"ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPODYLOTIC MYELOPATHY WITH 3 T MRI"

Dissertation submitted to

THE TAMILNADU Dr.M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the requirements of

M.D. DEGREE EXAMINATION
BRANCH – VIII– RADIODIAGNOSIS

MADRAS MEDICAL COLLEGE
&
RAJIV GANDHI GOVERNMENT GENERAL HOSPITAL
CHENNAI– 600 003

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
CHENNAI – TAMILNADU, INDIA

APRIL 2016

CERTIFICATE

This is to certify that the dissertation **"ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPONDYLOTIC MYELOPATHY"** titled submitted by **Dr.K.JANAKIRAMAN** appearing for **M.D (Radiodiagnosis)** degree examination in April 2016 is a bonafide record of work done by her under my guidance and supervision in partial fulfillment of requirement of the TamilNadu Dr. M.G.R Medical University, Chennai. I forward this to the TamilNadu Dr. M.G.R Medical University, Chennai.

Dr.S.BABU PETER , M.D.,D.N.B,
Guide,
Professor,
Barnard institute of Radiology,
Madras Medical College,
Rajiv Gandhi Government General Hospital,
Chennai – 600 003.

PROF.N.KAILASANATHAN, DMRD., MD.,
Professor & Head of Department,
Barnard Institute of Radiology,
Madras Medical College &
Rajiv Gandhi Government General Hospital, Chennai - 600 003.

Dr. VIMALA M.D
Dean,
Madras medical college,
Rajiv Gandhi Government General Hospital, Chennai - 600 003.

DECLARATION

I **Dr.K.JANAKIRAMAN**, solemnly declare that this dissertation titled **"ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPONDYLOTIC MYELOPATHY**" is a bonafide work done by me at the Barnard Institute of Radiology, Madras Medical College and Government General Hospital, under the supervision of the Professor S. Babu Peter, M.D., D.N.B., Professor, Barnard Institute of Radiology, Madras Medical College and Rajiv Gandhi Government General Hospital. This dissertation is submitted to The Tamil Nadu Dr. M.G.R Medical University, towards partial fulfillment of requirement for the award of M.D. Degree Radiodiagnosis.

Place: Chennai

Date: 30.9.2015 **Dr.k.Janakiraman**

ACKNOWLEDGEMENT

I express my heartful gratitude to the Dean, **Dr.R.VIMALA, M.D.,** Madras Medical College & Rajiv Gandhi Govt. General Hospital, Chennai-3 for permitting me to do this study.

I express my gratitude to **Prof. N.KAILASANATHAN, M.D., D.M.R.D.,** Head of the Department, Barnard Institute of Radiology, for his valuable guidance in doing the dissertation work.

I owe a lot to my guide, **Dr.S.BABU PETER, M.D., D.N.B.,** whose expert guidance constant encouragement created an interest for me to pursue this study on advanced MRI imaging. It is his constant supervision and support, that made me possible to finish this study without much difficulty.

I am extremely thankful to my Professors, **Dr.K.MALATHY, M.D.,D.M.R.D.,Dr.S.KALPANA,M.D.,D.N.B., Dr.D.RAMESH,M.D., Prof. A.P.ANNADURAI, M.D., D.M.R.D.,and** Assistant professors **Dr.J.CHEZHIAN, M.D., Dr.K.GEETHA, M.D., Dr.S.ANBUMALAR, M.D., D.N.B, FRCR Dr.SARANYA, D.M.R.D, and Dr. M.P.BALAN, D.M.R.D,** in the Barnard Institute of Radiology for their constant support, encouragement and advice during my study.

I also thank **my past and present fellow postgraduates** who helped me in carrying out my work and preparing this dissertation.

I thank **all Radiology technicians, Staff Nurses and all the Paramedical staff members** in Barnard Institute of Radiology, for their co- operation in conducting the study.

I thank my family members for their understanding and co-operation in completion of this work.

Last but not the least; I owe my sincere gratitude to the patients and their relatives who co-operated for this study, without whom the study could not have been possible.

INDEX

ABSTRACT

OBJECTIVES

To (1) obtain microstructural parameters (Fractional Anisotropy: FA, Mean Diffusivity: MD) of the cervical spinal cord in patients suffering from cervical spondylotic myelopathy (CSM) using tractography, (2) to compare DTI parameters with the clinical assessment of these patients (3) and with information issued from conventional sequences.

METHODS DTI was performed on 50 symptomatic patients with cervical spondylotic myelopathy,. FA and MD were calculated from tractography images at the C2-C3,C3-C4,C4-C5,C5-C 6level and compressed level in patients. Patients were clinically evaluated using a self-administered questionnaire.

RESULTS . A significant positive correlation between FA at the compressed level and clinical assessment was demonstrated. Increased signal intensity on T2-weighted images did not correlate either with FA or MD values, or with any of the clinical scores.

CONCLUSION FA values were significantly correlated with some of the patients' clinical scores. High signal intensity of the spinal cord on T2 was not correlated either with the DTI parameters or with the clinical assessment, suggesting that FA is more sensitive than T2 imaging.

KEYWORDs Diffusion tensor imaging . Cervical spondylosis. Tractography . Clinical correlation . Fractional anisotophy

INTRODUCTION

Cervical spondylosis is a very common degenerative disease of the spinal column in the elderly ,appearing as disc dessication herniation ,osteophytosis,and spinal canal narrowing.[1]

Cervical spondylosis myelopathy, commonly known as **cervical spondylotic myelopathy (CSM),** refers to impaired function of the spinal cord due to degenerative changes of the discs and facet joints in the cervical spine (neck). [2]

Cervical spondylotic myelopathy (CSM) is a condition that occurs due to chronic spinal cord compression by degenerative changes (disc dessication,bulge,osteophte formation) that occur as the age increases. After the age of 50 years the disease commonly occurs.

As the spinal cord carry nerve impulses to multiple regions in the human body, weakness and numbness in the upper &lower limbs , incoordination, and pain over the neck and shoulder occur in patients with compressive Myelopathy.

Magnetic resonance imaging (MRI) of the cervical spine (T2 Sequence) is the initial modality of choice in patients with symptoms of compressive myelopathy.[6]

MRI is non invasive and and highly useful in the evaluation of spinal cord in multiple planes(axial,sagittal.coronal),useful in the evaluation of spinal canal narrowing and to detect any intra medullary leisions that cause myelopathy symptoms like tumour,lipoma,cavernoma,contusion T2 . Hyperintensity in the spinal cord of patients with Cervical spodylotic myelopathy suggestive of myelomalacic changes.

Computed tomography (CT) is superior to MRI in the evaluation of spinal canal narrowing as MRI is not useful in the evaluation of bony structures and osteophtes.[7]

Myelography done by injecting contast medium in to the spinal canal followed by multiple x ray projection or CT .It is useful in some post operative cases with metallic implant where MRI contraindicated.

Plain X ray is useful in the initial evaluation of degenerative vertebral changes (osteophytes)

RATIONALE FOR THE STUDY

The radiological diagnosis of Cervical spondylotic myelopathy (CSM) has to be made as early as possible ,since surgery performed in earlier stages during the course of disease was reported to be more success when compared with chronic stages.[3]

MRI is the best imaging modality for the assessment of Cervical spondylotic myelopathy(CSM), but disparity between the patients clinical severity and T 2 hyperintensity noted in number of cases .Some patients have severe clinical symptoms with normal cord signal.

For this reason a advanced imaging approach that able to evaluate microstrutural abnormalities is needed for the evaluation of Cervical spondylotic myelopathy (CSM).[4-5]

Diiffusion tensor imaging(DTI) parameters (FA Values) able to show micro structural abnormalities that are not evaluated by conventional MR techniques.

DTI detect the microstructral abnormalities in the spinal cord earlier than the development of cord signal abnormality &thining on conventional sequences in patients with CSM, thereby useful in earlier diagnosis and prognosis of cervical spondylotic myelopathy

AIM AND OBJECTIVES OF THE STUDY

The aim & objectives of this study:

(1) Acquire micro structural para meters (FA-Fractional anisotrophy&ADC-Apparent diffusion coefficient) of the cervical .spinal cord in patients with symptoms cervical spondylotic myelopathy(CSM) using ROI method

(2)To compare DTI parameter (FA&ADC) with clinical symptoms(NURICK score)

(3) To compare DTI parameter (FA&ADC) with conventional T2 weighted (hyperintensity)imaging findings

REVIEW OF LITERATURE

The clinical condition that occurs from a disorder in the spinal cord that interrupts the normal transmission of the neural signals is called **Myelopathy.**

There are many causes of cervical myelopathy; anything that disturbs the normal flow of neural impulses through the spinal cord may cause a clinical myelopathy. Some of the conditions are trauma, viral etiology , inflammatory or autoimmune disorders, tumor, or degenerative processes including spondylosis and intervertebral disc herniation.

As we age, degenerative changes of the various parts (bone,ligament,tendon,disc) of the spine are a common occurence. The order of degenerative changes that occur in cervical spondylosis include 1.inter vertebral disc dessication, 2.intervertebral disc space height reduction , 3.osteophytes formation, and 4.hypertrophy of the ligamentumflavum, & facets. Spinal canal narrowing and cord compression occur due to these degenerative changes.

The clinical condition known as cervical spondylotic myelopathy(CSM) was not described until 1952 when "**Brain, Northfield and Wilkinson"** described a large number of patients with myelopathic symptoms associated with cervical spondylosis"[8]

"**Clarke and Robinson** et al" (1956) published the first study that lights on the natural history of cervical spondylotic myelopathy. They identified that myelomalacic changes once occur they mostly persist and progress with out remission.

Chun –Yi Wen et al says that "Spinal tracts were not uniformly affected in the myelopathic cervical cord. Changes in diffusion indices could delineate focal or extensive myelopathic lesions in CSM.. DTI analysis of spinal tracts might provide additional information not available from conventional diagnostic tools for prognosis of CSM."

Baro EM et al[39] says that"Various microstructural conditions of the compressed cervical cord, including gliosis, microcystic degeneration, demyelination and extracellular edema, may lead to increased water mobility (ADC) and decreased anisotropy (FA)"

Cheung et al.[40] "conducted DTI analysis on CSM rat models and revealed the characteristic increase in ADC and decrease in FA as late as 9 months after the start of compression"

Fernández de et[41] al says that "High signal intensity on T2-weighted images is often used to diagnose CSM, but this finding is not observed in every patient with clinical signs of myelopathy, and it sensitivity is reported to be low (between 15% and 65%) and also T2 HSI is generally observed only in later stages of the disease"

Recent studies conducted DTI analysis on CSM patients with neurological signs but without T2 HSI, and revealed significant reduced FA and increased ADC at the stenotic levels

Demir et al[42]. suggested that "ADC value had nearly a 80% sensitivity and 53% specificity for detecting myelopathy in patients with spinal cord compression"Budzik et al. reported "a positive correlation with FA and a self-administered questionnaire".

Jones et[43] al demonstrated "a strong correlation between FA and specific clinical assessments, including modified Japanese Orthopedic Association (mJOA) and Nurick scores and also reported that severely affected CSM patients with higher FA at the compressed level tended to achieve better functional recovery after decompression surgery when compared with subjects

with lower FA, indicating FA as a potential biomarker of better postoperative outcome"..

Similarly, in the study of Wen et al says that"FA was significantly correlated with mJOA score and enabled prediction of good surgical outcomes by Logistic regression (P = 0.030), while the presence of HSI on T2-weighted images did not (P = 0.176)"

Mamata et al[44] reported that "46% of the patients of CSM showed no elevation in ADC and no decrease in FA of the spinal cord at the narrow spinal canal level."

Fernandez de Rota A et[45] alsays that "there is no correlation between the presence or absence of increased signal intensity on T2-weighted images and the severity of the clinical symptoms before surgery."

Nagashima H et al[46] says that "The high signal intensity of the spinal cord probably represents a broad spectrum of lesions from reversible lesions (oedema) to more severe lesions (demyelination or cavitation)"

Fillard P et al concluded that "DT parameters are more sensitive than T2 signal analysis in assessing patients with CSM as well as other cervical spinal cord diseases".

Budzik, Jean-François, et al([47] concluded that "FA values were significantly correlated with some of the patients' clinical scores. High signal intensity of the spinal cord on T2 was not correlated either with the DTI parameters or with the clinical assessment, suggesting that FA is more sensitive than T2 imaging".

Our study found

- **A VERY STRONGnegative**correlation with Spearman's **rho** value of –0**.936**&**P value 0.005**noted between the Fractional anisotophy**(FA)**value at compression level and Nurick's clinical score.

- **A MODERATE positive** correlation with Spearman's **rho** value of 0.591 &**P value 0.0005**noted between the ADC value(apparent diffusion coefficient) at compression level and Nurick's clinical score.

- **A WEAK** POSITIVE correlation with Spearman's **rho**value of 0.309 &**P value 0.029** noted between the conventional T2 weighted image hyperintensity and Nurick's clinical score.

Like **Budzik, Jean-François, et al study**, Our study also concluded that**“**Highsignal intensity on T2 of the spinal cord is not correlatedeither with the DTI parameters or with clinical assessment suggesting that Fractional anisotrophy (FA) is more accurate than conventional T2 imaging in the diagnosis and assessment of prognosis & severity of the disease”

ANATOMY

The cervical vertebrae are identified by the presence of foramen transversia

- There are totally seven(7) cervical vertebrae out of that the third,fourth,fifth ,sixth cervical vertebrae is Typical vertebrae .
- First, second, and seventh vertebrae are Atypical.
- The cervical spine begins at the base of the skull.
- First cervical vertebrae is called the **atlas**

  ring-shaped,has neither a body or a spine

  supports the head.

- Second cervical vertebrae is called axix *axis* and it is identified by the presence of dens or odontoid process
- Atlas and dens helpful in rotation , side to side ,and forward and backward movement .

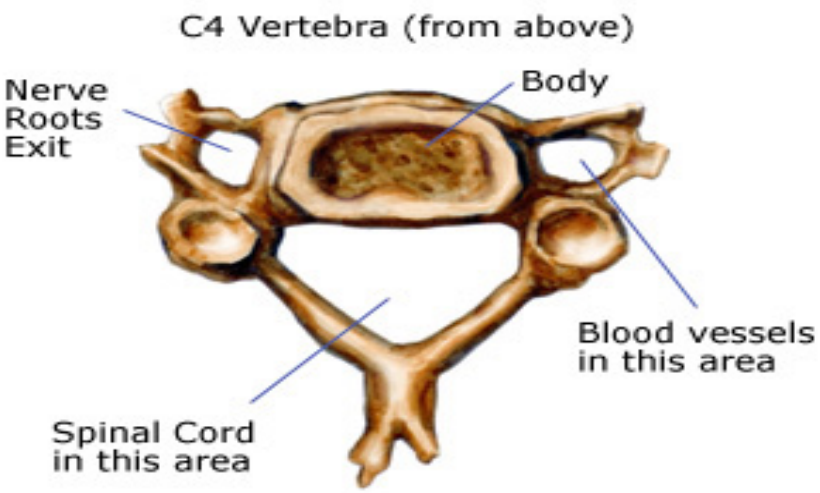


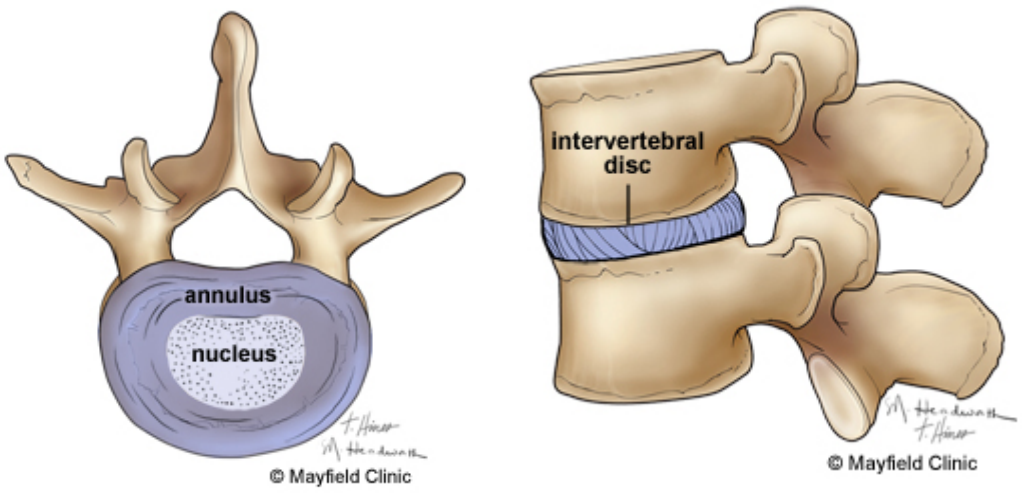
FIG: Typical cervical vertebrae

The seventh cervical vertebra – it is known as ***vertebra prominens*** as it has long spinous process ,the tip of the spinous process usually felt at the lower end of scapula

INTER VERTEBRAL DISCS

Inter vertebral disc is a pillow like cushion present between two vertebral bodies, and it acts like a shock absorber between two vertebrae during flexion and extension movement.

- Each intervertebral disc is made up of outer annulus fibrosus and inner nucleus pulposus.
- Inner nucleus pulposus contains jelly like material predominantly of water content
- Outer annulus fibrosus consists of multiple layers of collagen fibers.

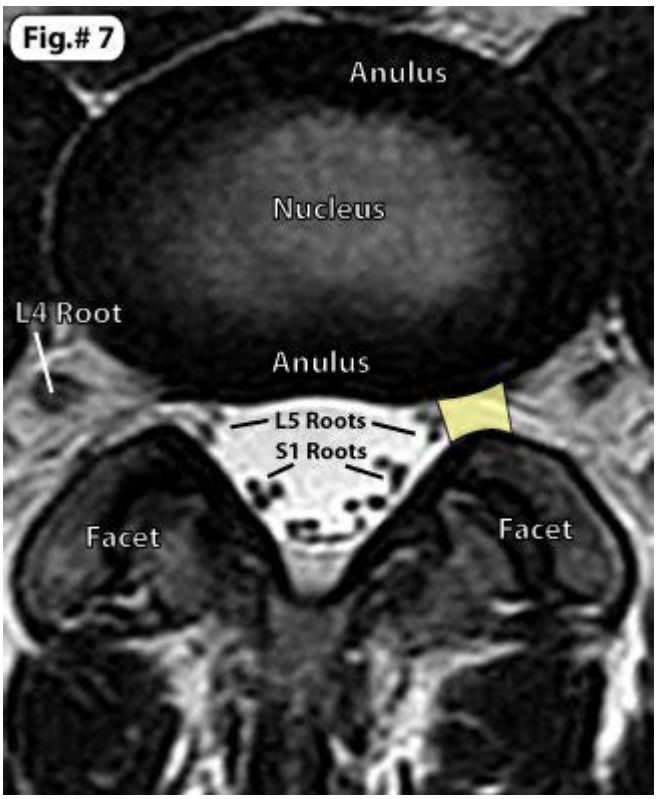


Figure; outer annuluar fibrosus and inner nucleus pulposus

.

Function of the nucleus pulposus is to distribute hydraulic Pressure in multible directions within the intervertebral disc

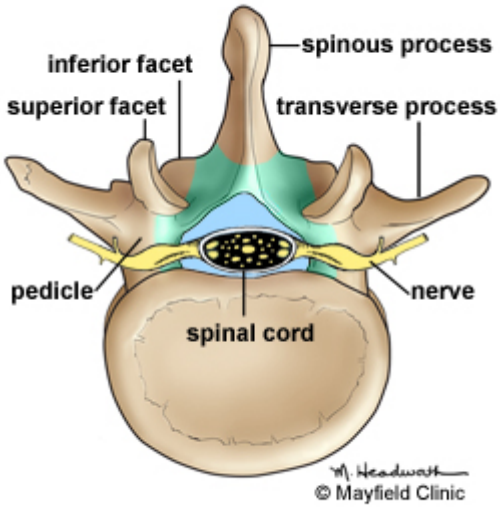
The content of glycosaminiglycans and water decreases With increasing age and degeneration.

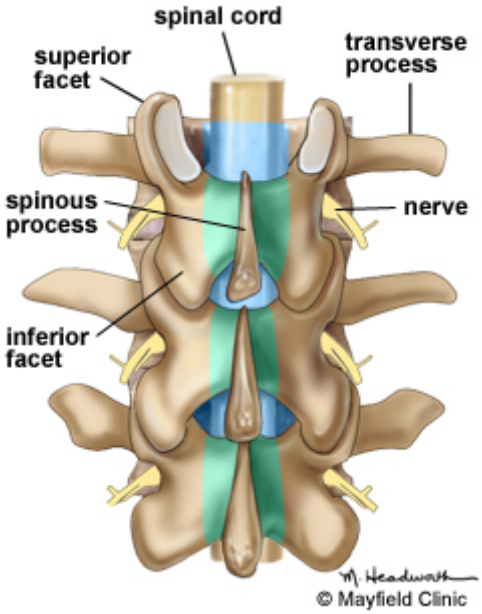


In T2 weighted MRI outer annulus fibrosus appears Hypointense due to collagen content & inner nucleus pulposus appears Hyperintensr due to water content.with degeneration nucleus becomes darker

Vertebral arch & spinal canal

The vertebral arch made up of two(2) pedicles and Two(2) Laminae with central spinal canal which contains spinal cord ligaments,and fat. The pedicles join the vertebral body with the arch.





Seven(7) processes arise from the vertebral arch: one spinous process, 2 transverse processes, 2 superior facets, and 2 inferior facets.

