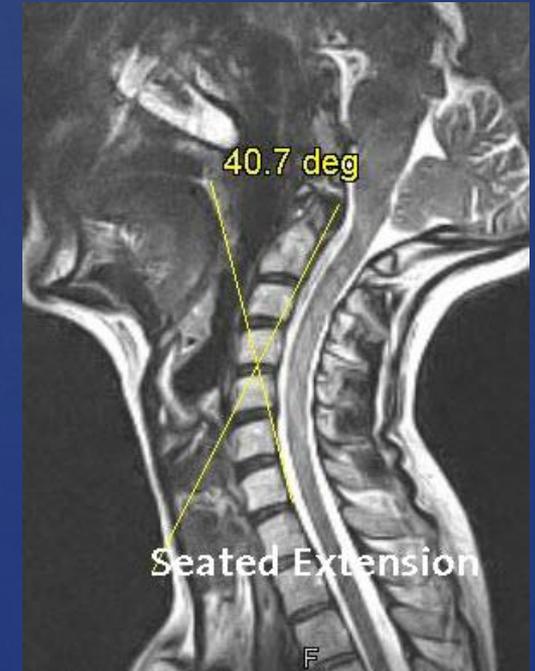
11.5°

18.1°

Extension

32.1°

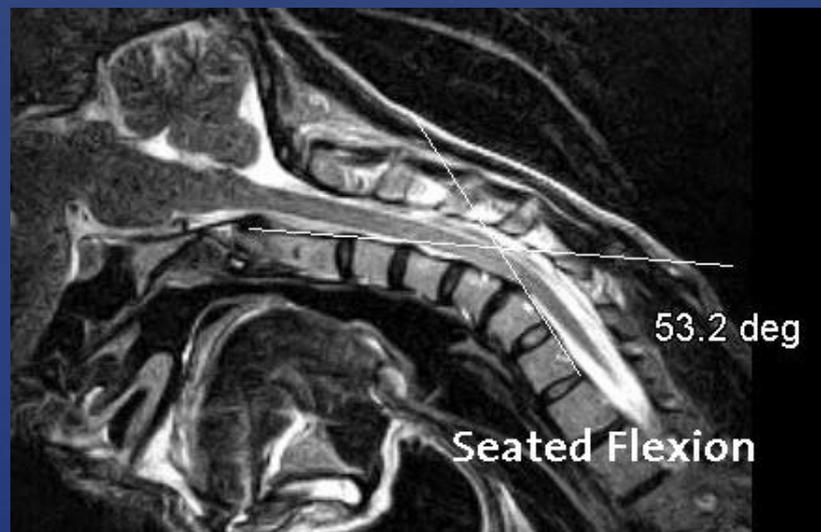
50.1°



Excessive extension



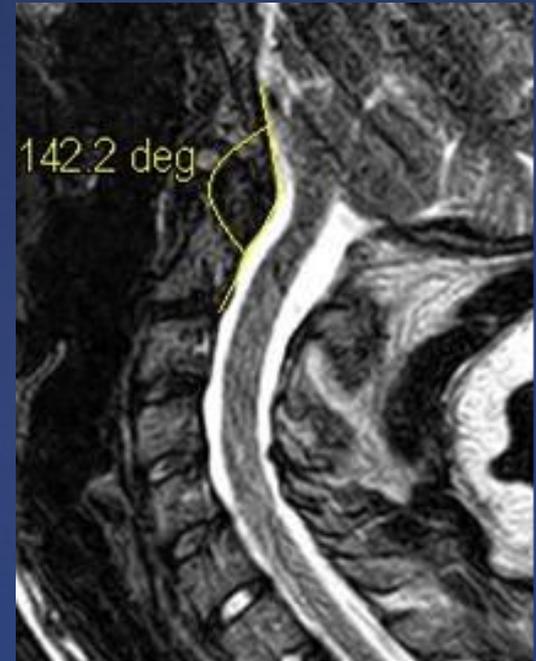
Ligament Laxity in flexion



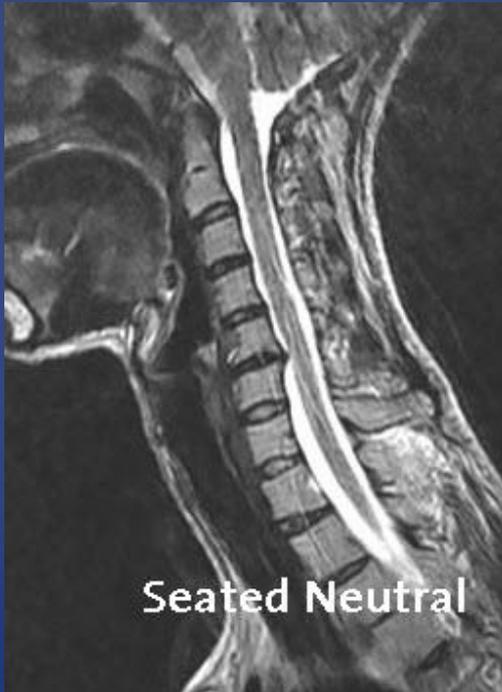
CLIVO-AXIAL ANGLE

Clivo-axial angle.	Normal	E.D.S.
Neutral	154°	146°
Flexion	148°	143°
Extension	160°	158 °

Basilar invagination

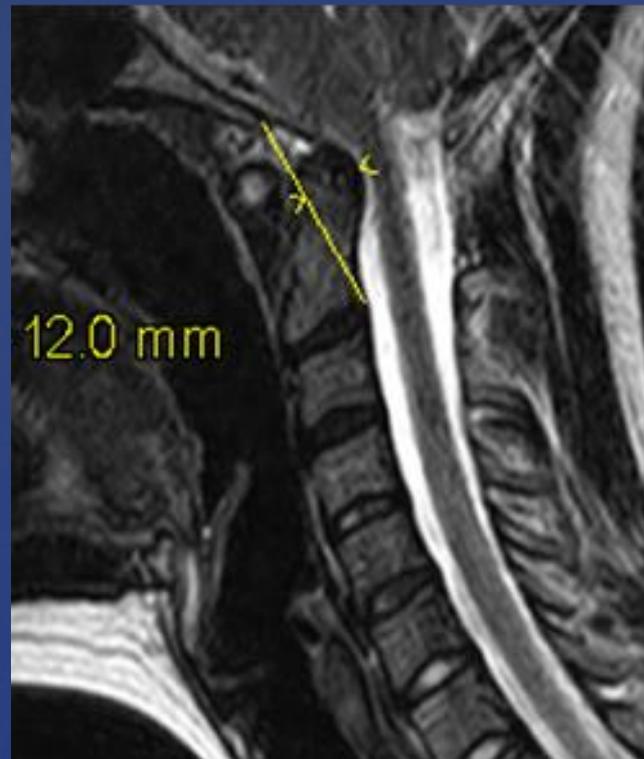


Ligament laxity



Grabb-Oakes Interval

(The Grabb-Oakes measurement is the perpendicular distance from the BpC2 line [Basion to posterior inferior C2 body] to the dura. A value greater than or equal to 9 mm indicates ventral brainstem compression)

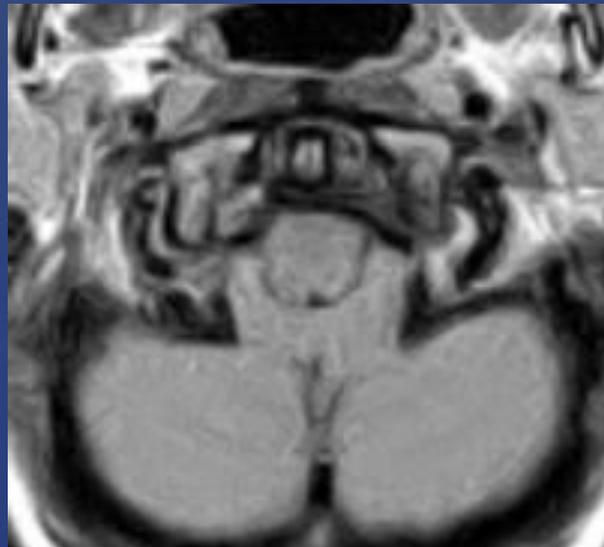
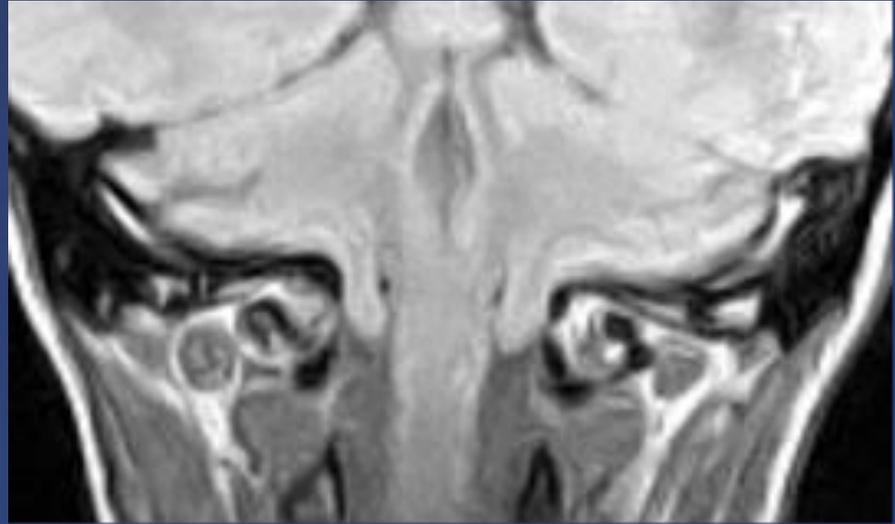
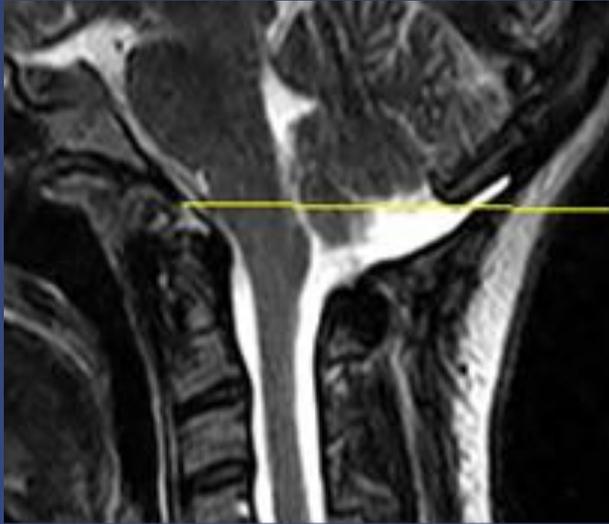