Surgeons usually do laminectomy to relieve the compression of the spinal cord and also to treat spinal narrowing , tumors, or herniated discs.

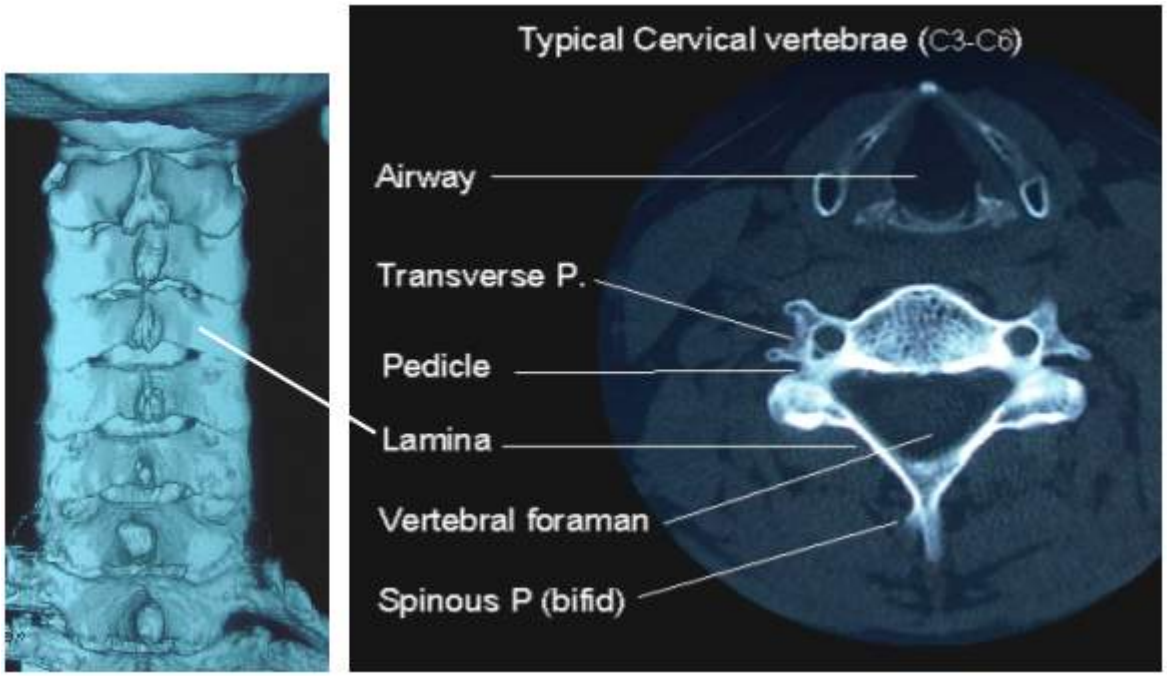
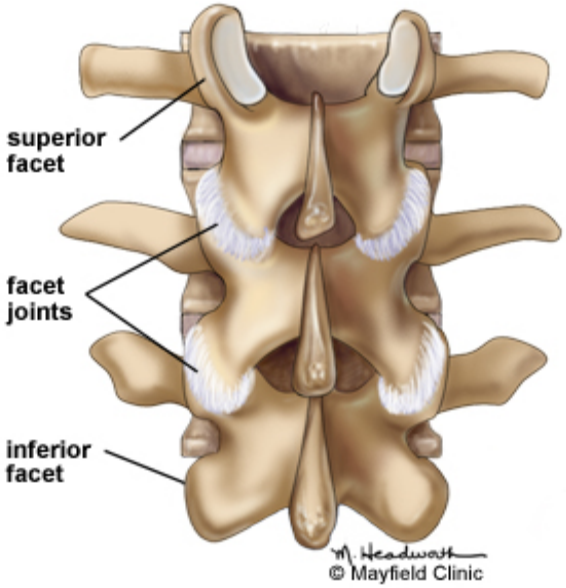


FIGURE: CT CERVICAL VERTEBRAE AXIAL ANATOMY showing pedicle and lamina

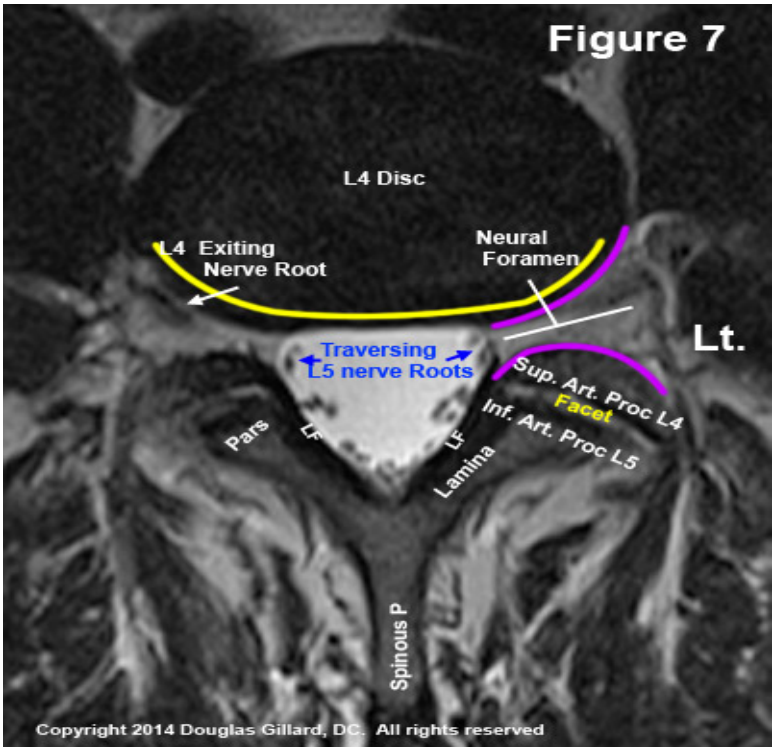
Facet joints

The facet joints of the spine make the back flexible . Each vertebra has four(4) facet joints, one(1) pair connects the vertebra above (superior facets) and one(1) pair connects the vertebra below(inferior facets)

FACETAL JOINTS



MRI FACETAL JOINJTS



LIGAMENTS

Three main ligaments in the spine are

1. Anterior longitudinal ligament (ALL)
2. Posterior longitudinal ligament (PLL)
3. Ligamentum flavum

Main function of these ligaments is to avoid excessive movement of the vertebral bones.

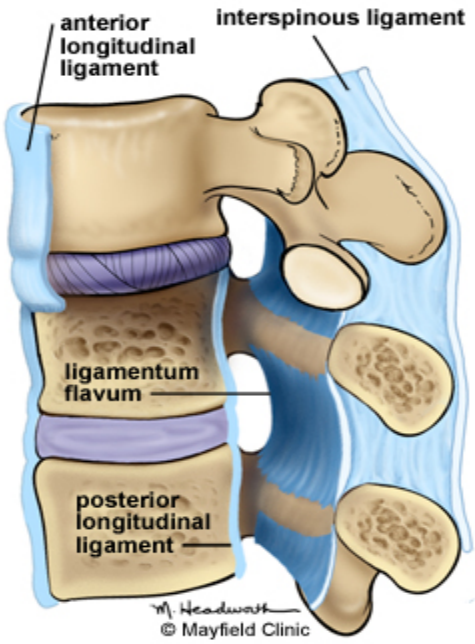
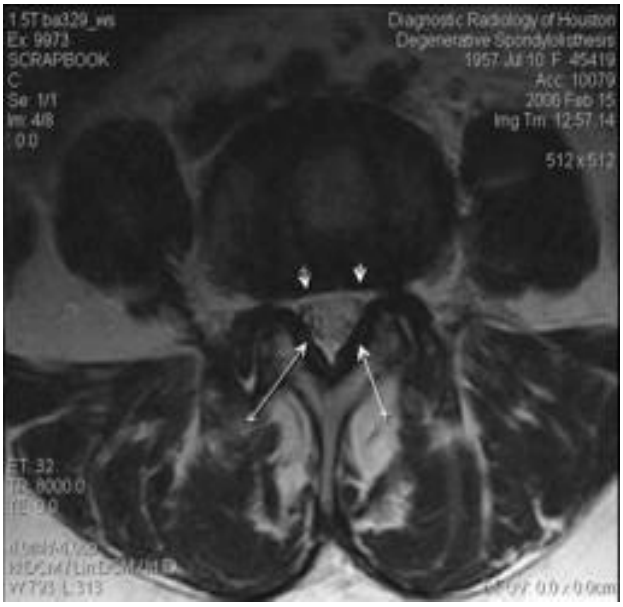
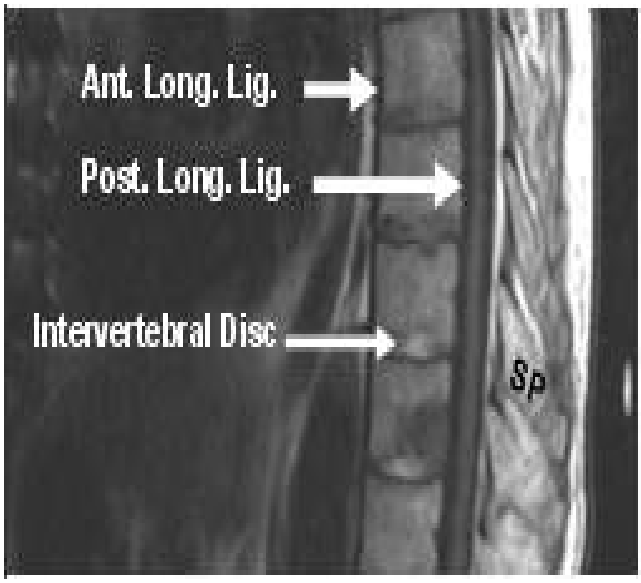


Figure 5. Major ligaments of spine.

MRI- LIGAMENTUM FLAVUM



MRI – ALL & PLL



SPINAL CORD

The spinal cord is about **45 cm** in length long and is the thickness of 13 mm. It extends from the foramen magnum upto the level of first or second lumbar vertebrae.

It enclosed by the protective bony spinalcanal . At the lower end of the cord, the fibers separates into the cauda equine. The spinal cord is the most important communication structure between the body and brain.

The brain transmit motor impulses to the all four limbs and the body through the spinal cord for allowing movement. “Spinal reflexes, are protect immediately our body from acute harm.

Quadriplegia or tetraplegia (paralysis of all four limbs)occur from cervical spinal cord injury, sensory and motor function lose usually occur below the level of spinal cord injury.

SPINAL NERVES

- 31 pairs of spinal nerves arise from the spinal cord.
- 8 cervical ,12 thoracic, 5 lumbar,5 sacral, 1 coccygeal

The spinal nerves act as “telephone lines,” carrying impulses between body and spinal cord to control . sensation and movement. Each spinal nerve has two(2) roots ventral and dorsal root.

“The ventral. (front) root carries motor impulses **from** the brain dorsal. (back) root carries sensory impulses **to** the brain”.

The two ventral and dorsal nerve roots fused together to form a spinal nerve, which enters in the spinal canal, along with the cord, it reaches its exit hole - the inter vertebral foramen’. When the nerve passes into the inter vertebral foramen, it branches and each branch has both motor and sensory fibers..

SPINAL NERVES

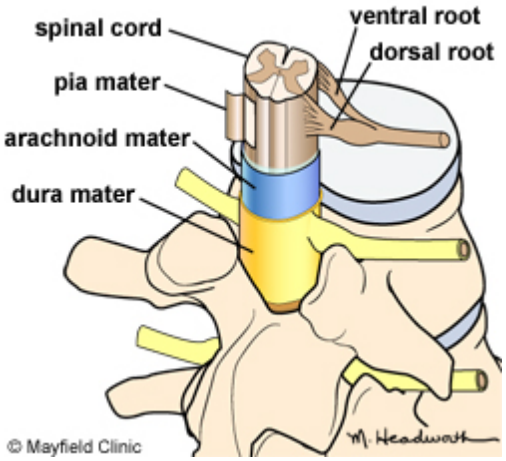
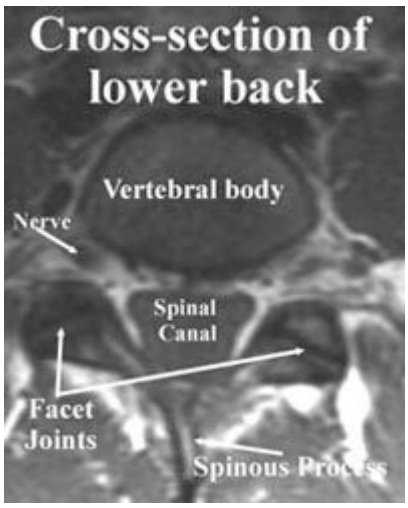


Figure 6. The both nerve roots join to form the spinal nerve. The cord is covered by three layers of meninges: inner pia, middle arachnoid and outer dura mater.



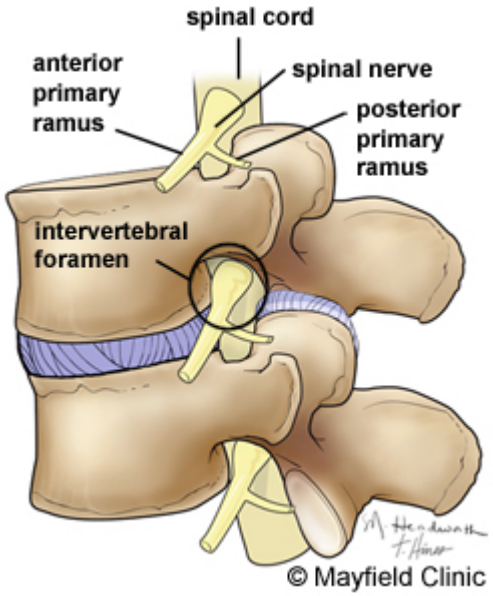


Figure 7. Spinal nerves leave the spinal canal through the intervertebral foramen below each pedicle.

- dermatomes are specific region of the body innervated by a specific nerve, this pattern useful to identify the location of a spinal problem based on the area of pain or muscle weakness.

For ex: sciatica usually denotes a problem at the level of L4-S3 nerves.

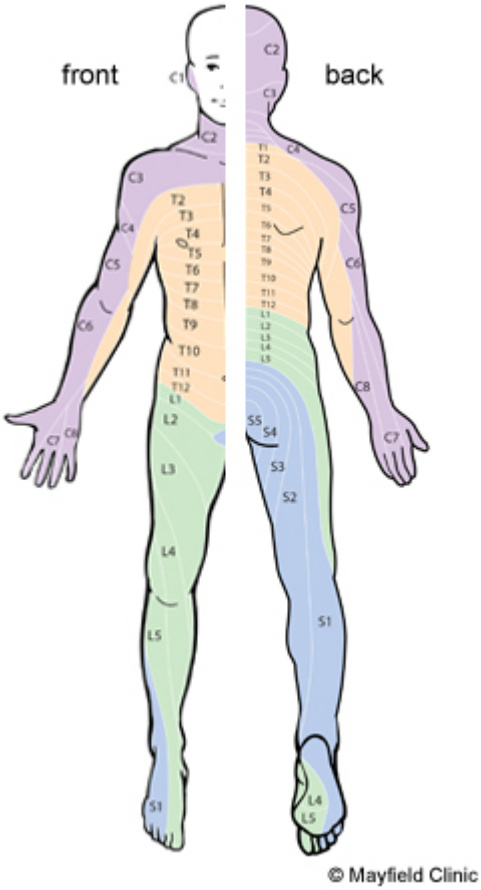
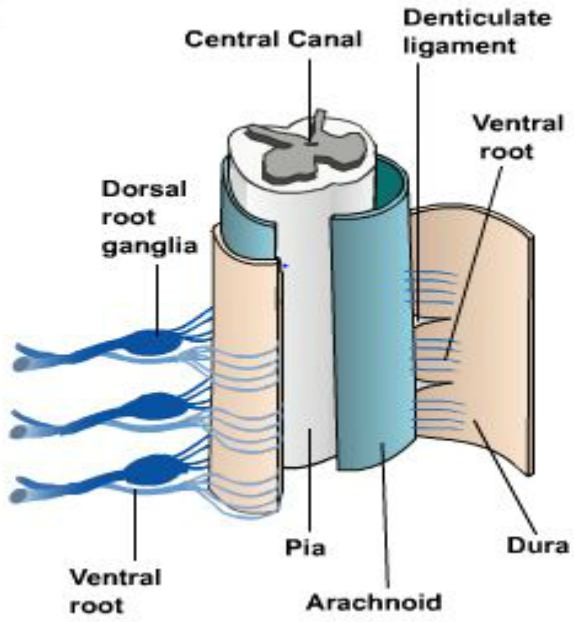


Figure 8. Dermatome pattern.

COVERINGS & SPACES

The spinal cord is covered by three layers of meninges with the inner membrane is the pia mater, which is intimately attached to the cord,middle membrane is the arachnoid materand the outer membrane is the tough dura mater . Between these membranes are subdural and subaracnoidspaces used..

SPINAL COVERINGS AND SPACES



Subarachnoid space - The space between the pia and arachnoid mater which surrounds the cord and contains CSF

Epidural space – The space between the dura mater and the bone

Subdural space – the space between the dura and arachnoid

SPINAL CORD STRUCTURE

The CNS usually categorised into white matter & gray matter. White matter is the one that contains myelinated axons which form the tracts ,that conduting information between multiple regions & structures in the central nervous system . “Gray matter made up of the cell bodies & dendrites -site of synaptic transmission”.

The gray matter of the cord usually arranged in three(3) horns.

Anterior horn - motor

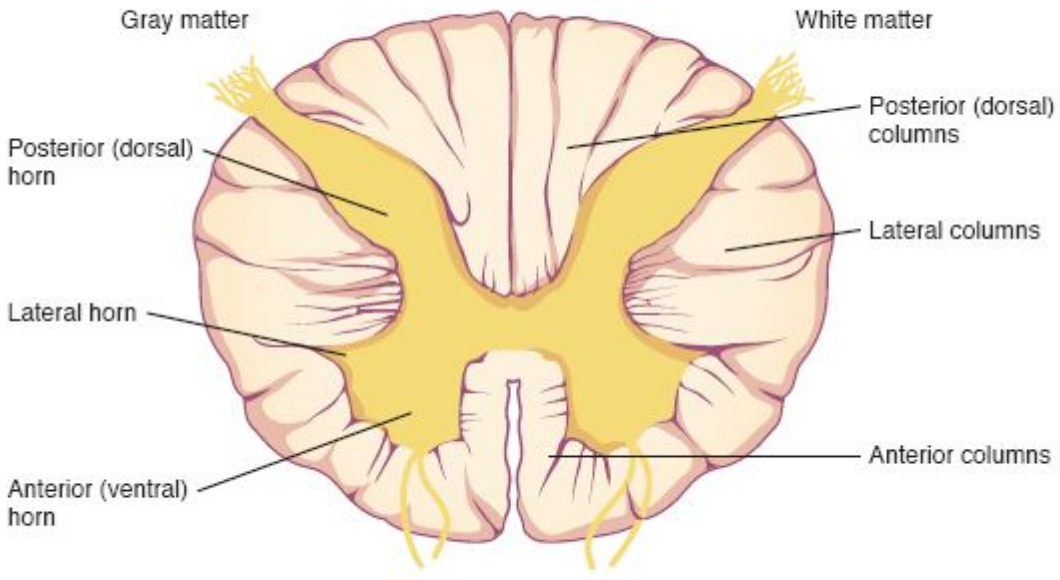
Lateral - visceral efferent & afferent

Posterior horn - sensory function

The anterior horn is further divided into a ventral part,head,dorsal partand the base.

In the brain, cortical (outer) region, made up of mainly gray matter while the the deep brain tissues contains various white matter tracts with some exceptions as deep grey nuclei (basal ganglia & thalamic nuclei) are composed of gray matter

Unlike brain, central butterfly shaped gray matter is surrounded by white matter in spinal cord indicating- “the spinal cord tracts carry information up and down along the outer aspects, and synaptic transmission occur more centrally”.



spinal cord segment - cross section view

LAMINAR ORGANISATION;

In thick cross section the cord appears to have a laminar pattern of arrangement.ten layers are identified known as laminae of rexed,- numbered from the tip of the dorsal horn moving ventrally into ventral horn.

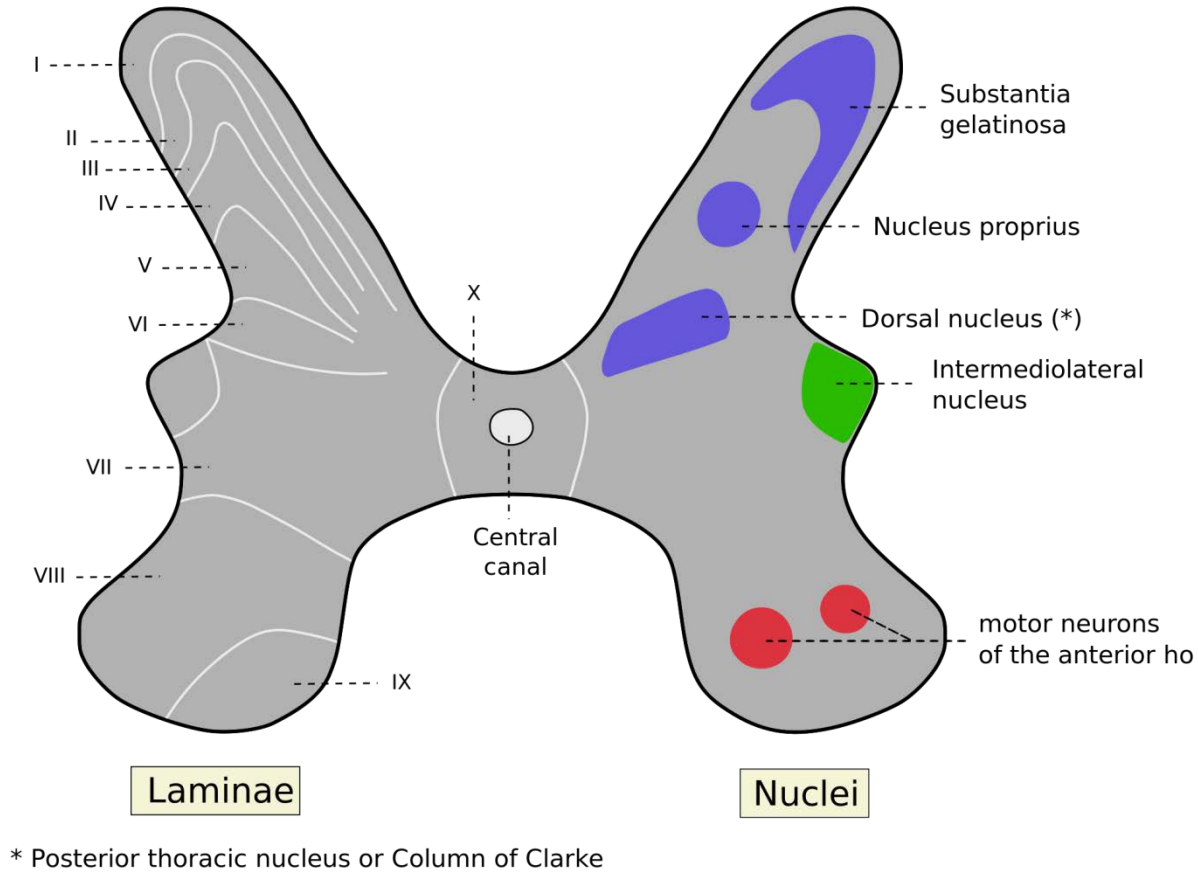


FIGURE: cell groups and various laminae in spinal cord

In the spinal cord , the central grey matter is susually "butterfly shaped", with each side of the "butterfly" contains a dorsal horn (posterior) and ventral (anterior) horn. Each horns is connected with the spinal nerve roots. [10]

WHITE MATTER OF SPINAL CORD

↓

SEGMENT

↓

COLUMNS

↓

TRACTS

COLUMNS:	**TRACTS:**
Anterior	Ascending
Posterior	Descending
Lateral	

SPINAL CORD TRACTS

A TRACT is a collection of multiple nerve fibers that connects two grey matter masses with in the CNS(central nervous system)

Tracts may be may be ascending or desending named after the grey matter masses connected by them.

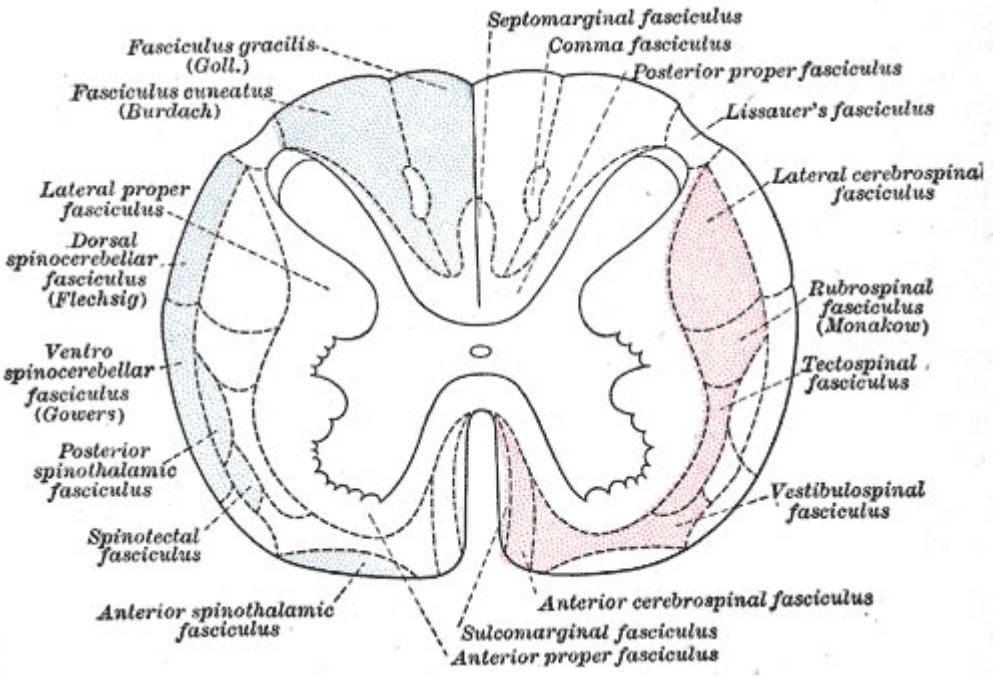
Tracts are also called “Fasiculi or leminisci”

The WM of the cord is divided into 1.posterior (dorsal), 2.lateral, 3.anterior (ventral) columns. These columns are sometimes called “funiculi”.

Sensory information carried from the periphery to the brain by ascending tracts , while the motor signals carried from brain to muscles and glands by the desending tracts.

The columns further divided into tracts (sometimes called “fascicule”) they are named according to the structures that they connect which. For EX: “the spinothalamic tract - carrying information from the spinal cord to the thalamus of the brainstem, and it is an ascending tract, so it carries sensory Information.

. Most of the motor control is contralateral. For Ex: right upper and lower limb is controlled by the motor area in the left cerebral cortex . Some tract have an origin and destination on the same side of the body known as - an ispsilateral relationship.



white matter columns &various tracts –cross section

Spinal Tracts

Tract	Column Location	Dessusitation location	Function
Ascending Tracts - Sensory			
Gracile fasciculus	posterior	medulla	below level T6: limb and trunk position sensations; deep touch; visceral pain; vibration
Cuneate fasciculus	posterior	medulla	level T6 and above: limb and trunk position sensations; deep touch; visceral pain; vibration
Spinothalamic	lateral and anterior	spinal cord	light touch, tickle, itch, temperature, pain, and pressure sensations
Spinoreticular	lateral and anterior	some fibers of the spinal cord	pain sensation from tissue injury
Posterior spinocerebellar	lateral	none	proprioception - feedback from muscles
Anterior spinocerebellar	lateral	spinal cord	proprioception - feedback from muscles
Descending Tracts - Motor			
Lateral corticospinal	lateral	medulla	fine limb control
Anterior corticospinal	anterior	spinal cord	fine limb control
Tectospinal	anterior	midbrain	head-turning reflex in response to visual and auditory stimuli
Lateral reticulospinal	lateral	none	posture and balance; awareness of pain regulation
Medial reticulospinal	anterior	none	posture and balance; awareness of pain regulation
Lateral vestibulospinal	anterior	none	posture and balance
Medial vestibulospinal	anterior	some fibers of the medulla	head position control

This table lists the major spinal tracts, indicates if they decussate, and provides a brief description of the types of information that they carry.

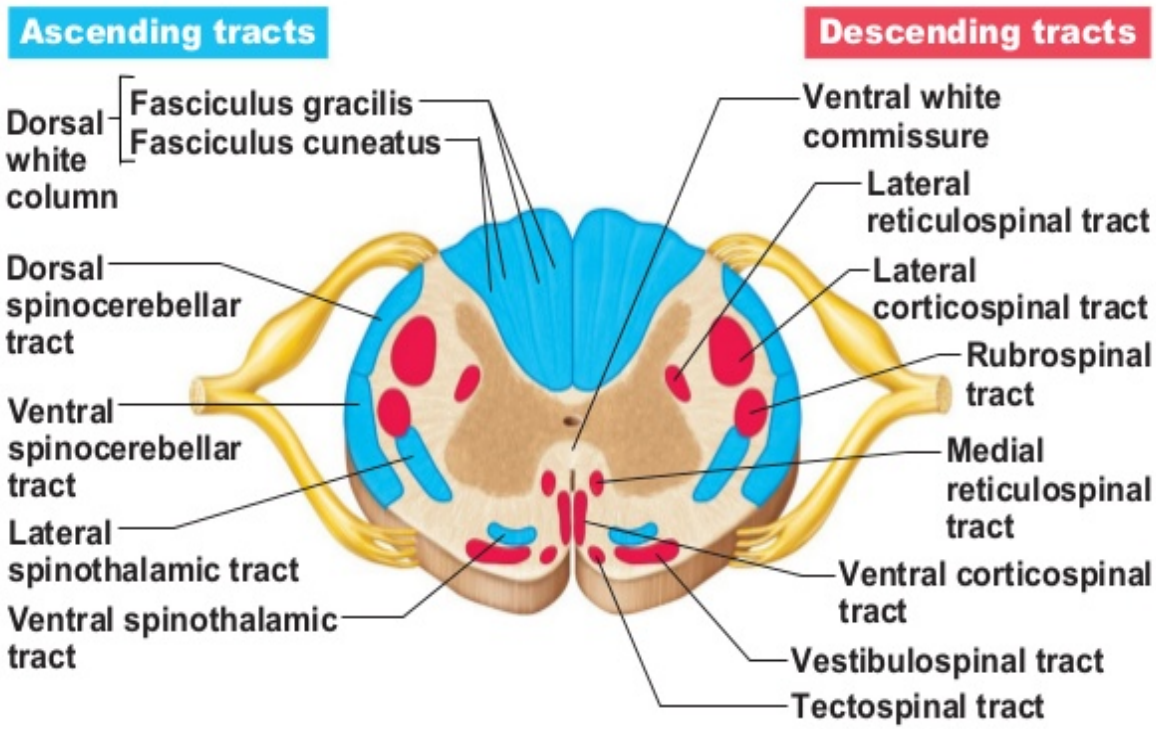


FIGURE: Graphic representation of spinal cord tracts

CERVICAL SPONDYLOTIC MYELOPATHY:

As we age sequence of degenerative changes occur in the vertebral column known as Spondylosis. Multiple facrors are responsible for this particularly environmental, and occupational and genetic factors play a major role.

Spondylotic changes includes disc dessication ,disc prolapse,osteophytes formation ,these changes compress the spinal cord and cause dysfunction may known as .cervical spondylotic myelopathy (CSM).

Cervical degenerative disease (spondylosis) is the very common cause of myelopathy in the cervical spine.[11] Unlike other spinal cord problems early surgery to decompress the cord is necessary in the management of cervical spondylotic myelopathy (CSM) and improve the patient outcome prognosis. Surgery done within a year from the onset of symptoms improve the prognosis in Cervical spondylotic myelopathy(CSM)[12,13]

Earlier detection of cervical spondyloyic myelopathy is usually difficult due to wide variations in the symptoms and signs among the patients. symptoms onset is usually slow and insidious.

PATHOLOGY:

Cervical spondylotic myelopathy(CSM) first defined by "Brain et al". in 1952 . The pathology of the cervical spondylosis and sunsequent development of myelopathy is a cascade in which number of factors play a key role.

Disc dehyrdtion &dessication

↓

Disc space collapse

↓

Mechanical stress on the end plates

↓

Formation of osteophytes

↓

Narrowing of spinal canal

↓

Spinal cord compression

↓

CERVICAL SONDYLOTIC MYELOPATHY

MECHANICAL FACTORS:

The factors responsible for cervical spondylotic myelopathy are categorised into

1.Static mechanical factors

2. Dynamic mechanical factors

Two mechanisms : by which the factors damage the spinal cord

1.direct trauma

2. ischemia [16]

1.STATIC MECHANICAL FACTORS:

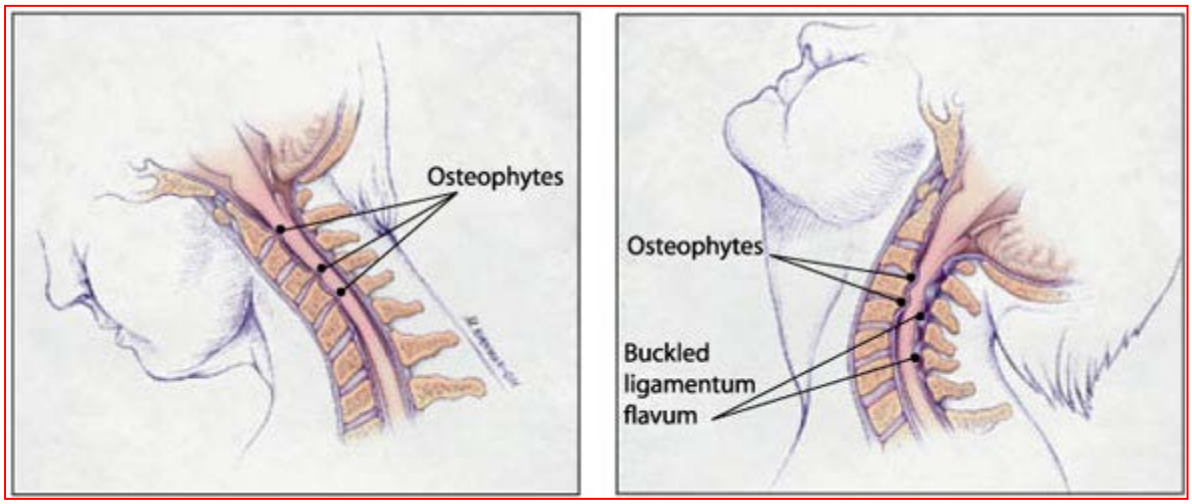
(1) Osteophyte's formation.

(2) Hypertrophied ligamentum flavum,

(3) Ossified posterior longitudinal ligament (OPLL)

(4)Subluxation, or kyphosis

These four static factors cause severe narrowing of spinal canal and compression on the spinal cord. [17]



DYNAMIC MECHANICAL FACTORS IN CSM"

During flexion, the cord is compressed agaist the osteophytes ridges. During extension, the cord compressed against the ligamentum flavum .

DYNAMIC MECHANICAL FACTORS:

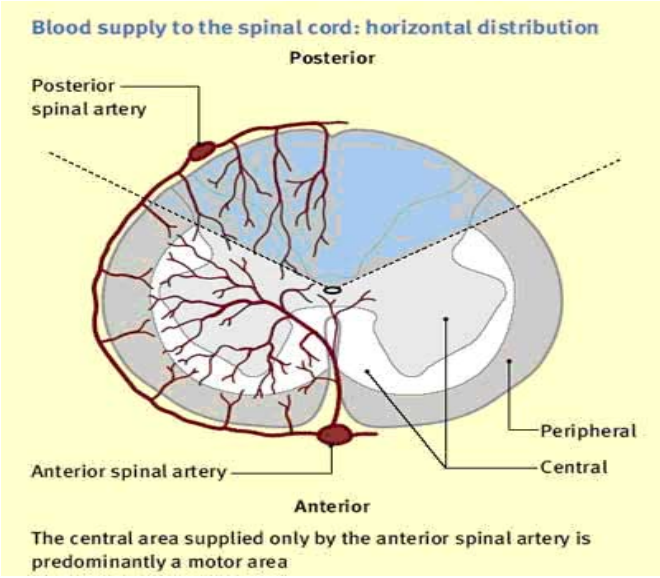
Dynamic factors refers to the abnormal movement of the cervical spine during flexion. & extension, which also grant to spinal cord injury in addition to static factors.

During flexion, the cord is compressed agaist the osteophytes ridges. During extension, the cord compressed against the ligamentum flavum[18]

ISCHEMIA:

Spinal cord supplied by anterior and posterior spinal artey when these vessels are compressed by degenerative elements ischemia occurs . Also compression of venous out flow lead to significant venous congestion and cause spinal cord ischemia.

Several post mortem(PM) analysis in CSM patients demonstrate spinal cord necrosis and cavitations, that leads to the conclusion that vascular pathology may be the more involved in the pathology of CSM . CSM most commonly affects the cord at C5 to C7 level which has the most vulnerable blood supply



SYMPTOMS:

In cervical spondylotic myelopathy the development of symptoms is slow and progress slowly over many years ,rarely in some the disease worsen rapidly.

In the First case series reported by "Brain et al, "the duration of symptoms extend from one(1) week to twenty six(26)years", and almost fifty percent of the patients present with symptoms for more than 1 year at the time of diagnosis .[12]

COMMON SYMPTOMS:

Symptoms
Hand clumsiness, difficulty with fine motor skills (e.g., buttoning, jewelry, handwriting)
Diffuse, non-dermatomal upper Extremity Numbness (usually the hands)
Gait Instability, bumping into walls, feeling "drunken" or "wobbly"
May or may not have neck or arm pain
Lhermitte's Symptoms - electric "jolts" down the spine with particular neck movements
Bowel/ bladder incontinence

.

SIGNS:

Signs
Motor Weakness (most commonly in the hands)
Upper motor neuron signs: Hyper-reflexia, clonus, babinski, scapulohumeral reflex
Objective gait disturbance: timed walking tests
Provocative signs: Hoffmann's, inverted brachioradialis reflex
Lhermitte's Sign
Muscle wasting (most commonly the hand)
Myelopathy hand: Finger Escape Sign, inability to rapidly grip and release

Table 1. Physical Findings Associated with Cervical Radiculopathy.*

Disk Level	Root	Pain Distribution	Weakness	Sensory Loss	Reflex Loss
C4–C5	C5	Medial scapular border, lateral upper arm to elbow	Deltoid, supraspinatus, infraspinatus	Lateral upper arm	Supinator reflex
C5–C6	C6	Lateral forearm, thumb and index finger	Biceps, brachioradialis, wrist extensors	Thumb and index finger	Biceps reflex
C6–C7	C7	Medial scapula, posterior arm, dorsum of forearm, third finger	Triceps, wrist flexors, finger extensors	Posterior forearm, third finger	Triceps reflex
C7–T1	C8	Shoulder, ulnar side of forearm, fifth finger	Thumb flexors, abductors, intrinsic hand muscles	Fifth finger	—

This table helps to locate the site of the leision

COMMON CLINICAL SCORING METHODS

1.Nurick-score,

2.Japanese-orthopaedic-association-score (JOA-Score),

3.Cooper-myelopathy-scale (CMS),

4.Prolo-score (modified for CSM)

5.European-myelopathy-score (EMS)

Nurick's classification system for myelopathy[24]

Grade	Root signs	Cord involvement	Gait	Employment
0	Yes	No	Normal	Possible
I	Yes	Yes	Normal	Possible
II	Yes	Yes	Mild abnormality	Possible
III	Yes	Yes	Severe abnormality	Impossible
IV	Yes	Yes	Only with assistance	Impossible

JAPANESE ORTHOPEDIC ASSOCIATIATION SCORING FOR CERVICAL SPNDYLOTIC MYELOPATHY[25]

Chart 1. *JOA Scale.*

Scale for clinical evaluation of myelopathy – Japanese Orthopedic Association (JOA): 0 to 17 points	Points
I – Motor function of the upper limb	
-Impossible to eat with cutlery or to button shirt	0
-Possible to eat with cutlery, impossible to button shirt	1
-Possible to button shirt, with great difficulty	2
-Possible to button shirt, with difficulty	3
-Normal	4
II – Motor function of the lower limb	
-Impossible to walk	0
-Needs cane or assistance on flat surface	1
-Needs assistance on stairs	2
-Walks unaided, but slowly	3
- Normal	4
III – Sensory function	
Upper limb	
-Apparent sensory disorder	0
-Minimal sensory disorder	1
-Normal	2
Lower limb	
-Apparent sensory disorder	0
-Minimal sensory disorder	1
-Normal	2
Trunk	
-Apparent sensory disorder	0
-Minimal sensory disorder	1
-Normal	2
IV – Bladder function	
-Urinary retention or incontinence	0
-Sensation of retention, loss of slight flow	1
-Urinary retention and/or increase in urinary frequency	2
-Normal	3

RADIOLOGICAL IMAGING MODALITIES:

Magnetic resonance imaging (MRI) of the cervical spine (T2 Sequence) is the initial modality of choice in patients with symptoms of compressive myelopathy.[6]

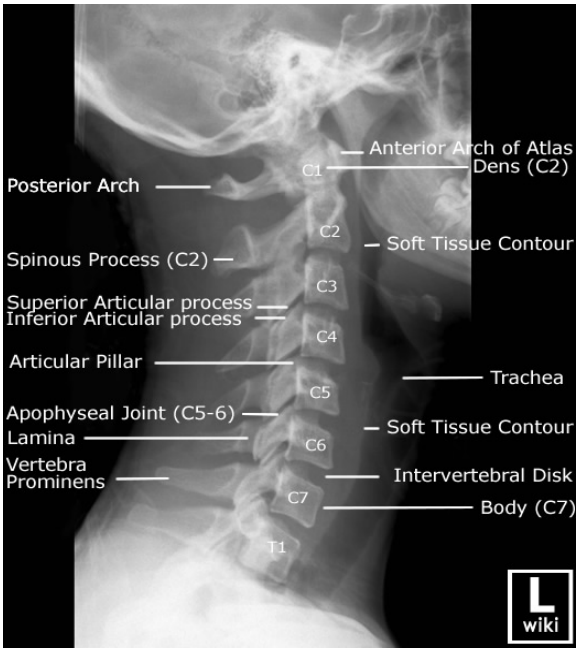
MRI is non invasive and and highly useful in the evaluation of spinal cord in multiple planes(axial,sagittal.coronal),useful in the evaluation of spinal canal narrowing and to detect any intra medullary leisions that cause myelopathy symptoms like tumour,lipoma,cavernoma,contusion. T2 weighted image Hyperintensity in the spinal cord of patients with Cervical spodylotic myelopathy - suggestive of myelomalacic changes.