Harris measurements of the basion axial interval and the basion dental interval

(The basion axial interval is the length of a line drawn between the tip of the basion and a line drawn along the posterior aspect of the odontoid peg. The basion dental interval is a distance measured between the tip of the basion and the tip of the dens. Both these measurements should be less than 12 mm. If they are greater than 12 mm, then occipito-atlantal disassociation has occurred. These measurements are often referred to as "The rule of 12")



Cerebellar Tonsillar Ectopia.



Post-traumatic ectopia of the cerebellar tonsils is best demonstrated when sitting

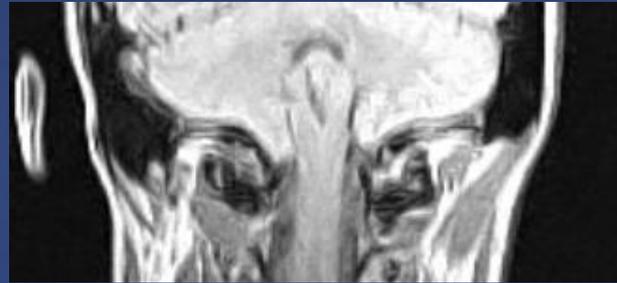


A case-control study of cerebellar tonsillar ectopia (Chiari) and cervical spine trauma.

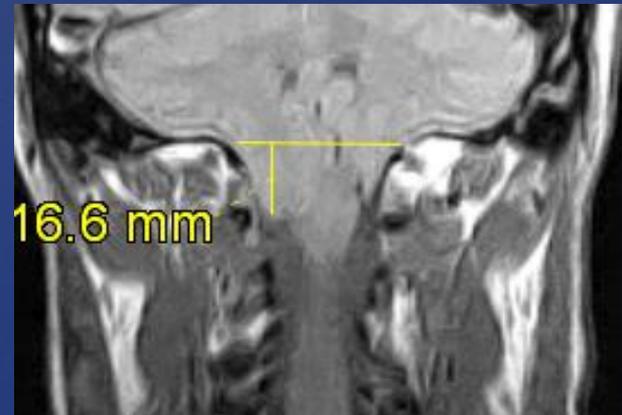
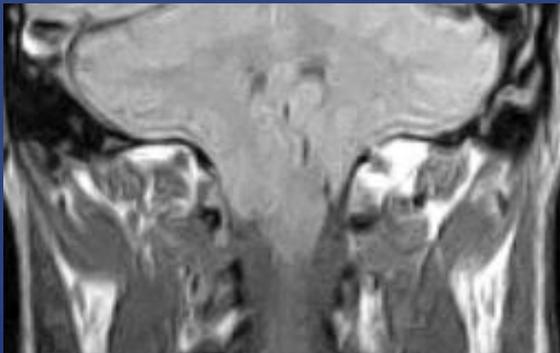
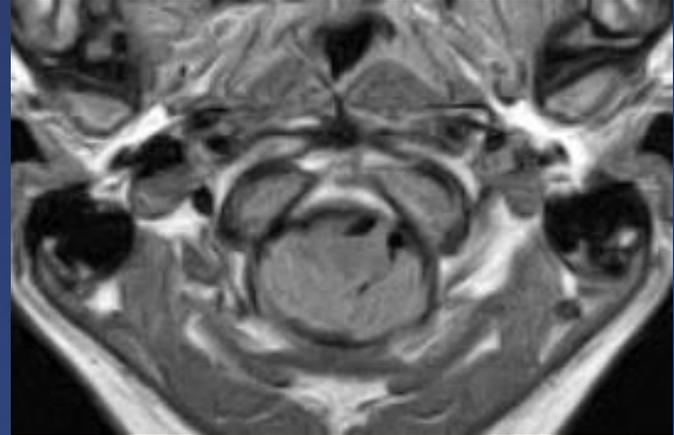
Freeman MD, Rosa S, Harshfield D, Smith FW Bennett R, Centano CJ, Kornel E, Nystrom A, Hefez DS, & Kohles SS