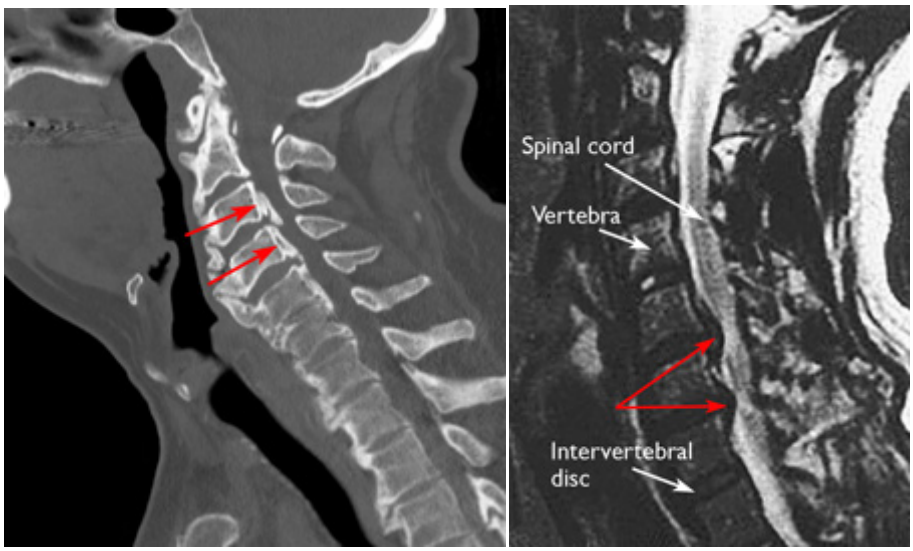
Computed tomography (CT) is superior to MRI in the evaluation of spinal canal narrowing as MRI is not useful in the evaluation of bony structures and osteophtes.[7]

Myelography done by injecting contast medium in to the spinal canal followed by multiple x ray projection or CT .It is useful in some post operative cases with metallic implant where MRI contraindicated.

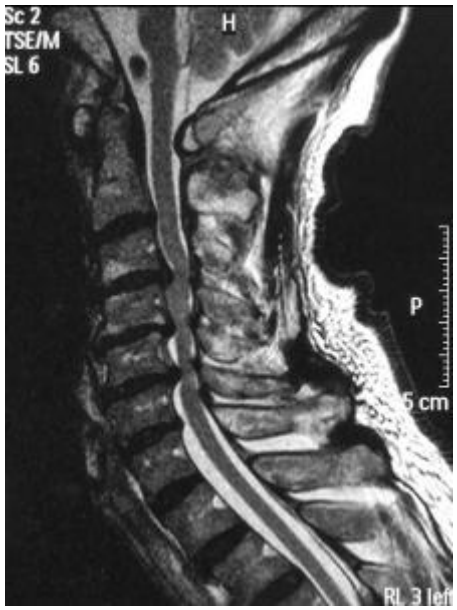
Plain X ray is useful in the initial evaluation of degenerative vertebral changes (osteophytes)

C.SPINE RADIOGRAPHY-LATERAL VIEW

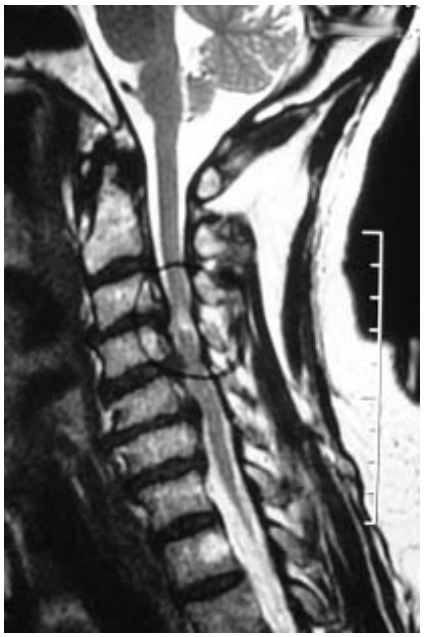




CT Cervical spine sagittal (bone window) scan shows osteophytes formation causing spinal canal narrowing .



This MRI T 2 weighted image shows multi level disc dessication &bulge com pressing on the spinal cord.



Spondylotic changes with T2 hyperintensity noted at the level of C3-C4 suggestive of myelomalacic changes

TREATMENT

Both conservative or medical and surgical approaches are available to treat CSM.

CONSERVATIVE MANAGEMENT

In patients who have mild symptoms of CSM, a “careful watching” is enough.

CONSERVATIVE TREATMENT METHODS:

1.cervical traction,

2.cervical immobilization (collar or neck brace),

. 3.skull traction and physical therapy

In the United States Cervical immobilization is the commonly used non surgical treatment method.

Several studies reported that symptomatic CSM patients deteriorate during immobilization since nonsurgical approach is usually not advisable in myelopathic patients. [28,29]

SURGICAL TREATMENT

Once symptoms of myelopathy occurs, surgical intervention is must. The aim of surgery is to relieve symptoms by "decompressing," or relieving pressure on, the cervical cord,usually by resecting some pieces of bone or soft tissue (such as a herniated disk) that may be taking up space in the spinal canal. This relieves pressure by creating more space for the spinal cord.

- **SURGICAL OPTIONS**: divided into

  1.anterior,

  2.posterior,

  3.combined anterior and posterior approaches.

CANDIDATES FOR SURGERY

Candidates for surgery include patients who have progressive neurologic changes with signs and symptoms of compressive myelopathy.. These neurologic changes may include:

- Weakness in the arms or legs
- Numbness in the hands
- Fine motor skill difficulties
- Imbalance issues
- Gait changes
- Severe disabling pain

FACTORS ASSOCIATED WITH BETTER SURGICAL OUTCOME

1.Younger

2.duration of symptoms < 6 months

3.Single area of spinal cord involvement

4.A larger available area for the spinal cord

.SURGICAL PROCEDURES:

The four surgical procedures commonly performed to treat CSM are:

- Anterior Cervical Diskectomy and Fusion
- Anterior Cervical Corpectomy and Fusion
- Laminectomy
- Laminoplasty

. Depending on the procedure, surgery for CSM can be performed either from anterior or posterior or combined approach.. Each approach has some advantages and disadvantages,

DIFFUSION TENSOR IMAGING

Diffusion tensor imaging(DTI) parameters (FA Values) able to show micro structural abnormalities that are not evaluated by conventional MR techniques.

DTI can detect the microstructral abnormalities in the cervical cord earlier than the development of cord signal abnormality &thining on conventional sequences in patients with CSM, thereby useful in earlier diagnosis and prognosis of cervical spondylotic myelopathy.

.PRINCIPLES OF DTI:

"Diffusion MR imaging (MRI) provides a measure of the displacement of water molecules in tissues"..

Our routine diffusion weighted imaging is mainly based on the principle of **isotropic** diffusion in a single direction.

Diffusion tensor imaging is based on the principle of **Anisotropic diffusion** of water molecules in multiple directions atleast six usually 12-24,with our 3 T Siemens SKYRA upto 256 directions can be obtained.

The axons in the whitematter of the nervous system allows diffusion of water molecules in a direction mainly parallel, rather than perpendicular to axonal fibers.

In Diffusion tensor imaging (DTI) fractional anisotropy (FA) and apparent diffusion coefficient (ADC) are the most commonly used parameters . other parameters are trace, b0,and regional anisotrophy(RA)

Fractional anisotrophy (FA) is an anisotropic parameter and its value ranges from 0 to 1, values close to one represents a more anisotropic structure.

ADC represents the water diffusion magnitude with high ADC indicating - high water mobility with only few boundaries to water diffusion.

Although DTI is not in routine clinical use, it has been proven to be a non-invasive technique for detecting very subtle damage to the spinal cord that appears to be normal on MR conventional T2-Sequence images .

Several studies have showed that “FA and ADC values changed significantly at compressive myelopathy levels compared with uncompressed levels or normal volunteers” .

FA Value is believed to better correlate with myelopathy severity and useful in the assessment of prognosis and to predict the postoperative success of Cervical spondylotic myelopathy(CSM) patients.

PHYSICS AND TECHNIQUE OF DTI

MR scanner axes X,Y &Z are never perfectly parallel to the white matter tracts at each point in the provided image.

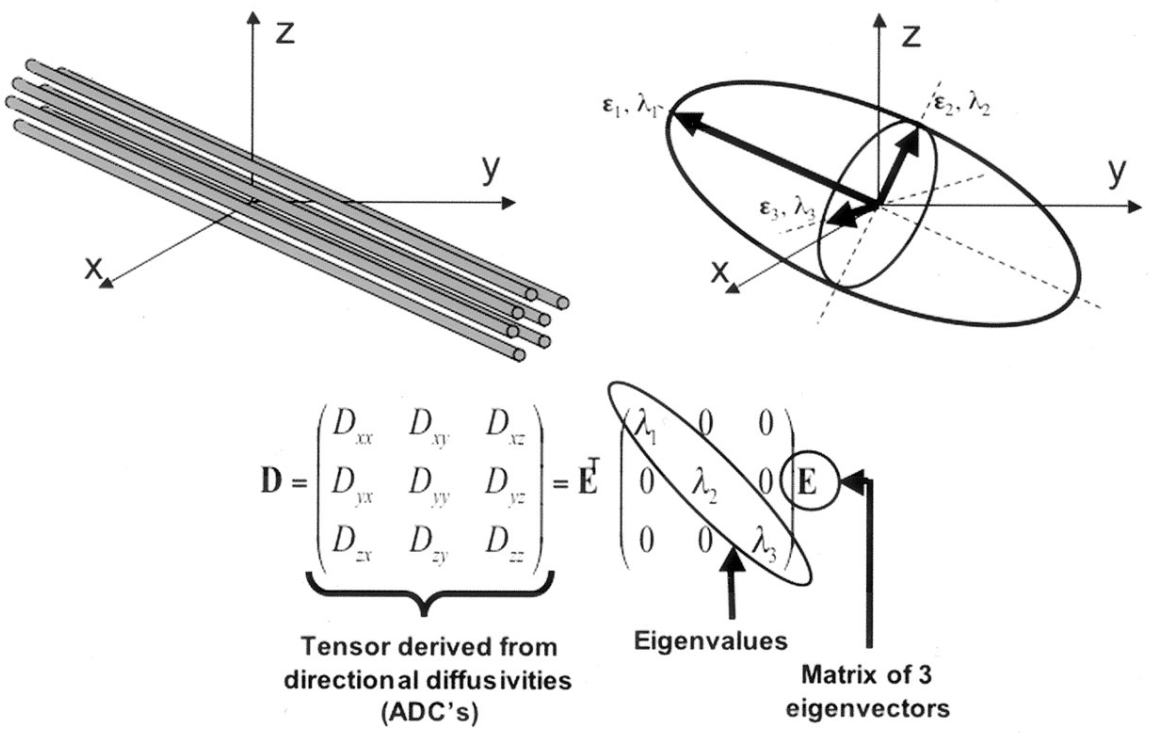
In Diffusion tensor imaging ,images are acquired in atleast six directions usually 12 – 24 directions instead of three in the usual trace diffusion.

Pure apparent diffusion coefficient for every pixel is calculated from these images in multiple directions,this is called as "**principal eigen value".**

The principal eigen value is calculated along the true axis of diffusion known as "**eigen vector".**

The image formed with principal eigen value is known as "Diffusion tensor image" that provides orientation of fiber tracts.

With higher tesla (3T) MRI diffusion of water molecules in upto 256 directions can be assessed.



$$FA_{\mathrm{DTI}} = \sqrt{\frac{3}{2}} \frac{\sqrt{(\lambda_1 - \bar{\lambda})^2 + (\lambda_2 - \bar{\lambda})^2 + (\lambda_3 - \bar{\lambda})^2}}{\sqrt{\lambda_1^2 + \lambda_2^2 + \lambda_3^2}}$$

$$\bar{\lambda} = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3}.$$

where $\bar{\lambda}$ denotes the mean of the three eigenvalues, which is equal to the directionally averaged diffusivity

"The direction of maximum diffusivity usually mapped by using **red, green, and blue (RGB) color** channels with color brightness adjusted by fractional anisotrophy(FA), results in a summary map from which the degree of anisotropy and the local fiber direction can be determined".[37]

DTI -TRACTOGRAMS

The White matter tracts are evaluated with tractography by using the tensor deflection algorithm.[38] Tracking is begin from a start location in both front and backward directions defined by "the major eigenvector at the seed point".

The propagation is usually terminated when the fiber tract reached a voxel with Fractional anisotrophy < 0.2 ("the estimated major eigenvector direction becomes less accurate as FA decreases and becomes very sensitive to image noise for FA less than 0.2") or when the angle between 2 subsequent steps was > 45°.

A whole set of fiber trajectories was acquired by putting the seeds in all the voxels with Fractional anisotrophy value > 0.4

Fiber trajectories are showed with colors (red,blue,green)that laid onto the gray-scale images in multiple 3 D projections,but not like the “directional color coding maps in which directional information is color-coded, individual tractograms are usually displayed by using fixed colors chosen ”

- RED - directions in the X axis- right to left
- GREEN - directions in the Y axis - Anteroposteror
- BLUE - directions in the Z axis - craniocaudal

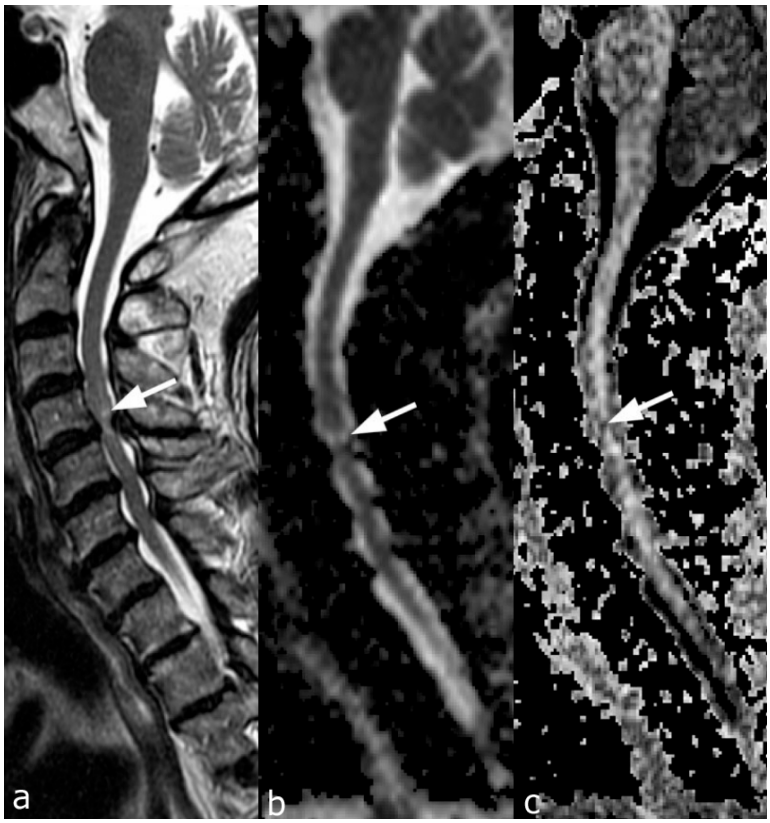
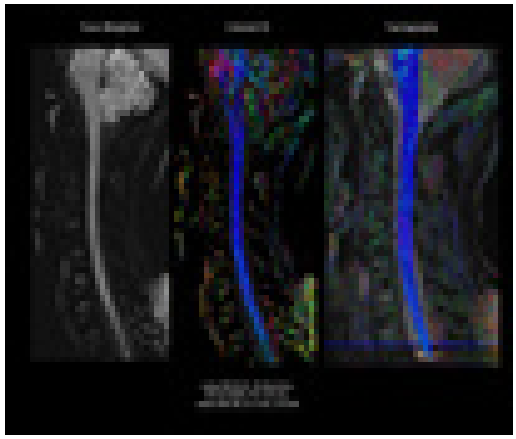
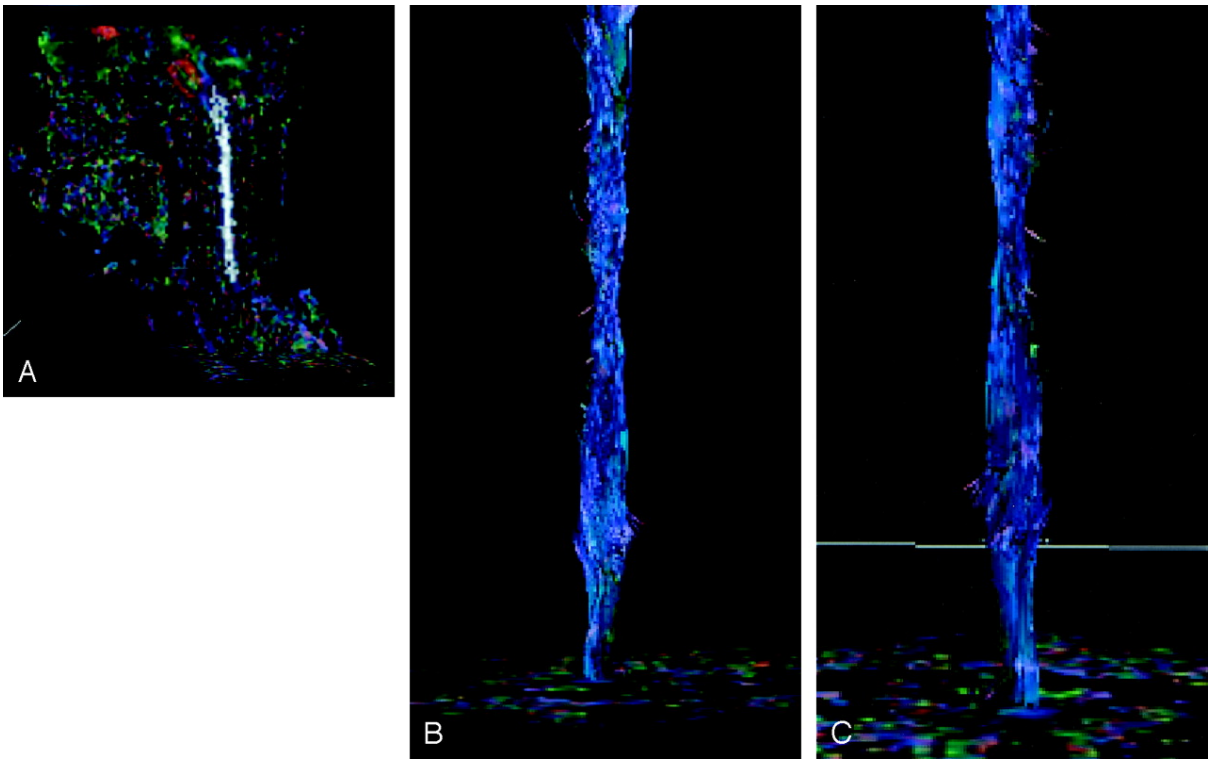


Image shows MRI T2 Sagittal , FA map, ADC map

NORMAL SPINAL CORD TRACTOGRAPHY DEPICTED IN BLUE COLOUR





AIM OF THE STUDY

The aim of our study are to

(1) Acquire micro structural para meters (FA-Fractional anisotrophy&ADC-Apparent diffusion coefficient) of the cervical cord in patients with symptoms of cervical spondylotic myelopathy(CSM) using ROI method

(2)To compare DTI(Diffusion tensor imaging) parameter (FA&ADC) with clinical symptoms(NURICK score)

(3) To compare DTI parameter (FA&ADC) with conventional T2 weighted (hyperintensity)imaging findings

- Study Design - Prospective observational study

- Sample size - 50 patients

- Study period - 6 months(march 2015 – august 2015)

- Study center - Barnard institute of radiology,
  Rajiv Gandhi govt general hospital,
  Madras medical college,

  - The study was done after getting approval by madras medical college ethics committee.
  - The study done only after getting written consent fron the patient or control .

Also twenty volunteers with out symptoms of myelopathy were studied to asses the normal DTI parameters value(Fractional anisotrophy & Apparent diffusion coefficient)

INCLUSION CRITERIA:

(1) patients with signs and symptoms of cervical myelopathy

(2) patients with cervical bony spinal canal narrowing and degenrative changes on conventional MRI or CT

EXCLUSION CRITERIA:

(1) Patients with out cervical bony spinal canal narrowing and degenrative changes on conventional MRI or CT

(2) Other known neurological disease

(3) Patients with previous spine surgery

(4) Patients with contraindication for MRI (pacemaker,cochlear implant)

(5)non consenting & uncooperative patients

MATERIALS AND METHODS:

At our institution , patients who presented with complaints of cervical myelopathy are routinely evaluated in the Neurology and Neurosurgery department clincally then referred for radiological evaluation .

The severity of their myelopathy evaluated and Nurick's score was assigned ,the score ranged from 1 to 5 with a high score indicates a high level of dysfunction.

All MRI were performed on 3 Tesla SIEMENS MRI(SKYRA).Dedicated spine channels were used for all images.