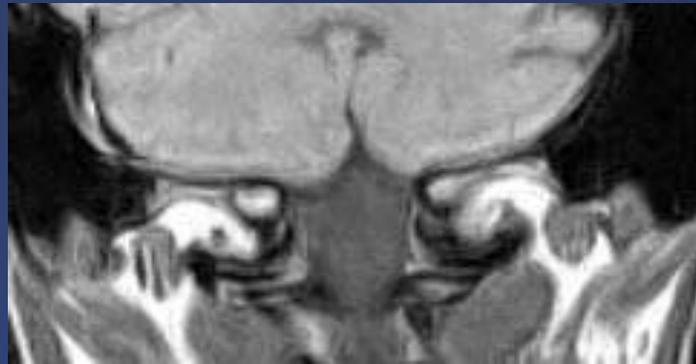
Brain Inj. 24 (7-8):988-94. 2010

Cerebellar Tonsillar Ectopia - E.D.S.

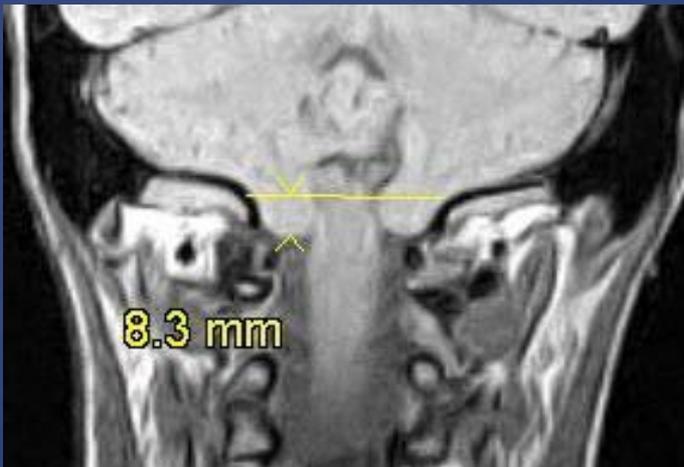


Cerebellar tonsillar ectopia – Chiari.

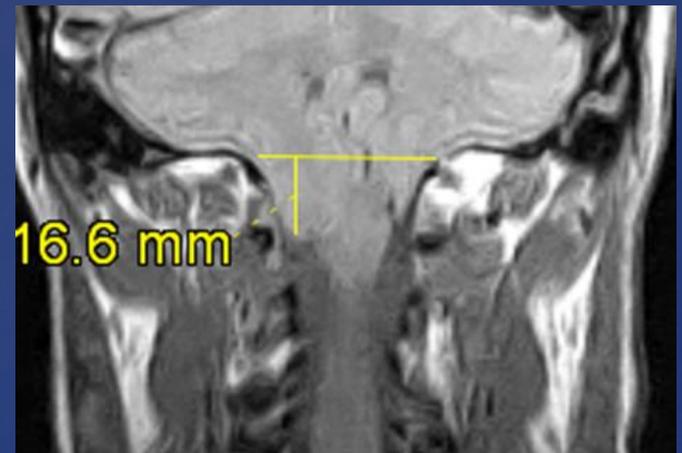




Normal



Ehlers – Danlos syndrome



Chiari



Atlanto-axial joint:

E.D.S.	49	average age	34.5yrs	(11 - 64)	42F	7M
Normal control	58	average age	58yrs	(22 – 78)	42 F	16 M

Stable joint	13/49	26%
Laxity of ligaments	25/49	51%
Dislocation	11/49	23%