The MRI proctocol

- Sagittal T1-weighted sequence
- Sagittal T2 weighted sequences.
- Axial T2 weighted sequences
- Sagittal diffusion tensor imaging

The DTI acquition - based on SSEPI (single shot Echo planar imaging) and includes

- **Diffusion weighted,**
- **Trace weighted**
- **FA mapping**
- **ADC mapping**
- **Mosaic**
- **Tensor**

- Diffusion measured in - 20 directions.
- the b factor - 700mm/s.
- TR/TE -2200./83 ms
- Field of view - 320 mm .
- Partial fourier acquition - 6/8.
- The bandwidth -1538.
- Fifteen (15) slices were obtained with out any spacing
- Slice thickness = 3 mm.
- This sequence last 3min 31 sec.

- The presence of spinal cord signal abnormality on T2-

  Or T 1 weighted sequences are first analysed.

- Diffusion tensor imaging (DTI) post-processing was done by syngo MR neuro 3D software program

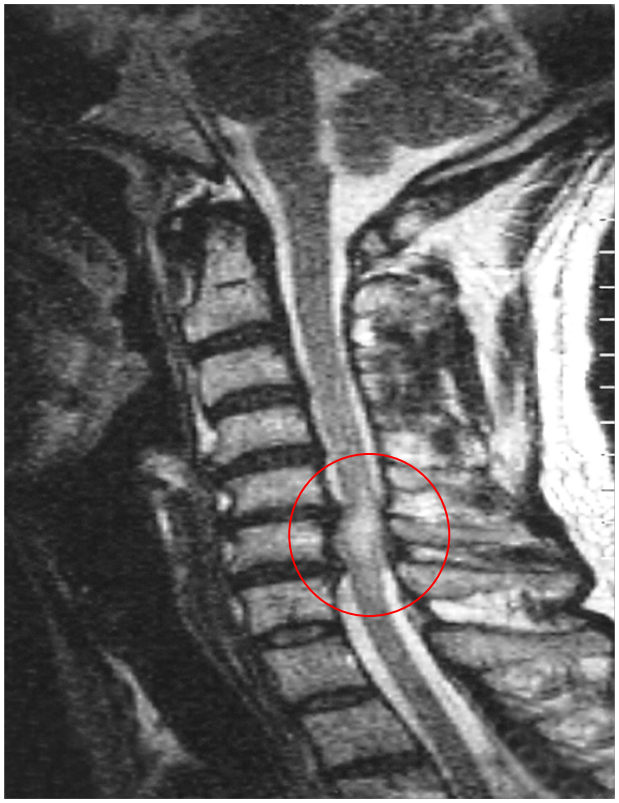
- The first step is determination of b0 threshold to remove any artefactual voxelcorresponding to noise.

- The FA & ADC map were then calculated automatically.

- The second step is acquiring Diffusion tensor imaging (DTI) values from the FA & ADC map ROI method , by drawing a circle or ellipsoid(ROI) on TENSOR images.

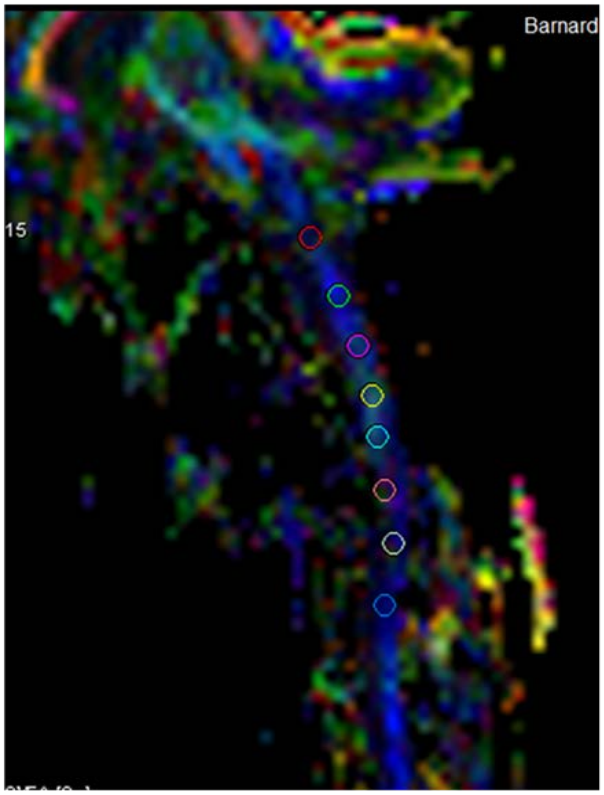
CASE 1

- **52/MALE**
- **H/o neck Pain and inability to use all four limbs(Quadriparesis)**
- **Power was 2/5 in all limbs**
- **Nurick's clinical score - grade 5**



- **Conventional T2 weighted image showed C5-C6 disc extrusion with cord hyperintensity at C5-C6 level**

TRACTOGRAPHY

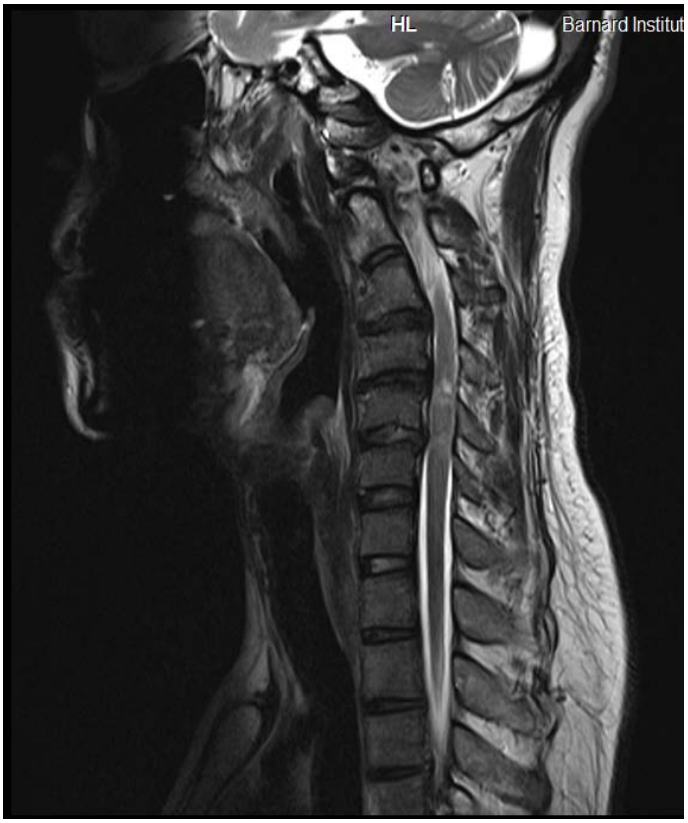


ID	FA Mean	FA SDev	ADC Mean	ADC SDev	TraceW Mean	TraceW SDev
	Size / Min / Ma		Size / Min / Ma		Size / Min / Ma	
1	249.3	25.2	2866.3	617.3	95.7	28.7
	3 / 214 / 271		3 / 2324 / 3730		3 / 59 / 129	
2	624.7	103.3	1180.7	265.3	85.3	17.0
	3 / 539 / 770		3 / 881 / 1526		3 / 67 / 108	
3	420.7	27.0	1219.7	59.8	134.3	6.1
	3 / 395 / 458		3 / 1143 / 1289		3 / 127 / 142	
4	540.0	83.0	699.0	8.0	127.0	6.0
	2 / 457 / 623		2 / 691 / 707		2 / 121 / 133	
5	450.0	58.2	1195.3	519.9	56.5	19.8
	4 / 352 / 501		4 / 659 / 1715		4 / 33 / 79	
6	266.7	92.0	1392.3	455.4	51.3	32.4
	3 / 137 / 340		3 / 845 / 1960		3 / 25 / 97	
7	314.7	96.0	1253.0	286.4	61.3	9.0
	3 / 200 / 435		3 / 848 / 1460		3 / 51 / 73	

- **In DTI there is significant reduction in FA value &increase in ADC value noted at C5-,C6 level suggestive of severe fiber disruption.**

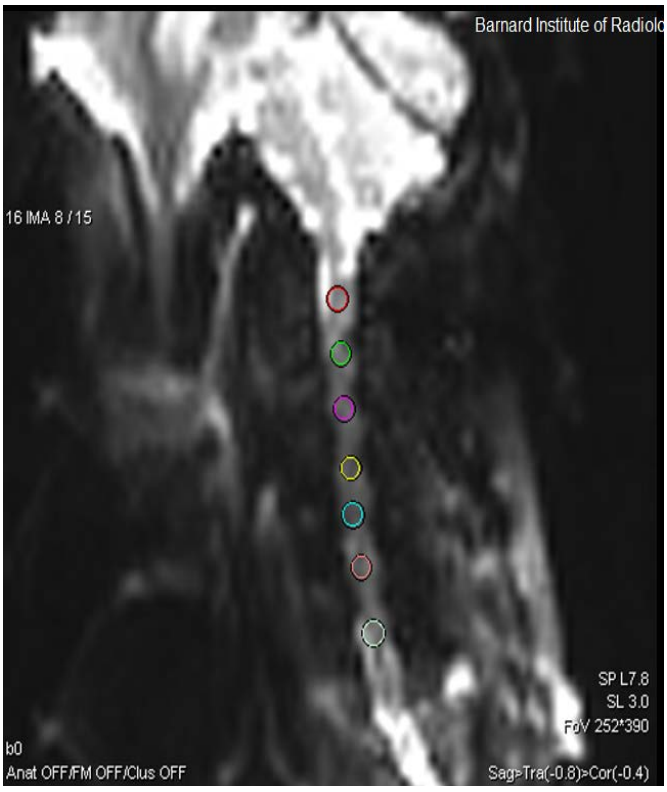
CASE 2

- **34/MALE**
- **H/o neck pain and weakness of all four limbs**
- **On examination power was 3/5**
- **Nurick's clinical score was – grade 3**

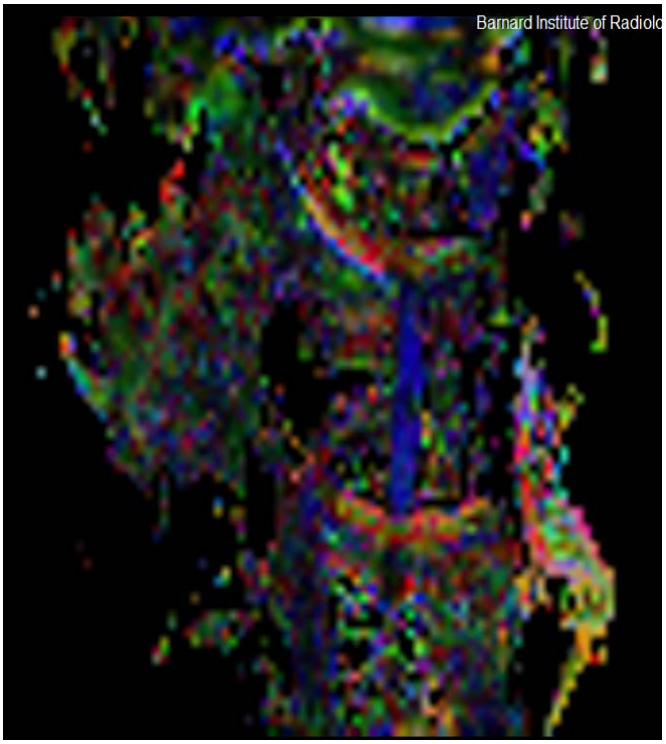


- **Conventional T2 weighted image showed C3-C4,C4-C5,C5-C6 disc osteophte complex with cord T2 hyperintensity at C4-C5 level**

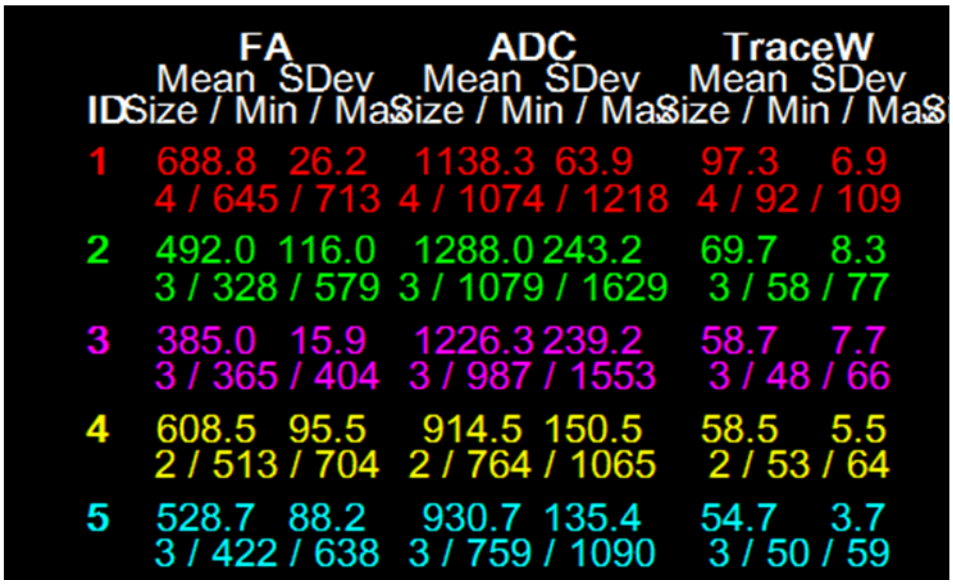
FRACTIONAL ANISOTROPHY MAP



TRACTOGRAPHY



DTI PARAMETERS TABLE



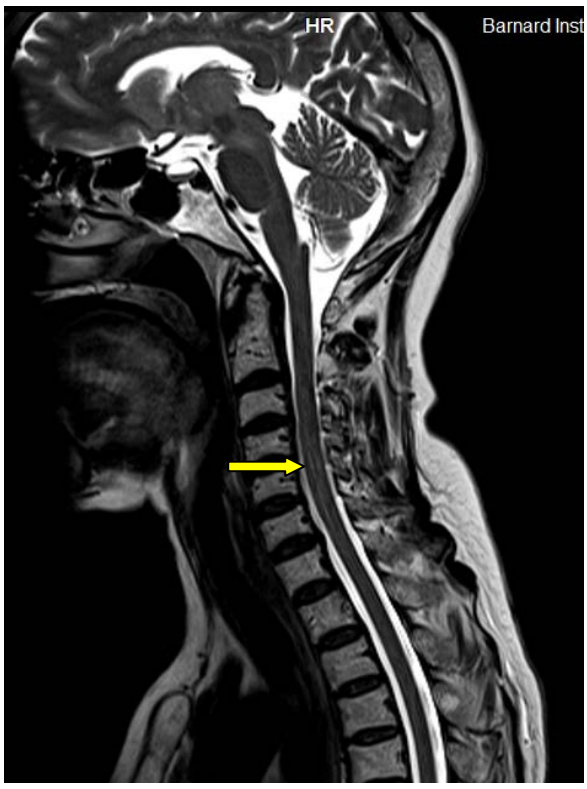
ID	FA Mean SDev Size / Min / Max	ADC Mean SDev Size / Min / Max	TraceW Mean SDev Size / Min / Max
1	688.8 26.2 4 / 645 / 713	1138.3 63.9 4 / 1074 / 1218	97.3 6.9 4 / 92 / 109
2	492.0 116.0 3 / 328 / 579	1288.0 243.2 3 / 1079 / 1629	69.7 8.3 3 / 58 / 77
3	385.0 15.9 3 / 365 / 404	1226.3 239.2 3 / 987 / 1553	58.7 7.7 3 / 48 / 66
4	608.5 95.5 2 / 513 / 704	914.5 150.5 2 / 764 / 1065	58.5 5.5 2 / 53 / 64
5	528.7 88.2 3 / 422 / 638	930.7 135.4 3 / 759 / 1090	54.7 3.7 3 / 50 / 59

- **In DTI there is significant reduction in FA value(0.38) &increase in ADC (1.22)value noted at C4-C5level suggestive of severe fiber disruption**

- **Patchy green colour noted at C4-C5 level in Tractography**

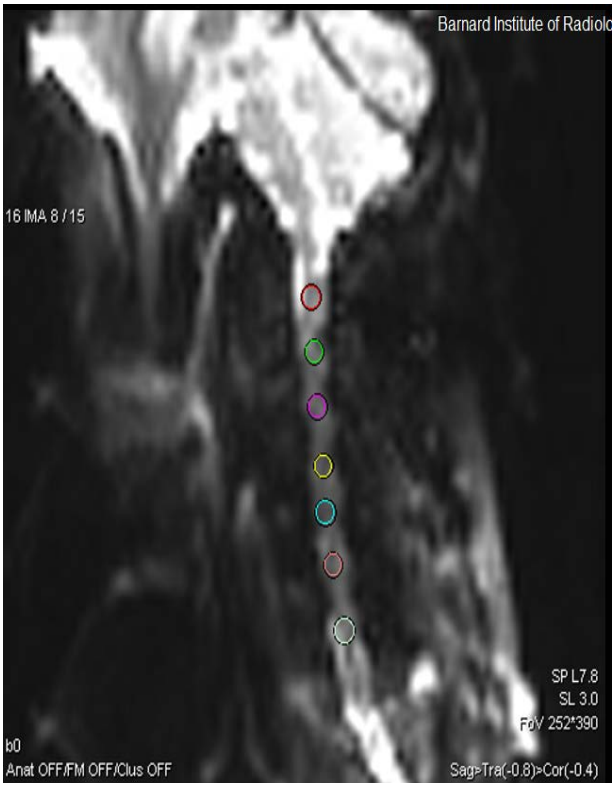
CASE 3

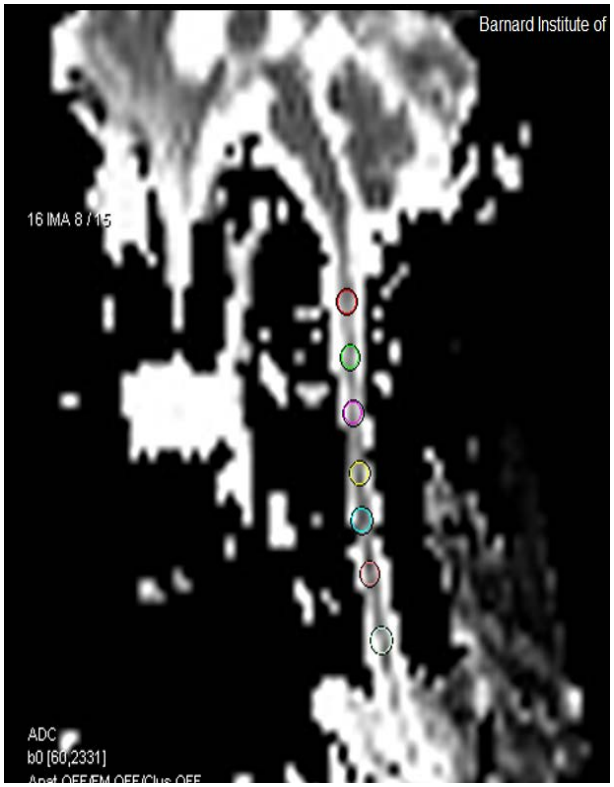
- **65/FEMALE**
- **H/o neck pain , numbness and weakness involving all four limbs**
- **Power was 4/5 in all four limbs**
- **Nurick's score – grade 3**



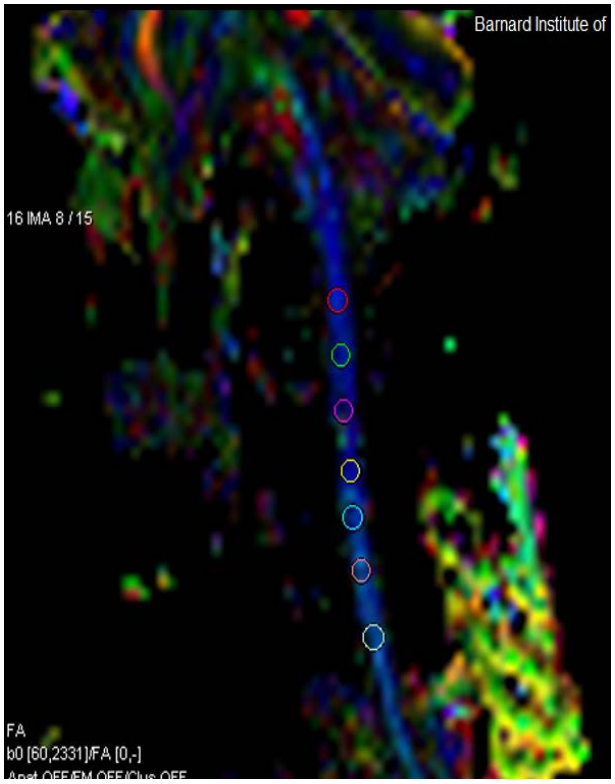
- **Conventional T2 weighted image showed mild hyperintensity from C3 to C6 level**

FA MAP **ADC MAP**

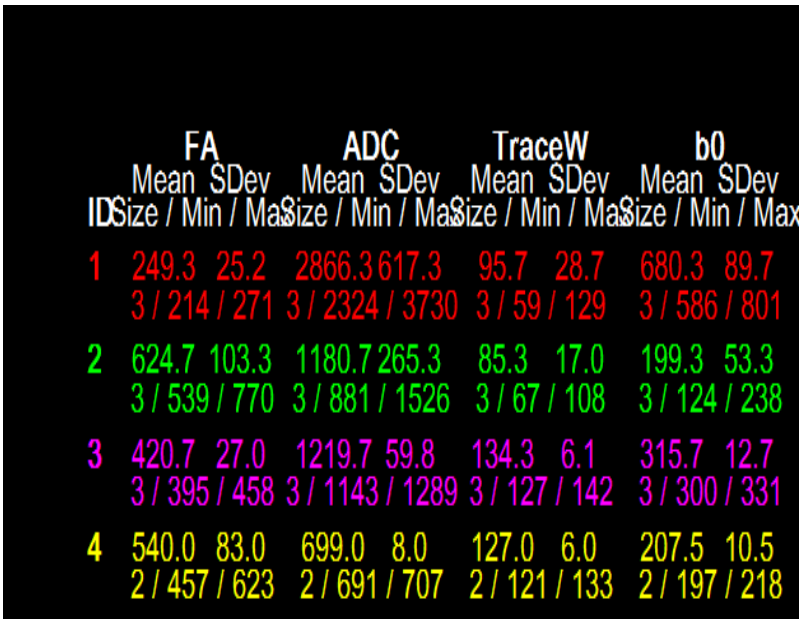




TRACTOGRAPHY



DTI PARAMETERS

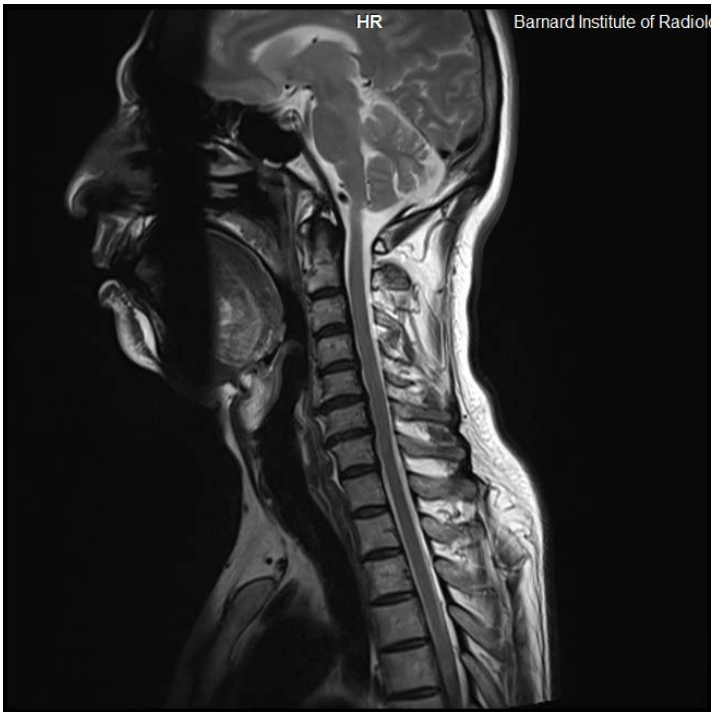


ID	FA Mean	FA SDev	FA Size / Min / Max	ADC Mean	ADC SDev	ADC Size / Min / Max	TraceW Mean	TraceW SDev	TraceW Size / Min / Max	b0 Mean	b0 SDev	b0 Size / Min / Max
1	249.3	25.2	3 / 214 / 271	2866.3	617.3	3 / 2324 / 3730	95.7	28.7	3 / 59 / 129	680.3	89.7	3 / 586 / 801
2	624.7	103.3	3 / 539 / 770	1180.7	265.3	3 / 881 / 1526	85.3	17.0	3 / 67 / 108	199.3	53.3	3 / 124 / 238
3	420.7	27.0	3 / 395 / 458	1219.7	59.8	3 / 1143 / 1289	134.3	6.1	3 / 127 / 142	315.7	12.7	3 / 300 / 331
4	540.0	83.0	2 / 457 / 623	699.0	8.0	2 / 691 / 707	127.0	6.0	2 / 121 / 133	207.5	10.5	2 / 197 / 218

- **In DTI there is significant reduction in FA(0.42) value &increase in ADC value (1.2) noted at C3-C4level suggestive of severe fiber distruption**

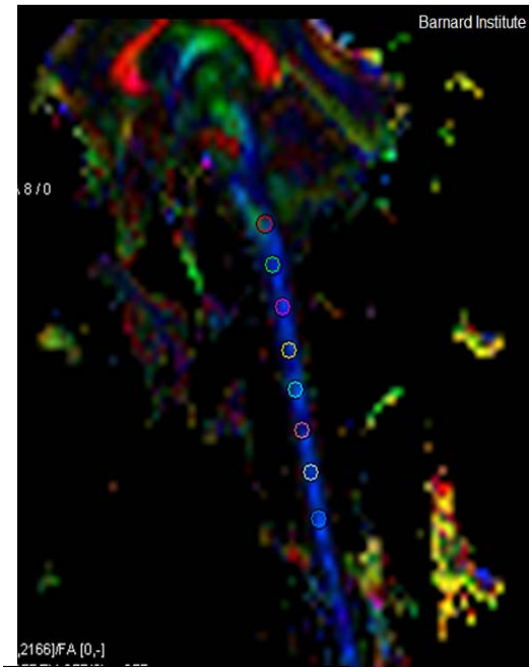
CASE 4

- **52/MALE**
- **H/o neck pain and numbness right upper limb**
- **Power was 5/5 in the right upper limb**
- **NURICK'S score – grade 2**



- **Conventional T2 weighted image showed disc osteophyte complex from C5 to C6 level with normal cord signal.**

TRACTOGRAPHY



FA		ADC		TraceW		b0	
Mean	SDev	Mean	SDev	Mean	SDev	Mean	SD
Size / Min / Ma		Size / Min / Ma		Size / Min / Ma		Size / Min /	
484.0	122.9	1046.3	102.1	153.3	13.1	318.3	25.
4 / 341 / 680		4 / 918 / 1203		4 / 137 / 173		4 / 294 / 3	
671.7	97.4	931.0	81.6	122.7	17.8	236.0	39.
3 / 582 / 807		3 / 854 / 1044		3 / 99 / 142		3 / 180 / 2	
752.0	204.6	853.3	341.9	93.0	3.6	173.3	40.
3 / 470 / 949		3 / 545 / 1330		3 / 90 / 98		3 / 143 / 2	
588.5	212.3	1047.8	418.0	68.3	11.1	142.5	25.
4 / 375 / 871		4 / 562 / 1496		4 / 51 / 81		4 / 120 / 1	
660.8	204.1	977.0	398.9	73.0	10.6	144.3	20.
4 / 459 / 961		4 / 420 / 1520		4 / 56 / 85		4 / 114 / 1	
487.3	93.2	1150.7	304.5	72.3	4.8	164.0	27.
3 / 377 / 605		3 / 824 / 1557		3 / 68 / 79		3 / 141 / 2	
645.7	80.5	962.7	192.6	67.0	10.2	130.0	2.4
3 / 533 / 716		3 / 720 / 1191		3 / 55 / 80		3 / 127 / 1	

In DTI there is significant reduction in FA value (0.48)&increase in ADC (1.15) value noted at C5-C6 level Suggestive of fiber disruption .

STATISICAL ANALYSIS

- The collected data analysed with "**SPSS 16.0"** version.

- To describe about the data descriptive statistics "frequency analysis&percentage analysis "were used for categorical variables and the mean & S.D were used for continuous variables.

- To find the significant difference between the bivariate samples in Paired groups **Wilcoxon signed rank** test was used.

- To assess the relationship between the variables **Spearman's rank Correlation** was used.In both the above statistical tools the probability value **.05** is considered as significant level.

SEX DISTRIBUTION

Frequencies

SEX

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	14	28.0	28.0	28.0
	M	36	72.0	72.0	100.0
	Total	50	100.0	100.0	

Table shows the sex distribution of experimental group.The table shows the predominance of male pat ient in the study group

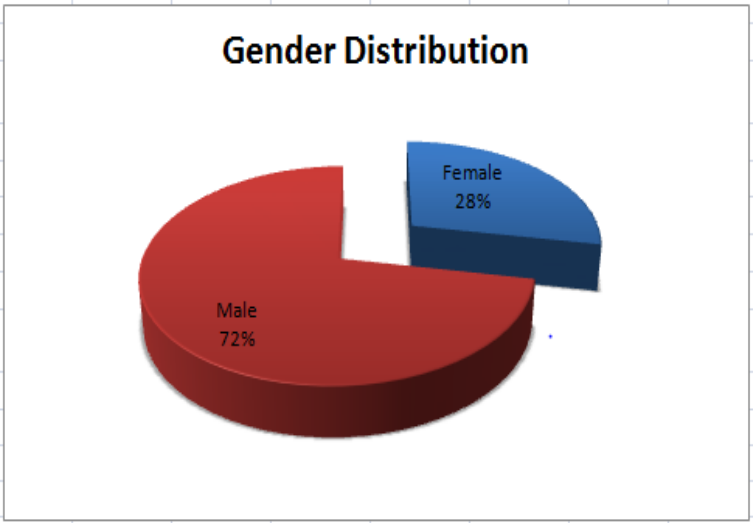


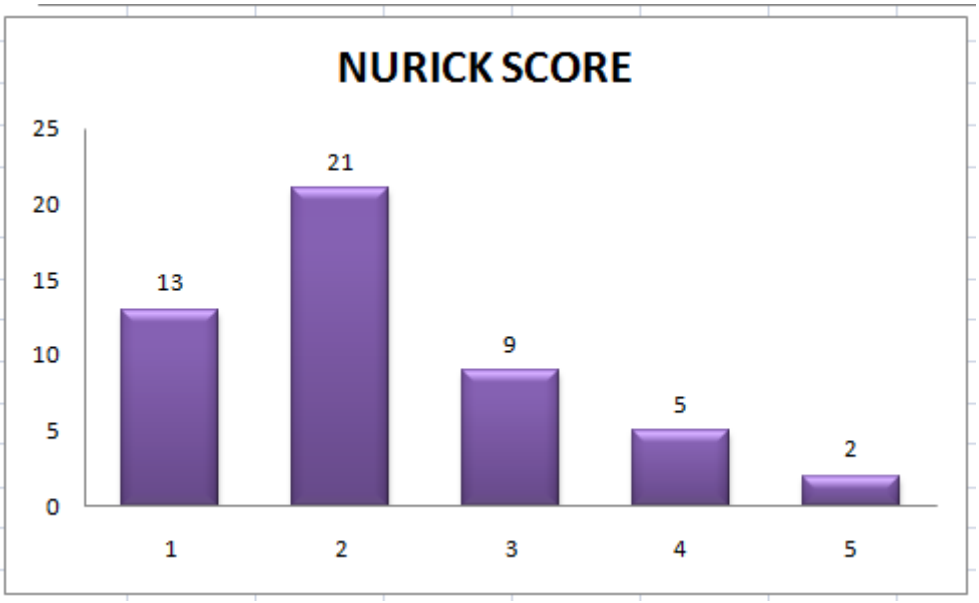
Fig: shows graphic representation of the percentage of male & female patient in the study group

NURICK'S SCORE FREQUENCY TABLE

NURICK SCORE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	26.0	26.0	26.0
	2	21	42.0	42.0	68.0
	3	9	18.0	18.0	86.0
	4	5	10.0	10.0	96.0
	5	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

Table : shows the frequency of distribution of sample group in each grading of nuricks score



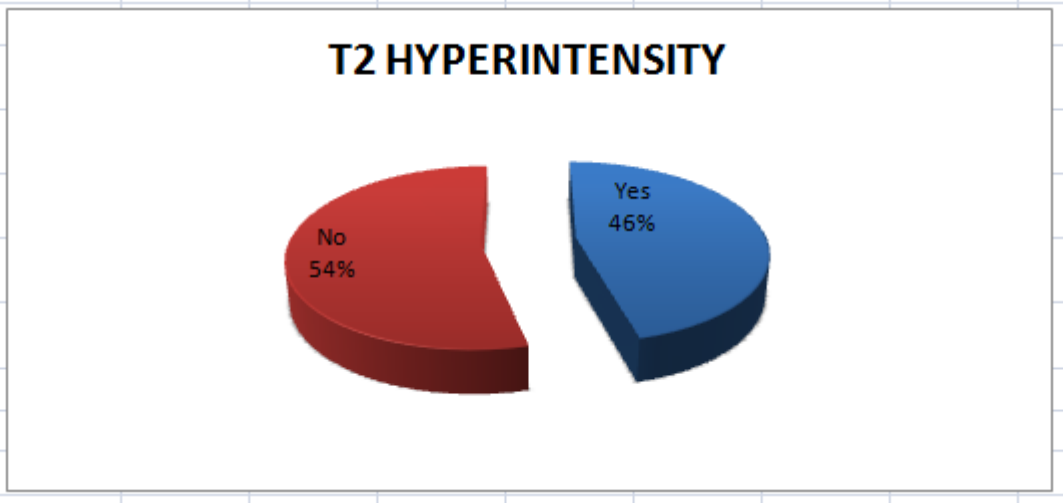
The above bar diagram is a diagrammatic representation of distribution of sample group in each grading of nurick's score

CONVENTIONAL T2 HYPERINTESITY POSITIVE FREQUENCY

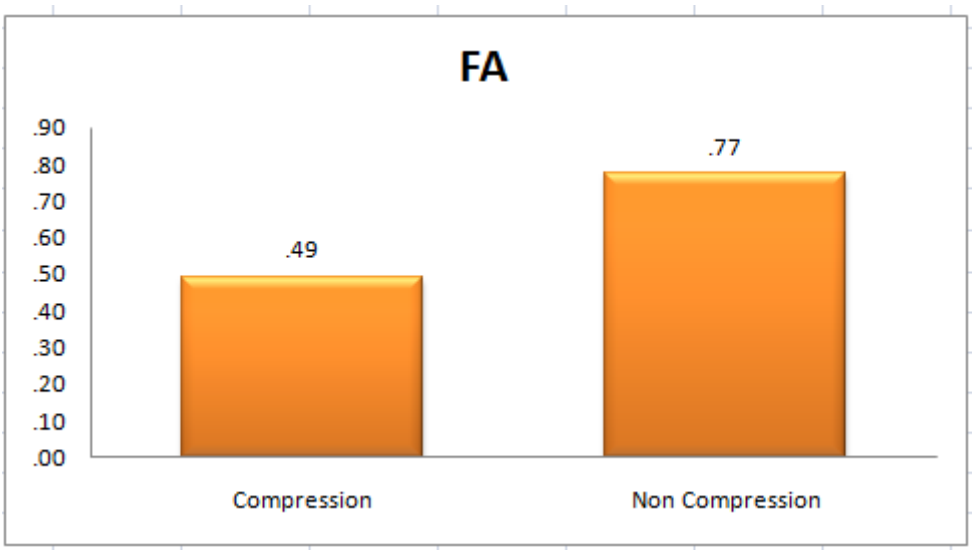
T2 HYPERINTENSITY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	23	46.0	46.0	46.0
	1	27	54.0	54.0	100.0
	Total	50	100.0	100.0	

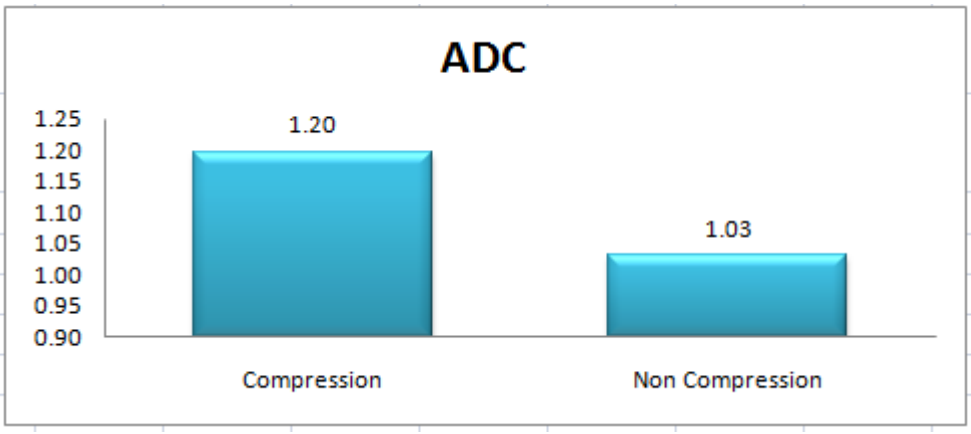
The above table: shows the number of cases positive in conventional T2 weighted image in the 50 study group. 27(54%) patients were positive and 23(46%) patients were negative



The above Pie diagram is a diagrammatic representation of conventional T2 weighted image positive rate



The above Bar diagram is a diagramatic representation of Mean Fractional anisotrophy(FA) value in cord compression and non compression level



The above Bar diagram is a diagramatic representation of Mean Apparent diffusion coefficient (ADC)value in cord compression and non compression level

- **Comparision of Mean FA&ADC value at cord compression and non compression level using Wilcoxan rank test**

NPar Tests

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
MEAN FA NC LEVEL - MEAN FA C LEVEL	Negative Ranks	0[a]	.00	.00
	Positive Ranks	50[b]	25.50	1275.00
	Ties	0[c]		
	Total	50		
MEAN ADC NC LEVEL - MEAN ADC C LEVEL	Negative Ranks	38[d]	27.47	1044.00
	Positive Ranks	10[e]	13.20	132.00
	Ties	2[f]		
	Total	50		

a. MEAN FA NC LEVEL < MEAN FA C LEVEL

b. MEAN FA NC LEVEL > MEAN FA C LEVEL

c. MEAN FA NC LEVEL = MEAN FA C LEVEL

d. MEAN ADC NC LEVEL < MEAN ADC C LEVEL

e. MEAN ADC NC LEVEL > MEAN ADC C LEVEL

f. MEAN ADC NC LEVEL = MEAN ADC C LEVEL

NC – non compressioon level C – Comprssion level

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MEAN FA C LEVEL	.4928	50	.13308	.01882
	MEAN FA NC LEVEL	.7736	50	.04543	.00643
Pair 2	MEAN ADC C LEVEL	1.1968	50	.16088	.02275
	MEAN ADC NC LEVEL	1.0312	50	.13175	.01863

Test statistics [a]

	Z VALUE	P VALUE
MEAN FA VALUE NC LEVEL- COMPRESSION LEVEL	**-6.158[b]**	**0.0005**
MEAN ADC VALUE NC - LEVEL COMPRESSION LEVEL	**-4.679[c]**	**0.0005**

a- Wilcoxan signed rank test
b- Based on positive rank
c- Based on negative rank

NC – Non compression C – compression level

P - Value	Highly Significant at P ≤ .01
P - Value	Significant at P ≤ .05

- **Mean FA value at cord compression level is 0.49 with SD OF 0.13**
- **Mean FA value at cord non compression level is 0.77 with SD OF 0.04**

➢ **When comparing both variables using wilcoxon signed rank test the**

Z value obtained is -6.158 with P VALUE OF 0.0005

- **Mean ADC value at cord compression level is 1.19 with SD OF 0.16**
- **Mean ADC value at cord non compression level is 1.03 with SD OF 0.13**

➢ **When comparing both variables using wilcoxon signed rank test the**

Z value obtained is -4.679 with P VALUE OF 0.0005

➢ **There is ststistically HIGHLY SIGNIFICANT diffence in the Mean FA & ADC VALUE between compression and non compression level with**

P VALUE OF 0.0005

SPEARMAN'S RANK CORRELATION TEST

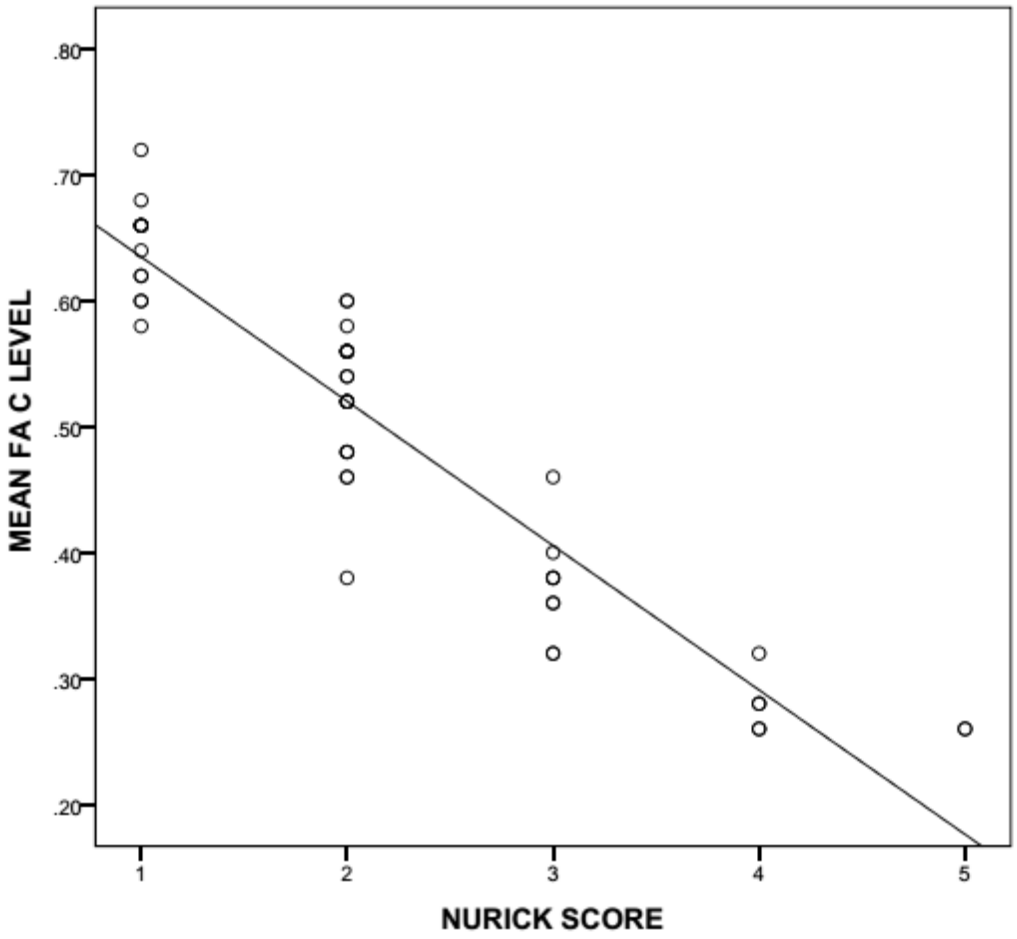
CORRELATION CHART

Nonparametric Correlations

Correlations

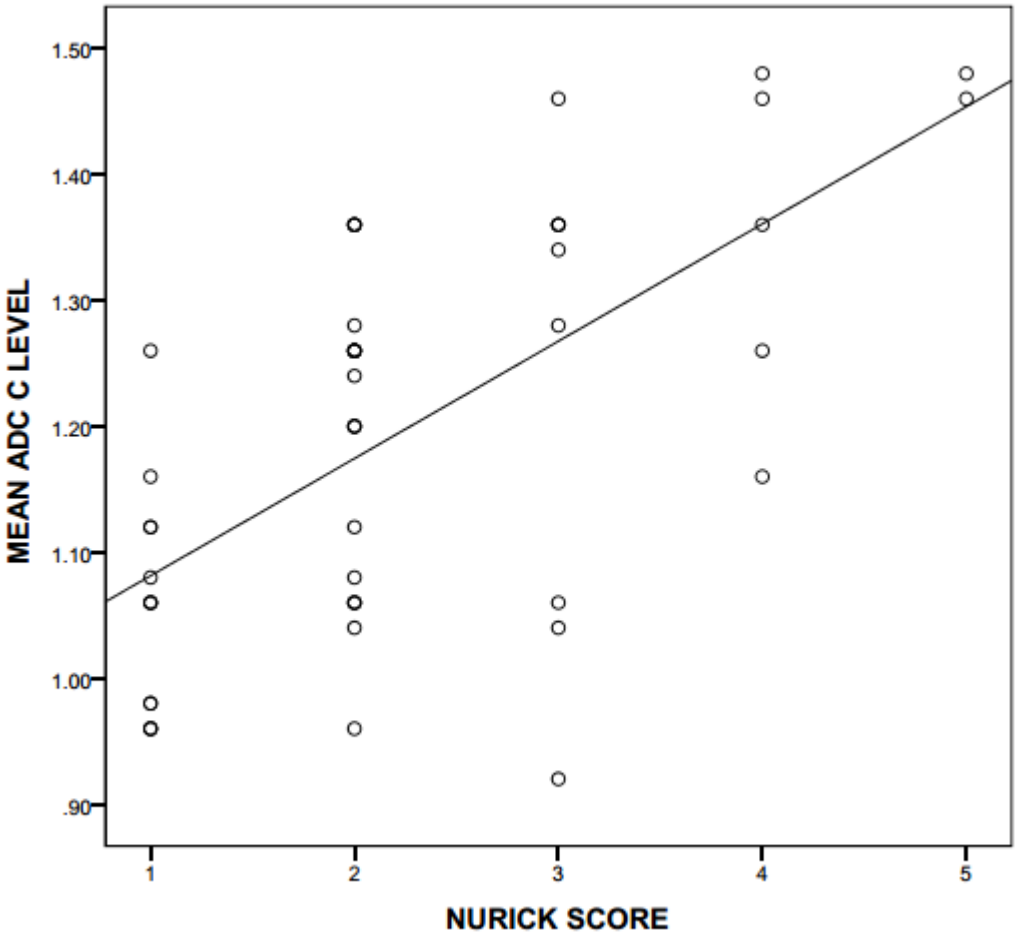
			NURICK SCORE	T2 HYPERINTENSITY	MEAN FA C LEVEL	MEAN ADC C LEVEL
Spearman's rho	NURICK SCORE	Correlation Coefficient	1.000	.309*	-.936**	.591**
		Sig. (2-tailed)		.029	.000	.000
		N	50	50	50	50
	T2 HYPERINTENSITY	Correlation Coefficient	.309*	1.000	-.252	.340*
		Sig. (2-tailed)	.029		.077	.016
		N	50	50	50	50
	MEAN FA C LEVEL	Correlation Coefficient	-.936**	-.252	1.000	-.575**
		Sig. (2-tailed)	.000	.077		.000
		N	50	50	50	50
	MEAN ADC C LEVEL	Correlation Coefficient	.591**	.340*	-.575**	1.000
		Sig. (2-tailed)	.000	.016	.000	
		N	50	50	50	50

GRAPH 1



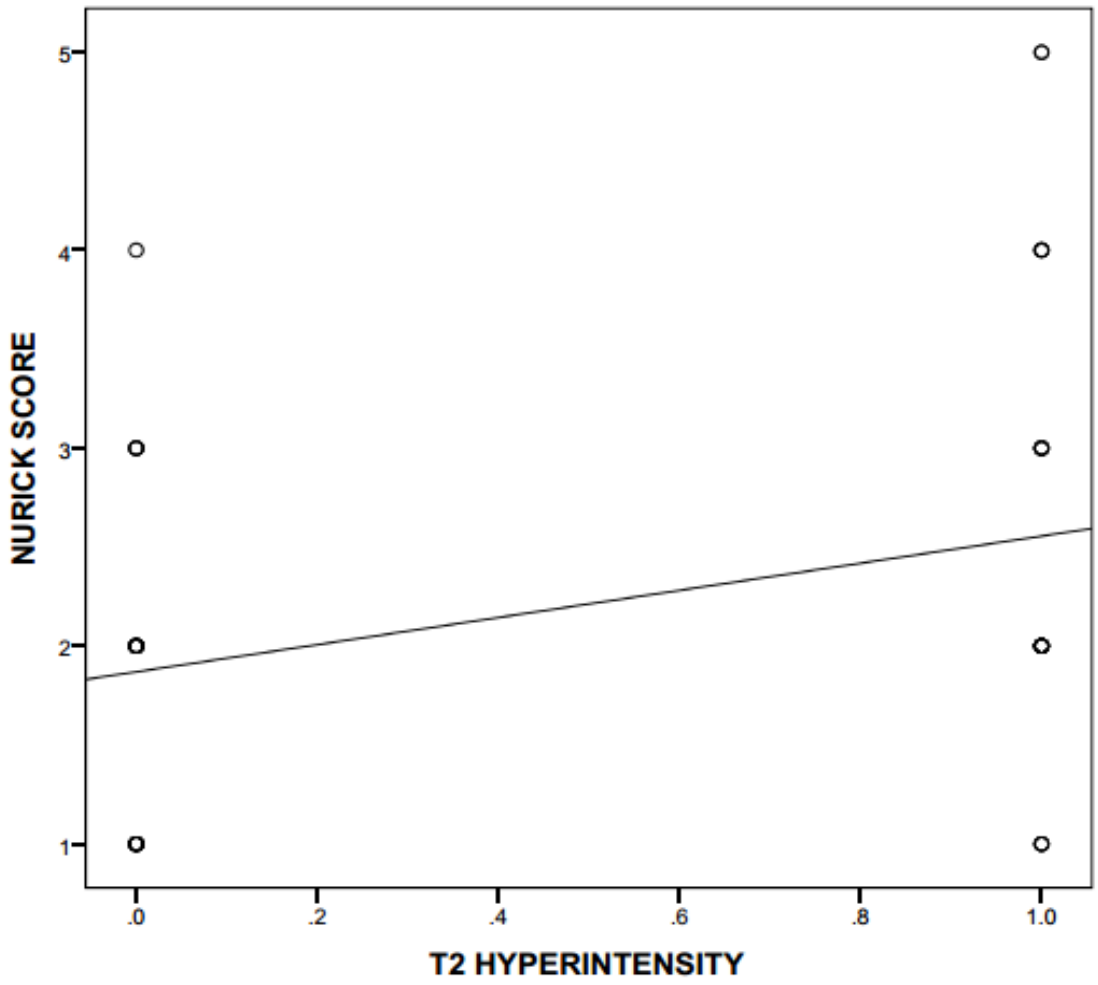
This graph shows correlation between **Fractional anisotrophy (FA)** with **Nurick's clinical score** It has a **VERY STRONG** negative correlation with Spearman's **rho** value of – 0.936 & "**P value 0.005"** (P value < 0.05). The percentage of correlation of 93.6%.

GRAPH 2



This graph shows correlation between **Apparent diffusion coefficient (ADC)** with **Nurick's clinical score** It has a **MODERATE** POSITIVE correlation with Spearman's **rho** value of 0.591 & **P value 0.0005** (P value < 0.05). The percentage of correlation of 59.1%.

GRAPH 3



This graph shows correlation between **Conventional T 2 hyperintensity** with **Nurick's clinical score** It has a **weak** POSITIVE correlation with Spearman's **rho** value of 0.309 & **P value 0.029**(P value < 0.05).

SPEARMAN'S rho and P VALUE

Variables	Rho value	P-Values
NURICK SCORE with T2	0.309	0.029 *
NURICK SCORE with FA C	-0.936	0.0005 **
NURICK SCORE with ADC C	0.591	0.0005 **
* Sig. at P < 0.05 & ** Highly Sig. at P < 0.01 level		

SPERMAN'S rho value	Degree of correalation
0.20 to 0.39	WEAK correalation
0.40 to 0.59	MODERATE correalation
0.60 to 0.79	STRONG correalation
More than 0.8	HIGHLY STRONG

P - Value	Highly Significant at P ≤ .01
P - Value	Significant at P ≤ .05

STATISCAL REVIEW & RESULTS

- Totally the sample includes 50 patients with symptoms of cervical spondylotic myelopathy **(Experimental group)**

- Mean Fractional anisotrophy(FA) value obtained from control was

  0.74 ± 0.06.

  Mean Apparent diffusion coefficient value obtained from control was

  1.04±0.08 x 10^{-3} mm^2

- Among the total of 50 patients 14 (28%)were Female 36(72%) were Male**.**

This study did not take in to account the age and sex of the patient however the sex distribution in the study showed male to be predominant than female patient

- **A**mong the 50 experimental cases only 23(46%)

  associated with abnormal conventional T 2 weighted imaging findings(T2 hyperintensity and spinal cord thining.

- Mean Fractional anisotrophy**(FA)** value obtained in the Experimental group at spinal cord compression level was **0.49**And at non compression level was **0.77**.

- There is ststistically HIGHLY SIGNIFICANT differnce in the Mean FA VALUE between compression and non compression level with Z value -6.158 & P VALUE OF 0.0005.

- Mean **ADC (**Apparent diffusion coefficient) value obtained in the Experimental group at cervical spinal cord compression level was **$1.20x10^{-3}mm^{2}$** And at non compression level was **$1.03x10^{-3}mm^{2}$**05.

- There is stastistically HIGHLY SIGNIFICANT differnce in the Mean ADC VALUE between compression and non compression level with Z value -4.679 & P VALUE OF 0.0005.

- Graph 1 shows correlation between **Fractional anisotrophy (FA)** with **Nurick's clinical score** It has a **VERY STRONG** negative correlation with Spearman's **rho** value of – 0.936 &"**P value 0.005"** (P value < 0.05). The percentage of correlation of 93.6%.

- Graph 2 shows correlation between **Apparent diffusion coefficient (ADC)** with **Nurick's clinical score** It has a **MODERATE** POSITIVE correlation with Spearman's **rho** value of 0.591 &"**P value 0.0005"** (P value < 0.05). The percentage of correlation of 59.1%.

- Graph 3 shows correlation between **Conventional T 2 hyperintensity** with **Nurick's clinical score** It has a **weak** POSITIVE correlation with Spearman's **rho** value of 0.309 & **P value 0.029**(P value < 0.05).

Variables	Rho value	P-Values
NURICK SCORE with T2	0.309	0.029 *
NURICK SCORE with FA C	-0.936	0.0005 **
NURICK SCORE with ADC C	0.591	0.0005 **
* Sig. at P < 0.05 & ** Highly Sig. at P < 0.01 level		

SPERMAN'S rho value	Degree of correlation
0.20 to 0.39	WEAK correlation
0.40 to 0.59	MODERATE correlation
0.60 to 0.79	STRONG correlation
More than 0.8	HIGHLY STRONG

P - Value	Highly Significant at P ≤ .01
P - Value	Significant at P ≤ .05

DISCUSSION

CSM (Cervical spondylotic myelopathy) is a very common disease occurs due to direct compression of the spinal cord by spondylotic changes.

MRI is the best imaging modality for the assessment of Cervical spondylotic myelopathy(CSM), but disparity between the patients clinical severity and T 2 hyperintensity noted in number of cases .Some patients have severe clinical symptoms with normal cord signal.

For this reason a advanced imaging approach that able to evaluate microstrutural abnormalities is needed for the evaluation of Cervical spondylotic myelopathy (CSM).

In our study ststistically HIGHLY SIGNIFICANT differnce in the **Mean FA VALUE** between compression and non compression level with Z value -6.158 & P VALUE OF 0.0005 noted.

In our study ststistically HIGHLY SIGNIFICANT differnce in the **Mean ADC VALUE** between compression and non compression level with Z value -4.679 & P VALUE OF 0.0005 noted.

- **VERY STRONG** **negative** correlation with Spearman's **rho** value of – 0**.936** &**P value 0.005** noted between the Fractional anisotophy **(FA)**value at compression level and Nurick's clinical score.

- **MODERATE** **positive** correlation with Spearman's **rho** value of 0.591 &**P value 0.0005** noted between the ADC value(apparent diffusion coefficient) at compression level and Nurick's clinical score.

- **WEAK** POSITIVE correlation with Spearman's **rho** value of 0.309 & **P value 0.029** noted between the conventional T2 weighted image hyperintensity and Nurick's clinical score.

CONCLUSION

Diffusion tensor imaging(**DTI)** parameter-Fractional anisotophy (**FA**)values were very strongly correlated with patients'clinical scores(nurick's score) .

ADC(Apparent diffusion coefficient) values were moderately correlated with patient's clinical score(Nurick's)

Our study Find that **"**high signal intensity on T2 of the spinal cord is not correlated either with the DTI parameters or with clinical assessment**"**, suggesting that Fractional anisotrophy (FA) is more accurate than conventional T2 imaging in the diagnosis and assessment of prognosis & severity of the disease.

DTI (Diffusion tensor imaging) can become a new technique for the evaluation of cervical spondylotic myelopathy(CSM).

BIBILIOGRAPHY

1.Crandall, Paul H., and Ulrich Batzdorf. "Cervical spondylotic myelopathy."*Journal of neurosurgery* 25.1 (1966): 57

.2. Montgomery, D. M., and R. S. Brower. "Cervical spondylotic myelopathy. Clinical syndrome and natural history." *The Orthopedic clinics of North America*23.3 (1992): 487-493.

3. Suri, Ashish, et al. "Effect of intramedullary signal changes on the surgical outcome of patients with cervical spondylotic myelopathy." *The Spine Journal*3.1 (2003): 33-45.

4. Chen, Chi-Jen, et al. "Intramedullary High Signal Intensity on T2-Weighted MR Images in Cervical Spondylotic Myelopathy: Prediction of Prognosis with Type of Intensity 1." *Radiology* 221.3 (2001): 789-794.

5. Fernández de Rota, Juan Jose, et al. "Cervical spondylotic myelopathy due to chronic compression: the role of signal intensity changes in magnetic resonance images." *Journal of Neurosurgery: Spine* 6.1 (2007): 17-22.

6. Al-Mefty, Ossama, et al. "Myelopathic cervical spondylotic lesions demonstrated by magnetic resonance imaging." *Journal of neurosurgery* 68.2 (1988): 217-222.

7. Freeman, T. B., and C. R. Martinez. "Radiological evaluation of cervical spondylotic disease: Limitation of magnetic resonance imaging for diagnosis and preoperative assessment." *Perspect Neurol Surg* 3.91 (1992): 34-54.

8. BRAIN, W. RUSSELL, Douglas Northfield, and Marcia Wilkinson. "The neurological manifestations of cervical spondylosis." *Brain* 75.2 (1952): 187-225.

9. Clarke, Edwin, and PETER K. ROBINSON. "Cervical myelopathy: a complication of cervical spondylosis." *Brain* 79.3 (1956): 483-510.

10. Brown, Alan Geoffrey. *Organization in the spinal cord: the anatomy and phisiology of identified neurones*. Springer, 1981.

11. Baron, Eli M., and William F. Young. "Cervical spondylotic myelopathy: a brief review of its pathophysiology, clinical course, and diagnosis." *Neurosurgery*60.1 (2007): S1-35.

12 BRAIN, W. RUSSELL, Douglas Northfield, and Marcia Wilkinson. "The neurological manifestations of cervical spondylosis." *Brain* 75.2 (1952): 187-225.

13. Furlan, Julio C., et al. "Functional and clinical outcomes following surgical treatment in patients with cervical spondylotic myelopathy: a prospective study of 81 cases: Clinical article." *Journal of Neurosurgery: Spine* 14.3 (2011): 348-355.

14. Kumaresan, Srirangam, et al. "Contribution of disc degeneration to osteophyte formation in the cervical spine: a biomechanical investigation." *Journal of Orthopaedic Research* 19.5 (2001): 977-984.

15. Hoff, J. T., and Ch B. Wilson. "The pathophysiology of cervical spondylotic radiculopathy and myelopathy." *Clinical neurosurgery* 24 (1977): 474.

16. Hsu, Wesley, Michael J. Dorsi, and Timothy F. Witham. "Surgical management of cervical spondylotic myelopathy." *Neurosurgery quarterly* 19.4 (2009): 302.

17. McCormick, William E., Michael P. Steinmetz, and Edward C. Benzel. "Cervical spondylotic myelopathy: make the difficult diagnosis, then refer for surgery." *Cleveland clinic journal of medicine* 70.10 (2003): 899-905.

18. McCormick, William E., Michael P. Steinmetz, and Edward C. Benzel. "Cervical spondylotic myelopathy: make the difficult diagnosis, then refer for surgery." *Cleveland clinic journal of medicine* 70.10 (2003): 899-905.

19. Ferguson RJL, Caplan LR. Cervical spondylitic myelopathy. *Neurologic Clinics*. 1985;3(2):373–382.

20. Firooznia, Hossein, et al. "Sudden quadriplegia after a minor trauma. The role of preexisting spinal stenosis." *Surgical neurology* 23.2 (1985): 165-168.

21. Vedantam, Aditya, Kumbhar Kartik Revanappa, and Vedantam Rajshekhar. "Changes in the range of motion of the cervical spine and adjacent segments at≥ 24 months after uninstrumented corpectomy for cervical spondylotic myelopathy." *Acta neurochirurgica* 153.5 (2011): 995-1001.

22. Gorter, K. "Influence of laminectomy on the course of cervical myelopathy."*Acta neurochirurgica* 33.3-4 (1976): 265-281.

23. Adams, Raymond D., et al. "Principles of neurology." *Cognitive and Behavioral Neurology* 10.3 (1997): 220.

24. Nurick S. The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain.1972;95:87–100. doi: 10.1093/brain/95.1.87.

25. Hukuda SMT, Ogata M, Schichikawa K, Shimomura T. Operations for cervical spondylotic myelopathy: a comparison of the results of anterior and posterior procedures. J Bone Joint Surg Br. 1985;67B:609–615

26. Al-Mefty, Ossama, et al. "Myelopathic cervical spondylotic lesions demonstrated by magnetic resonance imaging." *Journal of neurosurgery* 68.2 (1988): 217-222.

27. Freeman, T. B., and C. R. Martinez. "Radiological evaluation of cervical spondylotic disease: Limitation of magnetic resonance imaging for diagnosis and preoperative assessment." *Perspect Neurol Surg* 3.91 (1992): 34-54.

28. Roberts AH. Myelopathy due to cervical spondylosis treated by collar immobilization. Neurology. 1966;16:951–4

29. Zeidman SM, Ducker TB. Cervical disk diseases: part 1. Treatment options and outcomes.Nuerosurgy Quarterly. 1992;2:116–43

30. Moseley, Michael E., et al. "Diffusion-weighted MR imaging of anisotropic water diffusion in cat central nervous system." *Radiology* 176.2 (1990): 439-445.

31. Basser, Peter J., James Mattiello, and Denis LeBihan. "MR diffusion tensor spectroscopy and imaging." *Biophysical journal* 66.1 (1994): 259.

32. Papadakis, Nikolaos G., et al. "Minimal gradient encoding for robust estimation of diffusion anisotropy☆." *Magnetic resonance imaging* 18.6 (2000): 671-679.

33. Hasan, Khader M., Dennis L. Parker, and Andrew L. Alexander. "Comparison of gradient encoding schemes for diffusion-tensor MRI." *Journal of Magnetic Resonance Imaging* 13.5 (2001): 769-780.

34. Jones, D. K., M. A. Horsfield, and A. Simmons. "Optimal strategies for measuring diffusion in anisotropic systems by magnetic resonance imaging."*Magn Reson Med* 42 (1999).

35. Jellison, Brian J., et al. "Diffusion tensor imaging of cerebral white matter: a pictorial review of physics, fiber tract anatomy, and tumor imaging patterns."*American Journal of Neuroradiology* 25.3 (2004): 356-369.

36Basser, Peter J., and Carlo Pierpaoli. "Microstructural and physiological features of tissues elucidated by quantitative-diffusion-tensor MRI." *Journal of magnetic resonance* 213.2 (2011): 560-570.

37Douek, Philippe, et al. "MR color mapping of myelin fiber orientation." *Journal of computer assisted tomography* 15.6 (1991): 923-929..

38. Lazar, Mariana, et al. "White matter tractography using diffusion tensor deflection." *Human brain mapping* 18.4 (2003): 306-321.

39.Baron, Eli M., and William F. Young. "Cervical spondylotic myelopathy: a brief review of its pathophysiology, clinical course, and diagnosis." *Neurosurgery*60.1 (2007): S1-35.

40.Cheung, Matthew M., et al. "In vivo diffusion tensor imaging of chronic spinal cord compression in rat model." *Engineering in Medicine and Biology Society, 2009. EMBC 2009. Annual International Conference of the IEEE*. IEEE, 2009..

41. Fernández de Rota JJ, Meschian S, Fernández de Rota A, Urbano V, Baron M (2007) Cervical spondylotic myelopathy due to chronic compression: the role of signal intensity changes in magnetic resonance images. Journal of Neurosurgery: Spine 6: 17–22

42. Demir A, Ries M, Moonen CT, Vital JM, Dehais J, et al. (2003) Diffusion-weighted MR imaging with apparent diffusion coefficient and apparent diffusion tensor maps in cervical spondylotic myelopathy.Radiology 229: 37–43

43. Jones JGA, Cen SY, Lebel RM, Hsieh PC, Law M (2013) Diffusion tensor imaging correlates with the clinical assessment of disease severity in cervical

spondylotic myelopathy and predicts outcome following surgery. American Journal of Neuroradiology 34: 471–478.

44. Mamata H, Jolesz FA, Maier SE (2005) Apparent diffusion coefficient and fractional anisotropy in spinal cord: Age and cervical spondylosis-related changes. Journal of Magnetic Resonance Imaging 22: 38–43.

45. Fernández de Rota, Juan Jose, et al. "Cervical spondylotic myelopathy due to chronic compression: the role of signal intensity changes in magnetic resonance images." *Journal of Neurosurgery: Spine* 6.1 (2007): 17-22.

46..Morio Y, Teshima R, Nagashima H et al (2001) Correlationetween operative outcomes of cervical compression myelopathy and MRI of the spinal cord. Spine

47.. Budzik, Jean-François, et al. "Diffusion tensor imaging and fibre tracking in cervical spondylotic myelopathy." *European radiology* 21.2 (2011): 426-433.

LIST OF ABBREVATIONS

- DTI - Diffusion Tensor Imaging
- DT - Diffusion Tensor
- CSM - Cervical Spondylotic Myelopathy
- MR - Magnetic Resonance
- FA - Fractional anisotrophy
- MD - Mean diffusivity
- ADC - Apparent Diffusion Coefficient
- ROI - Region of interst
- FT - Fiber Tracking

PROFORMA

STUDY TITLE:

"DIFFUSION TENSOR IMAGING OF CERVICAL SPINE IN PATIENTS WITH SYMPTOMS OF CERVICAL SPONDYLOTIC MYELOPATHY(CSM) "

Sl.No:

Name :

Age/Sex :

Occupation :

Address :

Presenting Complaints:

NURICK MYELOPATHY SCORE:

FRACTIONAL ANISOTROPY VALUE

CORD LEVEL	FA VALUE	ADC VALUE
C2-C3		
C4-C5		
C6-C7		
MAXIMUM CORD COMPRESSION LEVEL		

- CONVENTIONAL T2 WEIGHTED MRI FINDINGS:

PATIENT CONSENT FORM

STUDY TITLE

THE ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPONDYLOTIC MYELOPATHY

STUDY CENTRE

Barnard Institute of Radiology & Oncology,

Rajiv Gandhi Government General Hospital,

Madras Medical College,

Chennai – 600 003.

PARTICIPANT

Name: Age: Sex:

I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the pitfall in the procedure. I have been explained about the safety, advantage and disadvantage of the technique. I understand that my participation in the study is voluntary and that I am free to withdraw at anytime without giving any reason.

I understand that investigator, regulatory authorities and the ethics committee will not need my permission to look at my health records both in respect to current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from the study.

I have been explained that the MRI DTI technique is a standard and approved technique. This may help in future research in the field of radiology. I consent to undergo this procedure.

Date: **Signature/thumb impression of Patient**

PATIENT INFORMATION SHEET

We are conducting a study on "THE ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPONDYLOTIC MYELOPATHY"

- **Your co-operation would be valuable for the same**
- **The privacy of patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.**
- **Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time: your decision will not result in any loss of benefits to which you are otherwise entitled.**
- **The result of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.**

Signature of the investigator **Signature of participant**

(K. JANAKI RAMAN)

MASTER CHART

S.NO	NAME	AGE	SEX	NURICK SCORE	T2 HYPERINTENSITY	MEAN FA-NC LEVEL	MEAN FA MAX C-LEVEL	MEAN ADC NC LEVEL	MEAN ADC C-LEVEL
1	SELVAM	42	M	3	N	0.76	0.38	1.06	1.06
2	KANNAPPAN	52	M	2	N	0.78	0.56	0.96	1.26
3	NANDHAN	56	M	2	Y	0.82	0.6	0.98	1.24
4	SIVAGAMI	48	F	1	N	0.8	0.62	0.96	1.16
5	KESAVAN	32	M	3	Y	0.74	0.38	1.8	1.46
6	SHANMUGAM	65	M	2	N	0.8	0.56	1.02	1.12
7	SANGAVI	25	F	4	Y	0.82	0.28	1.1	1.48
8	SIVALINGAM	48	M	2	N	0.84	0.56	0.98	1.36
9	AYYAPPAN	45	M	2	Y	0.76	0.58	0.9	1.36
10	RANGAN	58	M	3	N	0.68	0.36	0.88	0.92
11	KUMAR	45	M	2	N	0.7	0.38	1.02	1.26
12	SAMBASIVAM	56	M	2	Y	0.68	0.52	1.08	1.28
13	PANEER	52	M	2	N	0.8	0.48	1.06	1.36
14	KARPAGAM	54	F	4	Y	0.82	0.28	0.98	1.16
15	VARADHAN	51	M	1	N	0.8	0.6	0.96	1.12
16	MUNIYANDI	46	M	1	Y	0.68	0.66	1.04	1.12
17	KARTHIKEYAN	28	M	2	Y	0.76	0.54	0.98	1.26
18	RAJA	38	M	1	N	0.78	0.58	1.04	1.26
19	THANGAMANI	48	M	2	Y	0.8	0.48	1.06	1.36

20	MAYILVAGANAM	46	M	5	Y	0.82	0.26	1.08	1.48
21	PASUPATHY	49	M	4	N	0.8	0.26	0.96	1.36
22	PARVATHYAMMAL	57	F	3	N	0.78	0.32	0.98	1.34
23	UNNAMALAI	45	F	3	Y	0.76	0.4	0.96	1.28
24	JAYAVEL	65	M	1	N	0.74	0.72	1.04	1.06
25	CHELLAPAN	65	M	2	N	0.8	0.6	1.08	1.06
26	GANESAN	64	M	4	Y	0.84	0.32	0.94	1.26
27	DHANDAPANI	62	M	3	N	0.8	0.36	0.98	1.04
28	PUSHPA	58	F	2	Y	0.72	0.46	0.96	1.26
29	POONGAVANAM	47	M	3	Y	0.72	0.32	1.06	1.36
30	PARTHIBAN	35	M	2	Y	0.78	0.56	1.08	1.26
31	AMBIGA	34	F	2	N	0.8	0.52	1.02	1.06
32	SARAVANAN	62	M	1	N	0.84	0.62	1.04	1.08
33	KARUPAIAH	63	M	1	Y	0.8	0.6	1.06	0.98
34	RAGURAM	45	M	1	N	0.78	0.66	1.08	0.96
35	MURUGESAN	52	M	3	Y	0.76	0.46	1.04	1.36
36	AADHI	38	M	4	Y	0.8	0.26	0.96	1.46
37	ALAMELU	39	F	1	N	0.8	0.64	0.98	0.96
38	VALLI	48	F	2	Y	0.82	0.56	0.96	1.2
39	KANCHANA	46	F	2	N	0.74	0.52	0.9	1.2
40	GOVINDHAN	58	M	5	Y	0.72	0.26	0.88	1.46
41	SANTHANAM	52	M	1	N	0.7	0.66	0.92	1.06
42	SUSEELA	45	F	2	Y	0.68	0.48	0.9	1.06
43	THIYAGARAJAN	47	M	2	Y	0.7	0.52	1.1	0.96
44	LAKSHMI	48	F	1	N	0.82	0.66	1.08	0.98

45	EGAMBARAM	59	M	1	Y	0.8	0.66	1.02	0.96
46	VENKATESAN	54	M	2	N	0.78	0.52	1.08	1.08
47	DEVARAJ	29	M	2	Y	0.8	0.54	1.12	1.04
48	RANI	38	F	2	Y	0.78	0.46	1.1	1.2
49	ASIFA	36	F	3	Y	0.8	0.38	1.18	1.36
50	VEERAMANI	68	M	1	Y	0.78	0.68	1.16	1.06

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To

Dr.Janakiraman . K.
Post Graduate in Radio Diagnosis
Madras Medical College
Chennai 600 003

Dear Dr.Janakiraman .K,

The Institutional Ethics Committee has considered your request and approved your study titled **"THE ROLE OF DIFFUSION TENSOR IMAGING IN EARLY DETECTION OF CERVICAL SPONDYLOTIC MYELOPATHY WITH 3 T M.R.I. "** NO.22032015.

The following members of Ethics Committee were present in the meeting hold on 03.03.2015 conducted at Madras Medical College, Chennai 3

1. Prof.C.Rajendran, MD	:Chairperson
2. Prof.R.Vimala,MD.,Dean,MMC,Ch-3	: Deputy Chairperson
3. Prof.B.Kalaiselvi,MD.,Vice Principal,MMC,Ch-3	: Member Secretary
4. Prof.R.Nandini,MD.,Inst.of Pharmacology,MMC	: Member
5. Prof.K.Ramadevi, Director I/c,Inst.of Bio-Chem.MMC	: Member
6. Prof.Saraswathy,MD.,Director,Pathology, MMC	: Member
7. Prof.S.G.Sivachidambaram,MD.,Director I/c Inst.of Internal Medicine,MMC	: Member
8. Thiru S.Rameshkumar, B.Com., MBA.	: Lay Person
9. Thiru S.Govindasamy, BA., BL.,	: Lawyer
10.Tmt.Arnold Saulina, MA., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

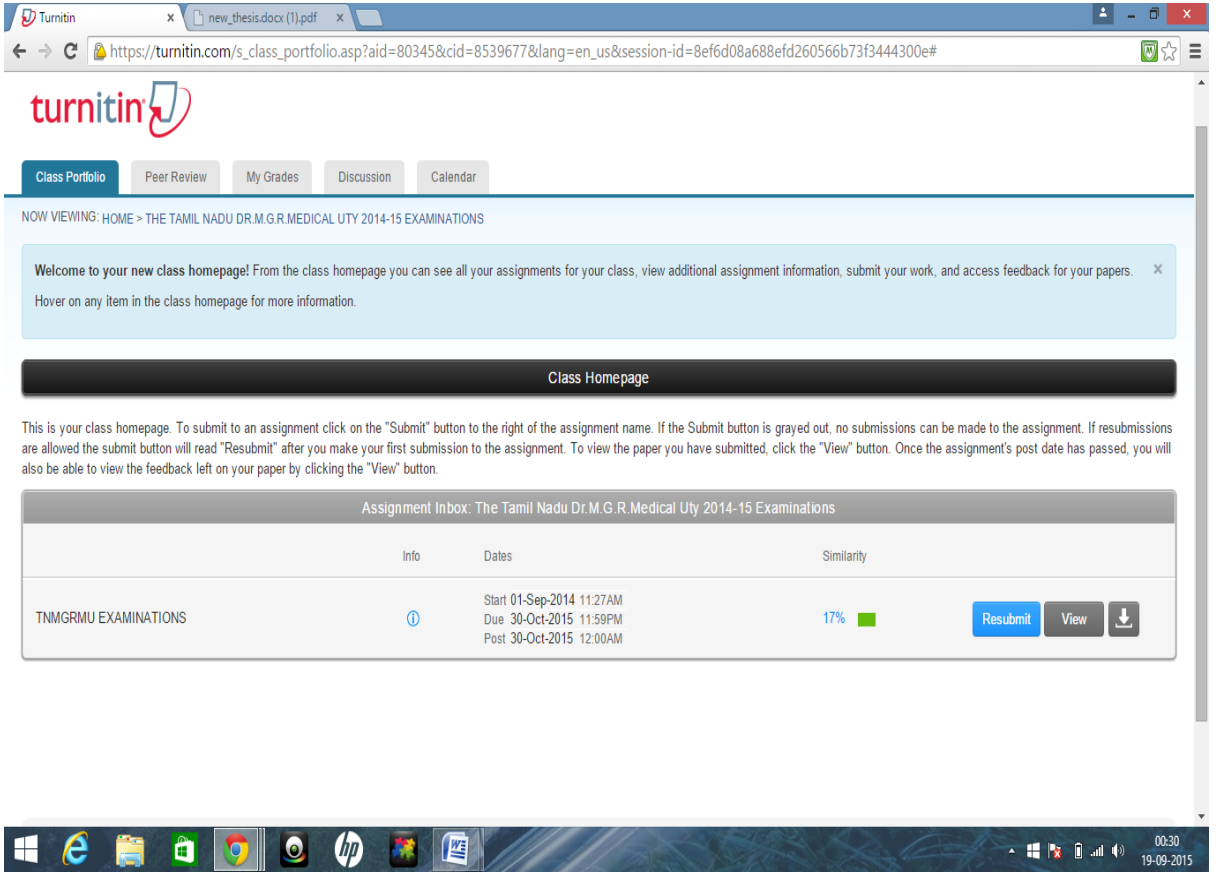
19/3/15

Member Secretary – Ethics Committee

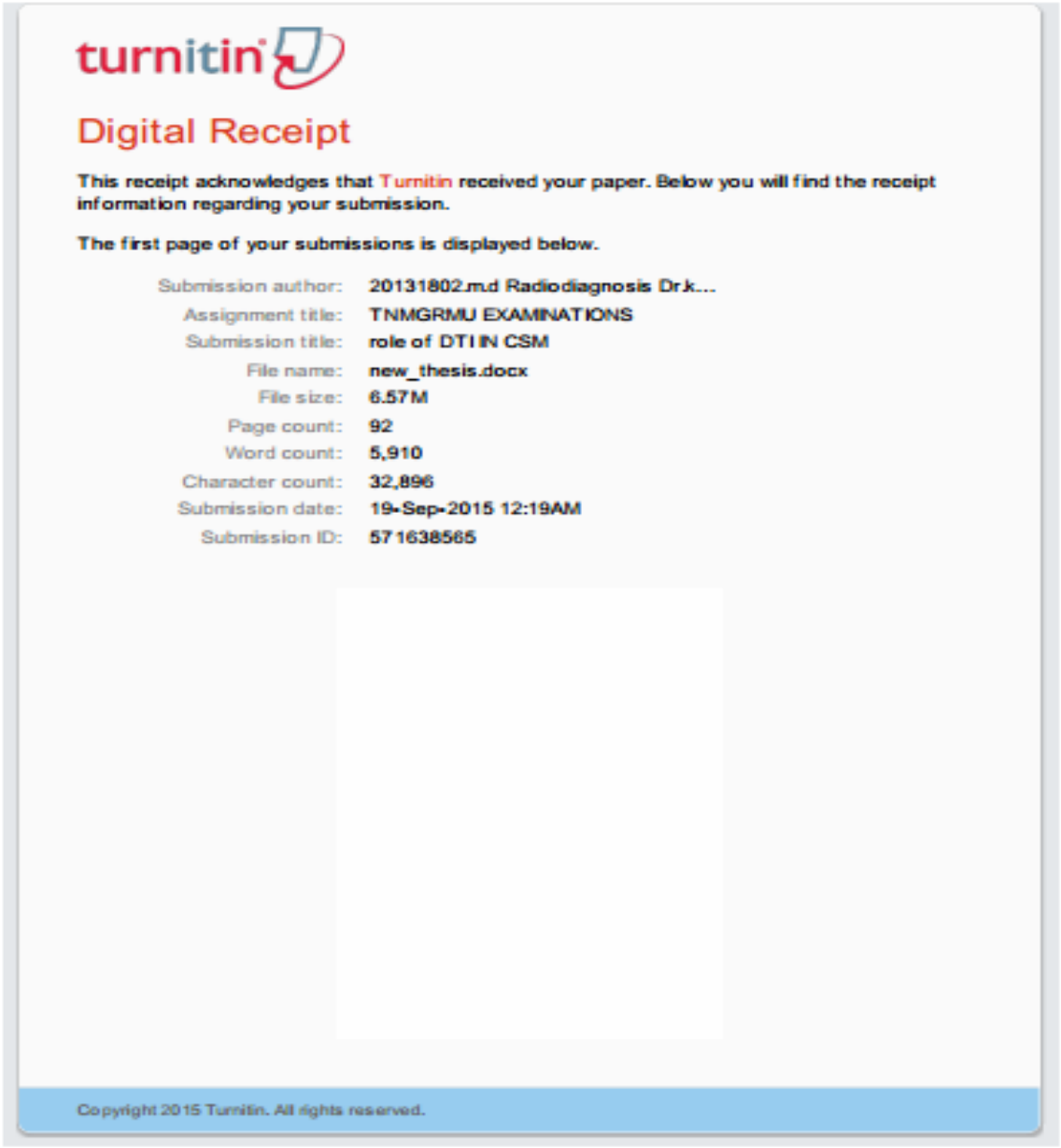
Sys 2

PLAGIARISM

Turnitin Document Viewer - Google Chrome
https://turnitin.com/dv?s=18&o=571638565&u=1042554788&student_user=1&lang=en_us&
The Tamil Nadu Dr.M.G.R.Medical...
TNMGRMU EXAMINATIONS - DUE 30-...
Originality
GradeMark
PeerMark
role of DTI IN CSM
BY 20131802.M.D RADIODIAGNOSIS DR.K.JANAKIRAMAM
turnitin
17%
SIMILAR
--
OUT OF 0
Match Overview
1 www.mayfieldclinic.com Internet source 3%
2 www.columbianeurosu... Internet source 2%
3 www.ajnr.org Internet source 1%
4 Guan, Xiaofei, Guoxin ... Publication 1%
5 Jean-François Budzik, ... Publication 1%
6 sci.rutgers.edu Internet source 1%
7 Submitted to Universit... Student paper 1%
8 Submitted to Higher E... Student paper 1%
INTRODUCTION
Cervical spondylosis is a very common degenerative disease of the spinal column in the elderly ,appearing as disc dessication herniation ,osteophytosis,and spinal canal narrowing.[1]
Cervical spondylosis myelopathy, commonly known as cervical spondylotic myelopathy (CSM), refers to impaired function of the spinal cord due to degenerative changes of the discs and facet joints in the cervical spine (neck).[2]
Cervical spondylotic myelopathy (CSM) is a condition that occurs due to chronic spinal cord compression by degenerative changes (disc dessication,bulge,osteophite formation) that occur as the age increases. After the age of 50 years the disease commonly occurs.
As the spinal cord carry nerve impulses to multiple regions in the human body, weakness and numbness in the upper &lower limbs ,
PAGE: 2 OF 62
Text-Only Report
00:29
19-09-2015


Turnitin
new_thesis.docx (1).pdf
https://turnitin.com/s_class_portfolio.asp?aid=80345&cid=8539677&lang=en_us&session-id=8ef6d08a688efd260566b73f3444300e#
turnitin
Class Portfolio
Peer Review
My Grades
Discussion
Calendar
NOW VIEWING: HOME > THE TAMIL NADU DR.M.G.R.MEDICAL UTY 2014-15 EXAMINATIONS
Welcome to your new class homepage! From the class homepage you can see all your assignments for your class, view additional assignment information, submit your work, and access feedback for your papers.
Hover on any item in the class homepage for more information.
Class Homepage
This is your class homepage. To submit to an assignment click on the "Submit" button to the right of the assignment name. If the Submit button is grayed out, no submissions can be made to the assignment. If resubmissions are allowed the submit button will read "Resubmit" after you make your first submission to the assignment. To view the paper you have submitted, click the "View" button. Once the assignment's post date has passed, you will also be able to view the feedback left on your paper by clicking the "View" button.
Assignment Inbox: The Tamil Nadu Dr.M.G.R.Medical Uty 2014-15 Examinations
Info
Dates
Similarity
TNMGRMU EXAMINATIONS
Start 01-Sep-2014 11:27AM
Due 30-Oct-2015 11:59PM
Post 30-Oct-2015 12:00AM
17%
Resubmit
View
00:30
19-09-2015

DIGITAL RECEIPT OF PLAGIARISM SUBMISSION



turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	20131802.md Radiodiagnosis Dr.k...
Assignment title:	TNMGRMU EXAMINATIONS
Submission title:	role of DTI IN CSM
File name:	new_thesis.docx
File size:	6.57M
Page count:	92
Word count:	5,910
Character count:	32,896
Submission date:	19-Sep-2015 12:19AM
Submission ID:	571638565